Bulletin 192

DEPARTMENT OF THE INTERIOR

ALBERT B. FALL, SECRETARY

BUREAU OF MINES

H. FOSTER BAIN, DIRECTOR

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BY

R. O. NEAL and G. St. J. PERROTT

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By Roy O. Neal.

INTRODUCTION.

As natural gas is a waning resource in many places, increased interest has attached to the use of gas for the manufacture of carbon black. Because of a large number of requests for information on the subject, the Bureau of Mines has undertaken a detailed study of the carbon-black industry, covering the mechanical details of commercial methods, with the purpose of increasing the recovery of carbon black by such processes. A study has been undertaken of the economic factors governing the carbon-black industry, the uses and properties of carbon black; the development of more accurate methods of testing carbon black, microscopic examination of different grades of black, physicochemical study of methods of manufacture now in use, and research on new methods of manufacture.

Part I of this paper covers the engineering and economic side of the industry; the other phases of the investigation which have been under the direction of G. St. J. Perrott, of the Pittsburgh station of the United States Bureau of Mines, are discussed in Part II.

DEFINITION OF CARBON BLACK.

Confusion exists in the use of the terms lampblack and carbon black, although in American trade lampblack is generally understood to be a soot formed by the smudge process. In this process oil, coal tar, resin, or some solid or liquid carbonaceous substance is burned in an insufficient quantity of oxygen or air. On the other hand, carbon black refers to a product resulting from the incomplete combustion of gas and is deposited by actual contact of a flame upon a metallic surface.

The various carbons, such as gas-retort coke, oil-retort coke, graphite, carbon black, lampblack, vine black, wood-pulp black, willow charcoal, and blacks made from refuse material, such as leather, do not possess the same flocculent characteristics, strength of color, chemical composition, or physical structure. Each black has its specific uses, and as a rule to-day it can not be substituted for another black. To apply the usual tests to determine which black to use is often difficult because of the modification in properties when a black is combined with other substances. In this paper the black resulting from incomplete combustion of gas is discussed and throughout the paper is designated as carbon black, although in the trade it is often referred to as gas black, natural-gas black, ebony black, jet black, hydrocarbon black, satin-gloss black, and silicate of carbon. These blacks are made by one of the following methods:

1. Formation by direct contact of a flame upon a depositing surface.

2. Production by combustion of an oil, tar, etc., in an inadequate supply of air, where soot is allowed to settle slowly on the floors and walls of the collecting chambers.

3. Carbonization of solids and subsequent reduction to a state of small subdivision.

4. Production by heating carbonaceous vapors or gases to a decomposition temperature by external heating with or without air in the forming chamber. This method is usually referred to as cracking or thermal decomposition, and so far is only experimental.

There is an almost universal misapprehension that these various substances are carbon, whereas they are essentially a mixture of hydrocarbons and other organic substances that may contain considerable mineral matter.

ACKNOWLEDGMENTS.

The writer wishes to express his gratitude for the many helpful suggestions given by Mr. G. L. Cabot, who has been connected with the technical and operative details of the carbon-black industry for 38 years. Only through the valuable assistance of Mr. Cabot has it been possible to unite certain sections of this paper, particularly those dealing with the plate or "Cabot" process. To Messrs. A. E. Whiting, Fred Padgett, B. W. Rumbarger, and G. A. Williams, for useful information, the writer is especially indebted. Acknowledgments are also due Messrs. J. H. Mann, Oscar Nelson, H. D. Briggs, N. H. Davis, P. F. Reardon W. M. McKinney, G. T. Thayer, jr., Reid L. Carr, J. D. Rowan, Geo. Taylor, W. E. Jones, E. Rutledge, J. P. Smoots, Dr. J. B. Garner, Roy Brownlee, F. Hartman, F. M. Knapp, J. A. Holden, C. A. Schwarm, and L. J. McNutt for information.

The writer expresses his personal appreciation of the aid of the following members of the United States Bureau of Mines: J. O. Lewis,

W. P. Dykema, and G. St. J. Perrott for valuable suggestions and criticisms during the preparation of the paper; to D. B. Dow, for analyzing gas samples; to J. G. Shumate and E. L. Sproat for drawings; and to Miss E. H. Burroughs for the bibliography of patents.

HISTORY OF CARBON-BLACK INDUSTRY.[1]

To certain manufacturers of printing ink it was known that the carbon made by burning artificial gas in a limited quantity of air gave the ink a very glossy and intense black. The first factory in which carbon black was successfully made on a commercial scale from natural gas was erected at New Cumberland, W. Va., in the year 1872, by Messrs. Haworth and Lamb, of Massachusetts. At this plant the gas well was connected to a gas holder having a blow off from which the surplus flow of gas not required at the plant might escape. At that time no regulating appliance was known, and a large waste of gas resulted from their enterprise.

The first actual use of natural gas for light in the United States occurred in Fredonia, N. Y., in 1826, but it was not until 1872 that pipes were laid in Titusville, Pa., for domestic purposes, the gas being transported through a 2-inch main from a gas well approximately 5 miles north of Titusville. The consumption of gas at that time was not enough to foster the development of regulating devices. Large quantities of natural gas were going to waste and could be obtained at a very low price; in fact, the oil pioneers considered natural gas as a dangerous nuisance to be blown off and disposed of in any way.

In the plant at New Cumberland the gas from the gas holder passed through pipes to gas jets arranged in the same horizontal plane beneath slabs of soapstone that were pierced with a number of orifices to permit the passage of excess smoke and the waste gases. The slabs were covered by a dome or roof that was provided with a damper for controlling the ventilation. The transverse horizontal scrapers below the slabs were supported and traveled in horizontal grooves in the lower and opposite sides of the dome. These scrapers from time to time removed the deposited carbon black, which fell into sheet-iron aprons or troughs that were supported from the burner pipe. From these troughs the black fell through pipes to a container that could be changed by hand when filled. The depositing surface was kept cool by pans through which water was continuously circulated. The resulting product sold for $2.50 per pound but did not possess all the properties of the product made from artificial gas. This plant

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[1] Taylor, G. E., The conservation of natural gas in West Virginia: Bull. of College of Eng., Univ. of West Virginia, July, 1918. Cabot, G. L., The preparation of carbon blacks from natural gas in America: Jour. Soc. Chem. Ind., 1894, vol. 13, pp. 128–130; Lampblack and carbon black: 8th Int. Cong. Appl. Chem., 1912, vol. 12, p. 13; discussion, vol. 27, p. 93; West Virginia Geol. Survey County Reports, 1912: Doddridge and Harrison Counties, pp. 656–660. Correspondence and personal interviews with carbon-black manufacturers.

was built of wood and was destroyed by fire after running a short time; it was then moved to Saronsburg, Pa.

The next innovation in the carbon-black industry was the use of a traveling car which hung from rails running parallel with the bench. This car carried a scraper and a shallow frame to which were attached on each side two deep receptacles of sheet iron that could be detached and emptied. The receptacles were just deep enough to pass over the burners without touching. An endless rope passing over a pulley moved the car in one direction for a given distance and then reversed it. The scrapers made contact by means of springs. Results soon showed that the dome was superfluous, that cast iron was better than soapstone as a depositing surface, and that there was practically no beneficial effect from artificial cooling.

Peter Neff built a plant at Gambier, Ohio, and through competition the price of carbon black was greatly reduced. This factory operated for 10 or 12 years, its maximum daily production being 125 pounds. Mr. Neff obtained a large number of patents, most of which were useless and impracticable.

In 1883 a considerable advance was made in the industry when L. Martin & Co. became interested in a small plant at Fosters Mills, Pa., that was not proving a financial success. Here five plates 24 feet in diameter, cast in segments, were supported by a central mast rotating with them upon bronze bedplates. Beneath these plates were fixed stationary burners of parallel, horizontal, 1¼-inch pipe. At this time carbon black could be purchased for 31 cents per pound.

In the same year A. R. Blood devised a method using a small disk or plate about 3 feet in diameter as the depositing surface. The advantage of this process over the use of 24-foot rings was that ventilation holes were not necessary and the wheels or plates could be made in one casting. A ratchet at the center revolved the plate. Beneath the plate was a scraper in the center of a radial hopper, through which the black fell into a longitudinal conveyor running beneath the row of plates. There were 16 rings in a row and 5 rows in a building. The buildings were constructed of sheet iron supported by a framework of pipe and angle iron, and had small openings near the bottom to permit the entrance of a sufficient supply of air. This method, with a few modifications, is still used and is known as the Blood or rotating-disk process.

By a patent issued in 1883, E. R. Blood began making carbon black by the roller process, using a burner with a small hole in the tip that gave a round flame. Although this method gave a very small yield of inferior color the black possessed certain properties that made it bring a high price. Even at present it is the most costly grade of carbon black on the market.

In 1892 L. J. McNutt procured a patent on the channel system of making carbon black, and a factory was constructed at Gallagher, Pa. This process used a system of channel beams turned with the flat side downward over a horizontal row of stationary burners. The channels had a reciprocating motion, being slowly drawn back and forth, and the black was scraped from the channel bottom and removed by a spiral conveyor. By using channel irons a smoother depositing surface was possible than by using unsurfaced cast-iron plates.

At this time in the industry an attempt was made to manufacture carbon black from petroleum by evaporating and burning the vapors through gas burners; the resulting product, however, contained hard particles of carbon similar to coke, which limited its utilization, and the cost of operating a plant burning petroleum vapors or gas enriched by oil vapor has proved so high as to be usually unremunerative.

A plant in West Virginia was constructed about 1902 in which the black was collected upon a hollow channel iron through which a blast of air was blown to cool the depositing surface and to increase the yield of black. This process has since been abandoned.

In 1913 G. Fernekes obtained a patent on a process for making carbon black by subjecting gas to a temperature which dissociates it into carbon and hydrogen. The decomposing chamber was heated by electric coils. This process is not used commercially.

A patent was issued to R. H. Brownlee and R. H. Uhlinger in 1916 for making carbon black and hydrogen from a hydrocarbon decomposed by burning in contact with a highly heated refractory material within an inclosed chamber, at a pressure in excess of atmospheric pressure, and then separating the black from the hydrogen. The carbon black is not collected but is blown, and its only use seems to be in making paints. The method of producing hydrogen, however, seems to be commercially practical.

Attempts have been made to increase the yield by using chlorine and carbon tetrachloride, but they have not been a commercial success. The theory back of these attempts was that the yield of carbon black would be increased by the reaction between hydrogen and chlorine in forming hydrochloric acid.

A plant has been constructed to make black from emulsified or cut crude oil, which constitutes an enormous waste in the oil fields. The waste oil was burned on hot plates and the soot was led through a chimney equipped with a Cottrell apparatus for electrical precipitation. A number of difficulties were encountered and the plant discontinued operation.

PRODUCTION OF CARBON BLACK IN UNITED STATES.

Statistics on the quantity of carbon black manufactured are very few and are difficult to correlate. Until the utilization of gas from the prolific gas fields at Monroe and Shreveport, La., 75 per cent of the world's total supply of carbon black was produced in West Virginia. Figure 1 shows the quantity and cost of gas used by carbon-black manufacturers since 1916. Data for this curve were obtained from G. E. Taylor, assistant engineer of the public service commission of West Virginia. The average price of gas has never been as high as 3 cents per thousand cubic feet, although in some districts where carbon-black factories are located the price of gas has increased to

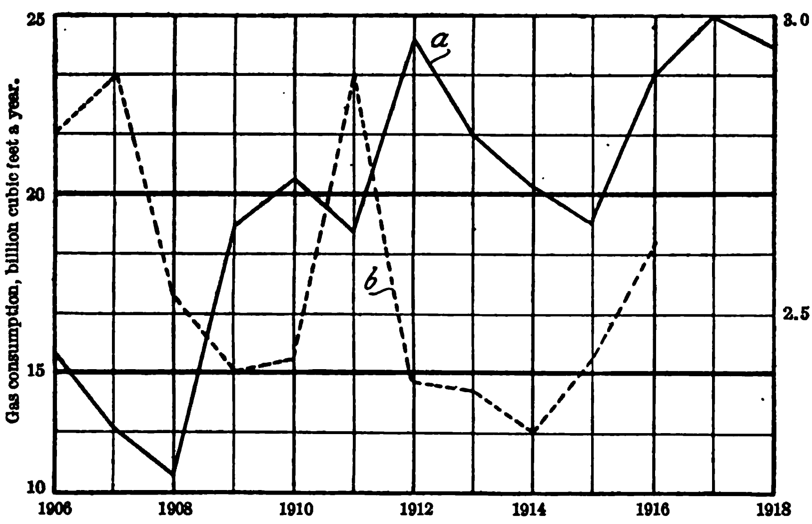

FIGURE 1.—Quantity and cost of gas used in West Virginia by manufacturers of carbon black: *a*, Gas consumption; *b*, price of gas.

8 cents per thousand cubic feet, thereby forcing the manufacturers to move their plants to isolated districts. In Louisiana the average price of gas is about 2 cents per thousand cubic feet; in Oklahoma the gas costs 5 to 6.5 cents per thousand cubic feet.

TABLE 1.—*Gas used for manufacture of carbon black in West Virginia.*

YEAR ENDING JUNE 30, 1918.

	Cubic feet.
Produced by gas utilities	246,519,553,000
Produced by producers	37,552,082,000
Errors in reports	113,000
Total production as reported	284,071,748,000
Produced by carbon-black companies not included above (estimated)	5,051,765,000
Total production [a]	289,123,513,000

[a] It is estimated that 24,830,697,000 cubic feet was used for the manufacture of carbon black.

TABLE 1.—*Gas used for manufacture of carbon black in West Virginia*—Continued.

	Cubic feet.
Consumed domestic and industrial	50,143,858,000
Consumed field and main lines	23,635,129,000
Consumed for carbon black (estimated)	24,830,697,000
Line loss, breakage of lines, etc	48,245,000
Total consumed	98,657,929,000
Transported out of State	194,952,900,000
Transported into State	4,487,316,000
Net transported out of State	190,465,584,000
Gas sold by utilities to other utilities	59,489,249,000
YEAR ENDING DEC. 31, 1917.	
Produced by gas utilities	251,935,229,000
Produced by producers	38,746,414,000
Produced by carbon-black companies not included above (estimated)	14,583,283,000
Total produced [b]	305,264,926,000
Consumed domestic and industrial	52,258,468,000
Consumed field and main lines	22,924,291,000
Consumed for carbon black (estimated)	26,062,706,000
Total consumed	101,245,465,000
Transported out of State	208,280,274,000
Transported into State	4,024,818,000
Net transported out of State	204,255,456,000

[b] It is estimated that 26,062,706,000 cubic feet were used for the manufacture of carbon black.

Recent reports of the public service commission of West Virginia, as shown in Table 1, indicate that for the year ending December 3, 1917, 8.5 per cent of the total gas produced and utilized in the State was used by the carbon-black industry, and for the year ending June 30, 1918, 8.7 per cent of the total gas produced and used was burned in the manufacture of carbon black.

Estimated production of carbon black in 1918.

State.	Pounds.
West Virginia	30,000,000
Louisiana	8,000,000
Wyoming	3,000,000
Oklahoma	1,500,000
Other States	1,000,000
Total	43,500,000

Factories are located in West Virginia, Louisiana, Wyoming, Oklahoma, Montana, and Kentucky. Several interests are contemplating constructing plants in the recently developed oil and gas field of Texas. The plants built were capable in 1918 of producing per annum the following quantities:

Capacity of carbon-black factories in six States.

State.	Pounds. [a]	Number of plants.
West Virginia	[b] 28,000,000	27
Louisiana	20,000,000	12
Wyoming	4,500,000	2
Montana	2,000,000	1
Kentucky	1,600,000	1
Oklahoma	1,500,000	1

[a] Estimated.
[b] Some of the plants have been moved to fields in other States or abandoned, so that the present capacity of plants in this State is less than the amount produced in 1918.

For an estimate of the distribution of carbon black to the trade see page 60.

The quantity of carbon black used by the rubber industry since 1917 has been abnormally high, on account of the large production of solid rubber tires for auto trucks during the war. The amount credited to export is small, on account of the closing of German and Austrian markets. Mr. G. A. Williams [1] has asserted that before the war at least one-third of the total production of carbon black was consumed by Austria and Germany. Although certain manufacturers claim that this figure is high, it is admitted that prewar exports to Germany and Austria were substantial. The increase in the quantity of black used by rubber manufacturers has more than offset the decrease in export. England, France, China, and Japan import a large amount of carbon black from American producers. For further information on the use of carbon black in rubber see page 61.

SELLING PRICE OF CARBON BLACK.

The first lot of 500 pounds of carbon black placed on the market sold for $2.50 per pound, the next 1,000 pounds brought $1.50, and the plant paid for itself in approximately three months. In 1881 the price had fallen to 35 cents per pound, in 1882 to 31 cents, and because of increased competition to 24 cents in 1883. During the next 10 years the average price was 12 cents per pound. The cost of gas steadily increased, and from 1891 to 1901 the average selling price of carbon black was 6 cents, and by 1912 had reached the low level of less than 5 cents.

An impetus was given the industry in the fall of 1915, when the beneficial result of the use of carbon black in the manufacture of rubber was discovered.

[1] Personal interview: Fuel City Manufacturing Co., Clarksburg, W. Va.

The market price of carbon black has increased since 1912 and has not fallen below 8 cents; during 1918 it sold as high as 16 cents. When foreign markets are reopened and a stable medium of exchange and credit is established, carbon black very probably will increase in price.[3] The fluctuation in the selling price of carbon black is shown in figure 2, the price being that of the grade of black used in the rubber industry or in making ordinary printer's ink. At present one large company has four grades of black that range in price from 8 cents to 40 cents per pound. Another company manufactures only one grade, selling for about 35 cents to 40 cents per pound. The high-grade blacks possess certain valuable properties and are used for

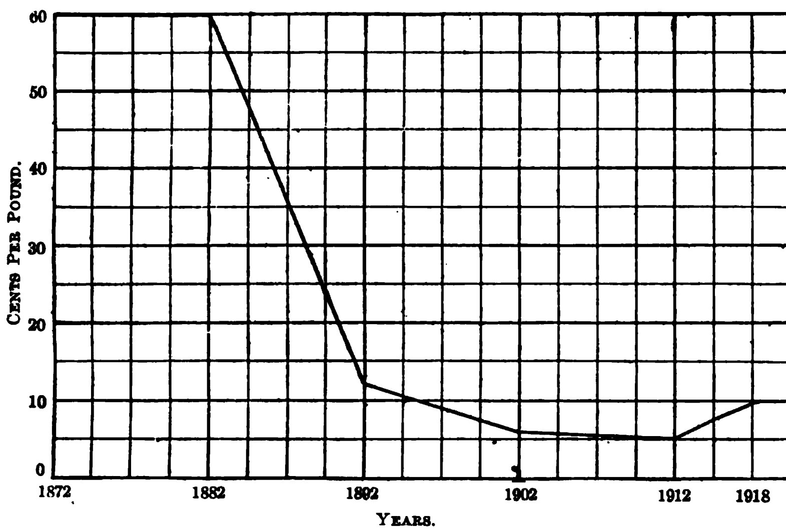

Figure 2.—Selling price of carbon black.

special purposes, such as making the finest lithographic and embossing inks.

There has been a general decrease in the difference between the selling price of carbon black and the cost of manufacture. The available supply of natural gas is steadily declining, and consequently it is only a matter of time until the price increases. Evidently the most effectual way of insuring conservation of this valuable resource is raising the price.

LOCATION OF PLANT.

In contemplating the construction of a carbon-black plant, definite information should be obtained on several subjects: The distance from a railroad or a navigable stream; State laws; the depth of wells; the thickness of gas-bearing strata; gas pressure; gasoline content; and whether the gas is casing head or dry gas; amount of proved territory;

[3] This paper was written during the early part of 1920.

history of field; drilling practice; location of field in regard to possible large gas-consuming centers; distance from trunk pipe lines for the transportation of natural gas; open-flow capacity of wells on prospective gas leases; and tests on the richness of gas to ascertain the approximate quantity of carbon black procurable per thousand cubic feet.

TRANSPORTATION FACILITIES.

Carbon-black plants are situated in isolated districts where there are no pipe lines and gas is cheap. In choosing a site for a factory, transportation facilities should be investigated thoroughly, as the necessity of building a railroad to the site chosen might make prohibitive the cost of constructing a plant. A large factory in West Virginia, for example, that is nearly 30 miles from a railroad, is greatly handicapped by the lack of adequate shipping facilities. The carbon black must be carried by boats to the railroad center; this procedure is possible only in the spring and early winter. During the summer the stream is practically dried up, and the company in order to dispose of its product during that season must haul it 16 miles over hilly roads by wagon or by motor trucks to the head of slack water. Haulage even by gasoline trucks is costly, as carbon black is light. An average railroad box car holds only 12 tons of it. By reason of the inadequate transportation facilities, the net earnings from the plant mentioned have been greatly reduced. Several carbon-black companies have had to build narrow-gage railroads in order to obtain a suitable outlet for their product.

HAZARDS IN GAS SUPPLY.

Several factors, some of them almost intangible, affect the ultimate supply of gas in a given territory. In selecting the location of a plant the life of the supply of gas from the apparent production or open flow of the wells should be estimated conservatively. An idea of the ultimate production of a well is indicated by the rock pressure, by the thickness of the gas-bearing strata, the porosity of the "sands," and the presence of intruding waters. A history of the field is necessary and also a knowledge of the drilling practice in developing the field. If proper methods are not employed, such as sealing off the gas-bearing zones in drilling oil wells, cementing off water-bearing beds,[4] and proper casing, rapid decline in the production of gas can be expected. For example, a company that was endeavoring to erect a plant with a capacity of 3,000,000 cubic feet of gas a day was not interested in any territory having an open-flow [5] capacity of even

[4] Tough, F. B., Methods of shutting off water in oil and gas wells: Bureau of Mines, 1918.

[5] "Open flow" is an engineering term and is referred to by the courts as synonymous to "natural flow" and necessarily means the entire volume of gas that will issue from the mouth of a gas well when retarded only by atmospheric pressure.

12,000,000 cubic feet unless considerable territory remained to be drilled and the amount of gas "in sight" was to be increased materially; its experience indicated that such a quantity of gas would dwindle to an inadequate amount soon after the completion of a plant.

If a newly developed field proves extensive and prolific, a gas pipeline is usually constructed to the field. Unless the production is extraordinarily large, the price of gas will increase gradually, and as the production and rock pressure decline and compressors are applied to the gas, such value will attach to the gas that the manufacture of carbon black will become prohibitive, even though the operators may have intrenched themselves by drilling their own wells. In some localities in West Virginia, where gas formerly sold for 2.5 cents per thousand cubic feet, the price increased suddenly to 8 cents upon the introduction of compression plants and transportation lines. The manufacturers of carbon black are unable to compete with gas-distribution companies when gas sells at this figure; although the carbon-black manufacturers own the wells, it is more profitable to sell gas to pipe-line concerns than to make carbon black. The industry is necessarily migratory, although some plants have operated in one vicinity as long as 20 years. The Monroe gas field of Louisiana has become a center of carbon-black plants because it gives promise of being a field of considerable importance. The producing wells are scattered over a territory 20 miles long and 3 to 8 miles wide. Very few dry holes have been drilled, and the productive wells have an open flow varying from 5 to 25 million cubic feet a day.

GASOLINE CONTENT.

Often the gasoline content of gas may be so large that the operator can pay a high price for the gas and still find the manufacture of carbon black profitable. At several of the plants in Louisiana, West Virginia, and Wyoming the gas is treated by the absorption process [6] to recover the gasoline. The plant operators claim that stripping the gas of the gasoline vapors has little effect upon either the quality or quantity of the carbon black produced. In 1883 G. L. Cabot made some laboratory experiments concerning the effect on the yield of enriching gas by gasoline vapors. He found that by passing preheated gas over gasoline the carbon-black recovery was increased by 11 per cent of the weight of the gasoline used. The quantity of carbon black should not be changed much, as the recovery of one-tenth of a gallon of gasoline reduces the volume of the gas three-

[6] Dykema, W. P., Recent developments in the absorption process for recovering gasoline: Bull. 176, Bureau of Mines, 1919. Burrell, G. A., Biddison, P. M., and Oberfell, G. G., Extraction of gasoline from natural gas by absorption methods: Bull. 120, Bureau of Mines, 1917.

tenths of 1 per cent. The gasoline content is usually determined by an absorption method.[7]

For further information on this point the reader is referred to Technical Paper 253 of the Bureau of Mines.

TESTING NATURAL GAS FOR CARBON BLACK.

Making tests of gas for carbon black preliminary to erecting plants is a matter of great importance. Variation in the amount of carbon black obtained from different qualities of gas by the same process is shown in Table 2.

TABLE 2.—*Carbon content and quantity of carbon black recovered.*

	A. Louisiana.	B. West Virginia.	C. West Virginia.	D. Wyoming.
Methane [a] .... per cent..	94.12	70.75	65.23	46.45
Ethane .... do....	3.44	24.14	30.07	43.10
Carbon dioxide .... do....	.50	.28	1.56	.96
Nitrogen .... do....	1.94	4.83	3.14	9.49
Heating value [b]	962	1,086	1,134	1,176
Carbon per 1,000 cubic feet of gas [c] .... pounds..	33.8	39.9	42.3	44.3
Carbon black per 1,000 cubic feet of gas reported obtained..do....	.80	1.00	1.10	1.40
Per cent recovery	2.4	2.5	2.6	3.1

[a] Analyses were made by D. B. Dow, junior chemist of Bartlesville station, United States Bureau of Mines.
[b] Net heating value in B. t. u. per cubic feet at 0°C, and 760 mm. pressure.
[c] Calculated from carbon content of methane and ethane.

The quantity recovered closely parallels the percentage of ethane[8] heating value, and the amount of elementary carbon from the hydrocarbons determined by analysis. The gas from Louisiana has the lowest percentage of nitrogen, and has the highest percentage of hydrocarbons, 97.56, yet when burned at a factory it gives the smallest yield of carbon black. This result is due to the larger proportion of methane which contains 33.5 pounds of carbon per thousand cubic feet, whereas an equal volume of ethane contains 67 pounds of carbon. The two gases from West Virginia have similar compositions and give approximately the same yield of carbon black. The gas supplied to the plant in Wyoming has the highest calorific value, carbon content, and ethane content of the gases, and produces the greatest yield. From the gases richer in higher hydrocarbons not only the actual quantity of carbon obtained is larger, but the percentage of recovery increases. A chemical analysis of a gas is probably as trustworthy an indication of the available carbon black as the result obtained with a small portable apparatus in which a measured

[7] Dykema, W. P., and Neal, R. O., Application of the absorption process to recover gasoline from the residual gases of compression plants: Tech. Paper 232, Bureau of Mines, 1920. 41pp.

[8] For the chemical analysis of natural gas, *see* The sampling and examination of mine gases and natural gas," by G. A. Burrell and F. M. Seibert, Bull. 42, Bureau of Mines, 1913; and Gas analysis, by L. M. Dennis, 1913.

quantity of gas is burned and the deposited carbon black collected and weighed.

The writer has designed an apparatus for determining the quantity of carbon black to be obtained from an unknown gas. This apparatus is made of 16-gage sheet iron and held together with one-eighth-inch rivets. The carbon black is deposited on a plate measuring 8 by $10\frac{3}{4}$ by $\frac{1}{4}$ inches and removed by a hand-operated scraper measuring 1 by 8 by $\frac{1}{16}$ inches. Draft control is by eight 1-inch ventilating holes provided with covers pivoted above the holes, and by a revolving damper at the top of the hood. The pipe carrying

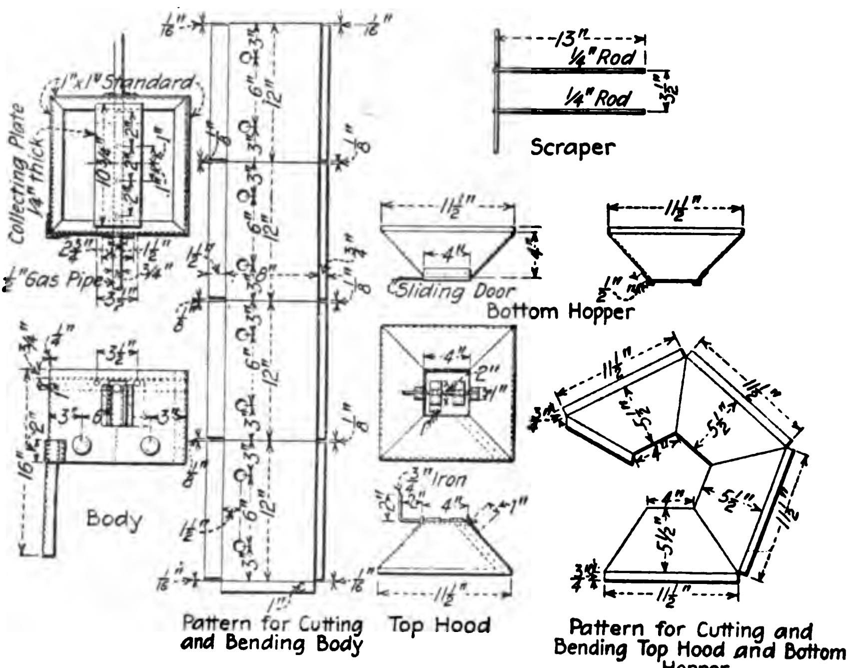

FIGURE 3.—Details of portable testing apparatus.

the lava tips can be lowered or raised beneath the depositing plate and held at any distance by attaching a plug in the stopper holes below the supports. In the hopper is a sliding door for removing the carbon black. Lava tips capable of burning about eight cubic feet of gas per hour are used. The hood, hopper and legs are detachable and fit into the central part of the device to facilitate transporting in the field. The apparatus ready for transporting is shown in Plate I, *A;* its details in figure 3. It can be used by connecting directly to the supply of gas and by using suitable wind breaks if assembled in the field, or it can be used in the laboratory by obtaining a sample of gas under pressure in a steel cylinder.

The source of supply of the gas to be examined is connected with a meter registering a quantity at least as small as one-tenth of a cubic foot; on this line should be a quarter-inch needle valve for limiting the flow of gas through the apparatus. Between the meter and the gas-burning apparatus is attached a U-tube for determining the pressure of the gas. The top of the lava tips should be about 2½ inches below the depositing plate, and a gas pressure of one-half to one inch of water should be maintained. These factors of course will differ for the examination of different gases, and in the preliminary tests adjustments should be made until the largest recovery is obtained. A test should last for an hour at least, during which time 15 to 20 cubic feet of gas should be burned. It is possible to make a test in the field without using the meter by previously calibrating the apparatus against a meter, different pressures on the manometer tube being observed and the time recorded. This will give fairly accurate results on volumes, provided of course the lava tips are not broken, plugged, or partly restricted by foreign matter after the apparatus has been standardized. During the test the carbon black should be removed from the collecting plate by the scraper every ten minutes, and at the end of the test the carbon deposited on the sides of the apparatus and plate is removed with a small brush. This accumulated carbon black is weighed. From the data on the volume of gas burned, the quantity of carbon black collected, and the pressure on gas, can be calculated the quantity of carbon black probably obtainable in plant operation from a given gas. This apparatus, assembled, is shown in Plate I, *B*.

By the use of either method only comparative results are obtained. The portable apparatus gives results approximating those procured in commercial plants using the channel system, but if some other process is to be used, the apparatus should be standardized against a plant where conditions are similar to those under which the gas under test will be burned.

COMMERCIAL METHODS OF MAKING CARBON BLACK.

In commercial practice are four different processes of manufacturing carbon black from natural gas—the channel system, the small rotating disk, the roller or rotating cylinder, and the large-plate processes. These methods differ mainly in the size and shape of the surface upon which the carbon is collected and the rate of travel of the moving devices. The channel process is probably the best method and is the one most extensively used. Classified according to the quantity of carbon black produced, the order is as follows: (1) Channel process, (2) small rotating disk process, (3) large plate process, and (4) roller process. At present the production of carbon black by cracking or thermal decomposition methods is not extensive.

A. APPARATUS FOR DETERMINING THE CARBON-BLACK VALUE OF NATURAL GAS, KNOCKED DOWN FOR TRANSPORTATION.

B. APPARATUS FOR DETERMINING THE CARBON-BLACK VALUE OF NATURAL GAS, SET UP FOR USE.

A. MANOMETER TANK FOR REGULATING FLOW OF GAS.

B. MAIN SHAFT AND SUPPORTS OF GAS LINE AROUND CONDENSING BUILDINGS.

CHANNEL PROCESS.

THE CONDENSING BUILDINGS.

The buildings in which the channels and burners are installed are made of 24-gage sheet iron, held by wire to a steel frame made of ¼ by 1¼ by 1¼ inch angle iron. Figure 4 shows the structural details of a typical building, sometimes referred to as the condensing building. The ridge piece does not extend the entire length of the building, as spaces are left to allow the escape of the gases of combustion. The ridge pieces are flexibly attached so that the spaces can be changed and the draft regulated. In the design of some plants chimneys are provided. Along the bottom of the buildings are slits or slide doors for controlling the supply of air, but usually they are not adjusted to meet the various conditions of the weather.

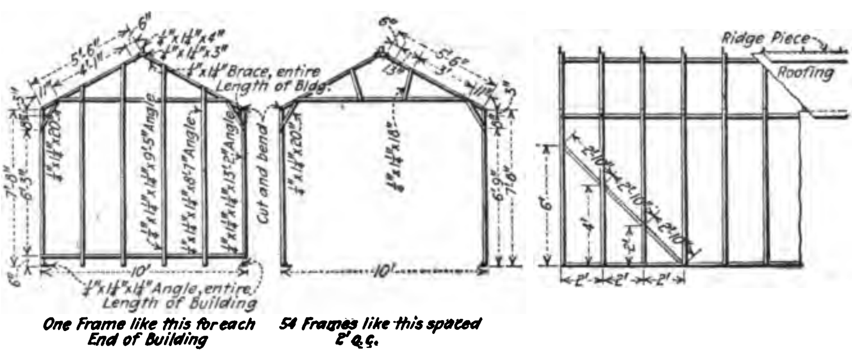

FIGURE 4.—Details of condensing building used in channel process.

A door at each end and one or two doors on each side furnish access to the interior. Buildings that have one group of channels bolted together into one table are 8 or 10 feet in width by 80 to 115 feet in length. The dimensions of two-table buildings vary from 18 to 20 feet in width and from 80 to 115 feet in length.

The buildings are arranged in parallel rows 3 to 5 feet apart at right angles to and on both sides of an alleyway about 15 feet wide. The number of one-table buildings per unit—that is, whose power is furnished by one engine—varies from 24 to 30. In some districts, particularly Louisiana, a larger yield has been obtained with one-table buildings than with larger units because of the atmospheric temperature. With two-table buildings, the number of buildings per unit varies from 12 to 16. The units have a daily capacity ranging from 60 barrels, or 3,000 pounds, to 100 barrels, or 5,000 pounds, of carbon black. The largest plant inspected by the writer had six units and consequently six packing houses, six engines for furnishing power, and an equal number of main driving shafts. The entire plant comprised 180 condensing houses.

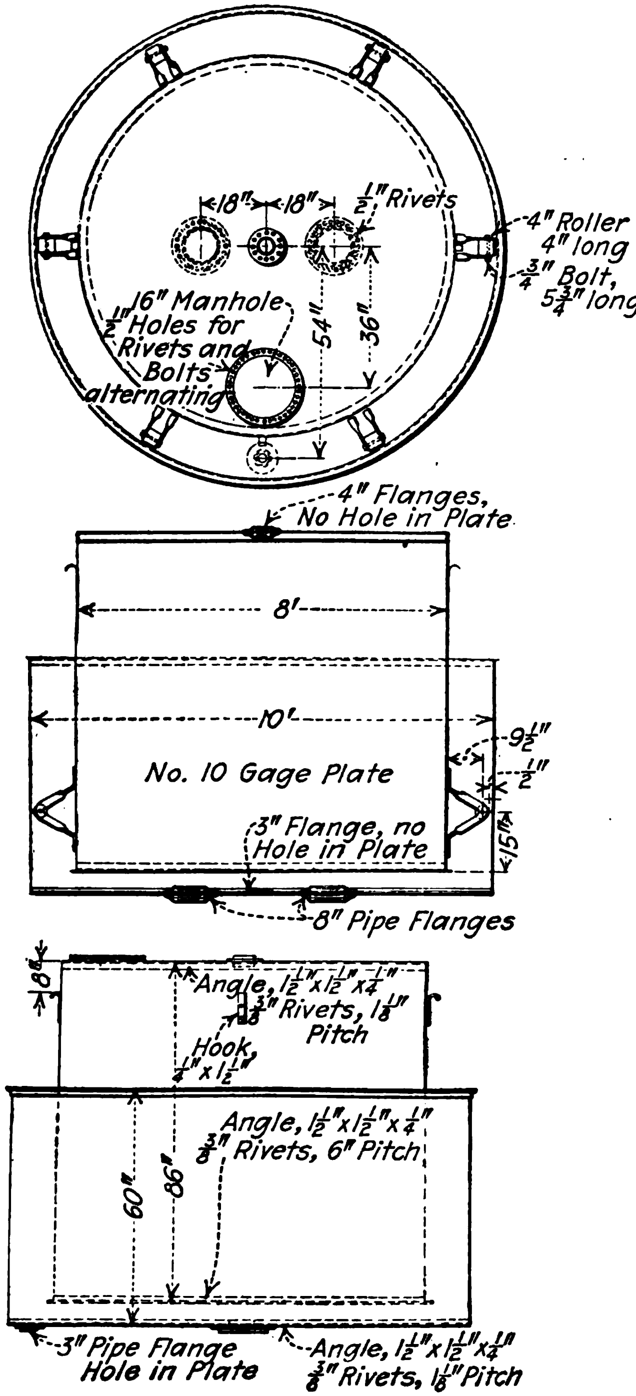

FIGURE 5.—Details of gasometer.

TRANSMISSION OF GAS.

The gas coming from the wells, from gasoline plants, or from mains has its pressure reduced by suitable regulators, and after passing through the regulators goes through a gasometer tank that is partly filled with water. Details of a typical gasometer are shown in figure 5. It consists of two tanks made of boiler plate, one inverted in the other. The gas passes into the inverted tank where it is held by a water seal. The pressure of the gas blowing from the gasometer will be determined by the weights on top of the tank and the height to which the tank rises. A lever arm connects the inverted tank to a butterfly valve on the intake gas line, so that as the pressure increases, the tank rises and the butterfly valve is closed. (See Pl. II, *A*.) The flow of gas is controlled by the gasometer so that the discharge pressure of the gas is less than 1 ounce.

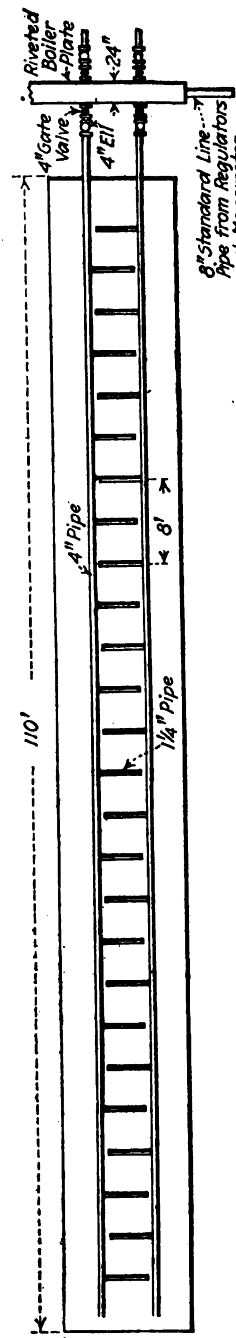

FIGURE 6.—Arrangement of gas pipes and lines of distribution.

In a plant with one-table condensing buildings, the gas is piped from the gasometer tank to a 24-inch distribution pipe made of riveted boiler plate, which lies in the middle of the alley. Two 4-inch lines connect the distributor to each building, each of which is provided with a 4-inch gate valve. In the buildings a 1¼-inch pipe connects to a 4-inch line every 8 feet. Between each 1¼-inch pipe a 1-inch rod or riser 3 inches high is welded, upon which the overhead channel work is supported. Figure 6 shows this arrangement.

In another design, an 8-inch gas line completely encircles the condensing buildings and is connected to two 4-inch inlet pipes at each end of the buildings. (See Pl. II, *B*.) The method of piping must be capable of distributing the gas evenly throughout the entire unit, and the fact that the gas is held under such low pressure demands considerable attention.

CHANNELS.

The channels upon which the carbon black is deposited are made of mild steel, 7 to 8 inches wide and weighing about 12½ pounds per linear foot. They hang from trucks that run on overhead rails. Standard 1¼-inch pipe resting either on concrete piers or upon the gas-distributing pipes support the channels, trucks, rails, and other accessories. The uprights are spaced approximately 4 feet, and are stabilized by means of 1 by ¼ inch cross strap-iron braces.

At the top of each upright is a small cast-iron rail chair. The steel rails weigh 16 to 20 pounds per yard. Running on the rails are 10-inch double gudgeon truck wheels. Each wheel has lugs projecting from the axis on each side to regulate its position, and it is held rigid longitudinally by two short lengths of 2 by 2 inch angle iron, although it can move within a fixed distance along the rails.

Attached to the angle iron on both sides of the truck wheel are transverse channel beams, weighing 6½ pounds per foot; to these beams are bolted the channels upon which the carbon black is deposited. Each trestle is about 6 feet wide and is called a table. Most plants have eight rows of channels on each trestle. Plate III, *A* and *B*, show an installation of this type under construction. The channels are bolted together in lengths as great as 100 feet, and the trestle work is 10 to 15 feet longer to allow for the oscillations of the table.

HOPPERS.

Below the channels are the carbon collecting hoppers, spaced approximately 4 feet apart. Each hopper is made up of three parts—the crown, the body, and the base. The crown is supported on the trestle by a ¼ by 1½ by 1½ inch angle on each side and sits loosely in the body, which is about 6 feet in width in the upper portion and tapers down to about 10 inches. The base is about 15 inches high and carries the conveyor pipe at the bottom. All three parts of the hopper are 6 inches wide, and the crown contains 4 notches which retain the scrapers, as shown in figure 8.

SCRAPERS.

There are two classes of scrapers for removing the carbon from the channels, (1) those that operate continuously, and (2) those that are in direct contact with the channels while the tables are moving in one direction only. The latter practice is considered the best, as it gives a more uniform grade of black. The scrapers are made of steel $\frac{1}{16}$ by 1¼ inches wide and 8 to 11 inches in length; they have two blades attached to a 20-inch arm carrying a loop to which is appended a weight if the scrapers remove the deposited carbon continuously. Scrapers that remove carbon only while the channels are moving in one direction are actuated by a system of levers moved by an automatic trip, termed by the workmen a "grasshopper."

Most plants have side scrapers for removing the carbon on the sides of the channel beams. A table having 8 channels would have 9 side scrapers over each hopper. The side scraper is made of a strip of strap iron ¼ by 32¼ by 1 inch, which is bent in the shape of a narrow U-tube having 15-inch legs and about a 2-inch arch. The upper ends, 3 inches from the uppermost extremity, are bent at right angles to the arch.

CONVEYORS.

Spiral or screw conveyors of galvanized iron at the base of the hoppers carry the carbon from the different condensing buildings. The conveyor under the channels is 7 or 8 inches in diameter, the outside pipe being made of sheet iron throughout and crimped at one end of each section. The screw is usually made at the carbon

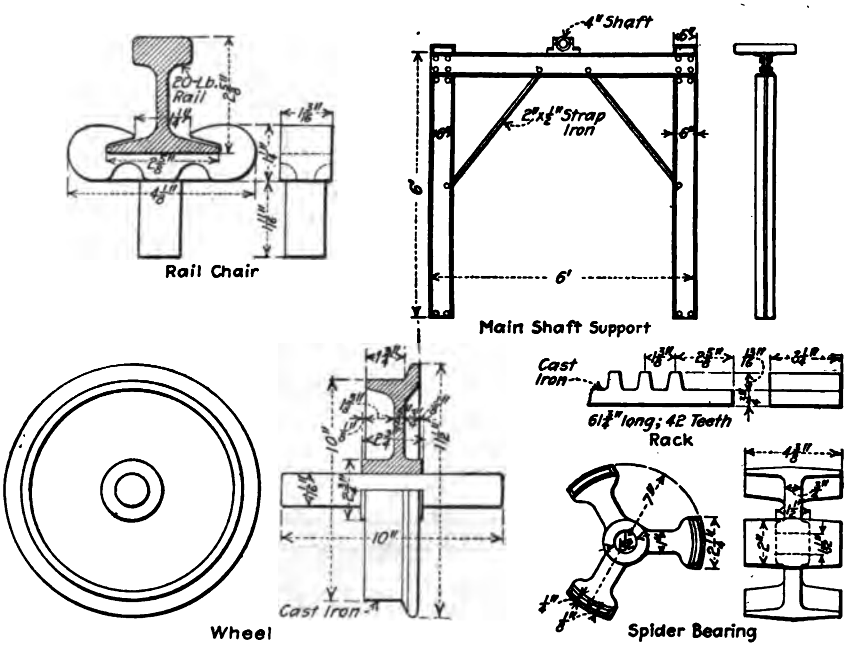

FIGURE 7.—Assembly drawing of table.

plants by a simple tinner's machine which cuts disks of sheet iron slightly less than 7 inches in diameter, if a 7-inch conveyor is being used, and bores a small hole in the center about 2 inches in diameter for the shaft. The shaft is made of 1-inch standard pipe supported every 8 feet by a spider bearing or conveyor hub made of cast iron. The concentric disk is cut and wrapped around the shaft in helicoidal form and is held rigid by one-eighth-inch rivets. Figure 7 shows the details of a spider bearing, truck wheels, and rail chairs. Some carbon black operators prefer to purchase spiral conveyors from machine shops where the helicoid is rolled from a single strip of metal before the pipe is inserted. This type of conveyor is strong, and resists to the full strength of the metal the lateral pressure due to pushing the material forward.

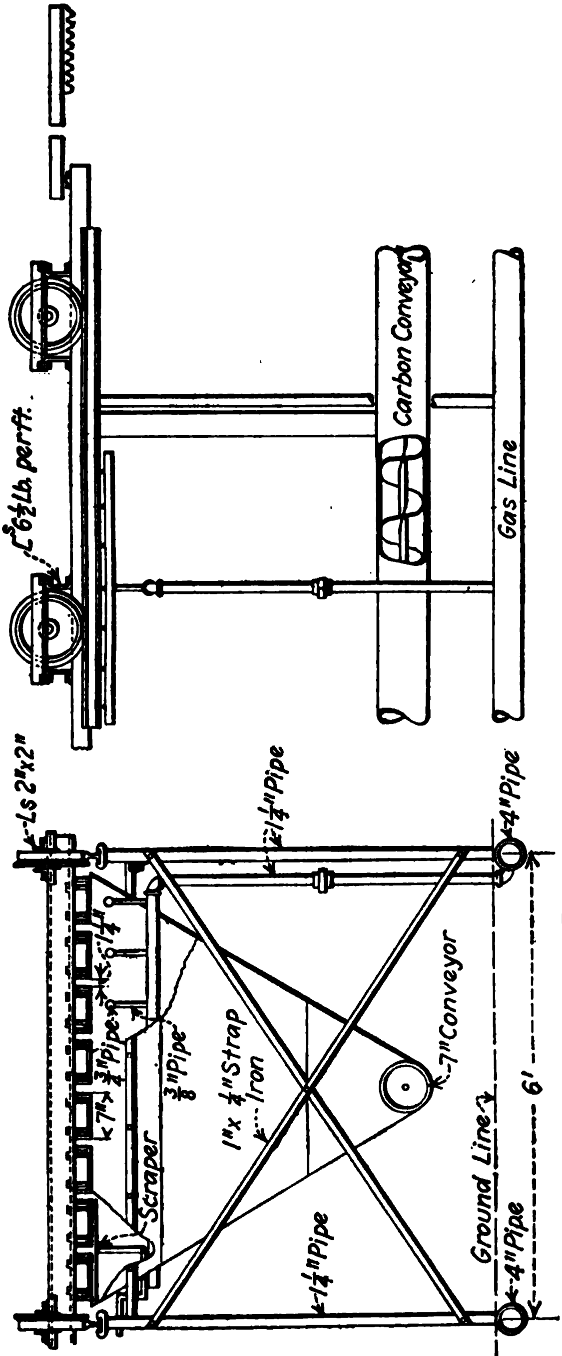

FIGURE 8.—Details of parts of machinery used in channel process.

A. CHANNEL PLANT IN PROCESS OF CONSTRUCTION.

B. ANOTHER VIEW OF CHANNEL PLANT DURING CONSTRUCTION.

A. DRIVING WORM GEAR, CHANNEL PROCESS.

B. BOLTING MACHINES FOR REMOVING PARTICLES FROM CARBON BLACK.

At the discharge end of each conveyor is an overflow tee consisting of a short pipe connected to the conveyor at an angle of 30 degrees. This tee carries a sheet-iron cap. Below the tee and connected at a right angle to the conveyor is a pipe about 5 inches long and crimped at the end which delivers the collected carbon to the main conveyors on each side of the alley.

BURNERS.

The space between the hoppers constitutes one section of the trestle. In this space are the burners. The gas is delivered to the section by a 1¼-inch pipe, to which is connected a ⅜-inch pipe that carried the ¾-inch burner. The burner is parallel to and about 3 to 4 inches below the channels. Each burner holds 8 to 10 lava tips. A typical 60-barrel plant would contain the following number of lava tips: 8 lava tips per burner, 64 tips per section, 1,600 tips per building, 38,400 tips per plant having 24 buildings.

The lava tips are made of selected steatite, which is easily machined in its green condition to any desired form by turning, milling, and grinding, and is then heated to a temperature of about 2,000° F. to make it hard and strong. Most of the manufacturers of lava tips are in the vicinity of Chattanooga, Tenn.

Of the great variety of tips used the most common type burns 4 to 14 cubic feet of gas per hour. The requisites for good tips are uniform flames and uniform gas consumption. A typical lava tip has a slot 0.2 inch deep and 0.034 inch wide. The tips are tapered slightly so that by drilling in the burner pipe a hole slightly larger than the smallest outside diameter of the tip, the tips can be held securely and made gas-tight by the application of white lead. Figure 6 gives the general arrangement of burners, hopper, conveyors, and channels.

DRIVING MECHANISM AND ACCESSORIES.

Each unit is equipped with a separate gas engine, which is usually of about 20 horsepower and of the two-cycle type. Some factories make use of a simple steam engine, utilizing gas pressure instead of steam [9] thus effecting an appreciable saving in the cost of operation. The engine is connected to a shaft from which the conveyors, elevators, bolting machines, packing machines, and the reversing gear shift that actuates the channels are driven. Plate V (p. 24) gives a detailed plan of a complete carbon-black plant.

A working drawing of a reversing-gear shift is shown in figure 9. Power for the device is transmitted by a belt from the overhead drive shaft. Pulley *d* is connected to pinion *b* by means of a sleeve;

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[9] Dykema, W. P., and Neal, R. O., Application of the absorption process to recover gasoline from the residual gases of compression plants: Tech. Paper 232, Bureau of Mines, 1920.

pulley *e* in an idler and *f* actuates pinion *c* through a collar. A carriage traveling along the threaded shaft *g* shifts the belt from *f* over *e* to pulley *d* periodically by means of a lever system, consequently changing the direction of rotation of bevel gear *a*. This change takes place about every 15 minutes. The gear keyed to the shaft in the middle of the alley meshes with the worm gear *h*. Another arrangement with a worm-gear drive is given in Plate IV, *A*.

The main shaft that moves the channels extends the entire length of the alley and is usually 3 or 4 inches in diameter. It is supported

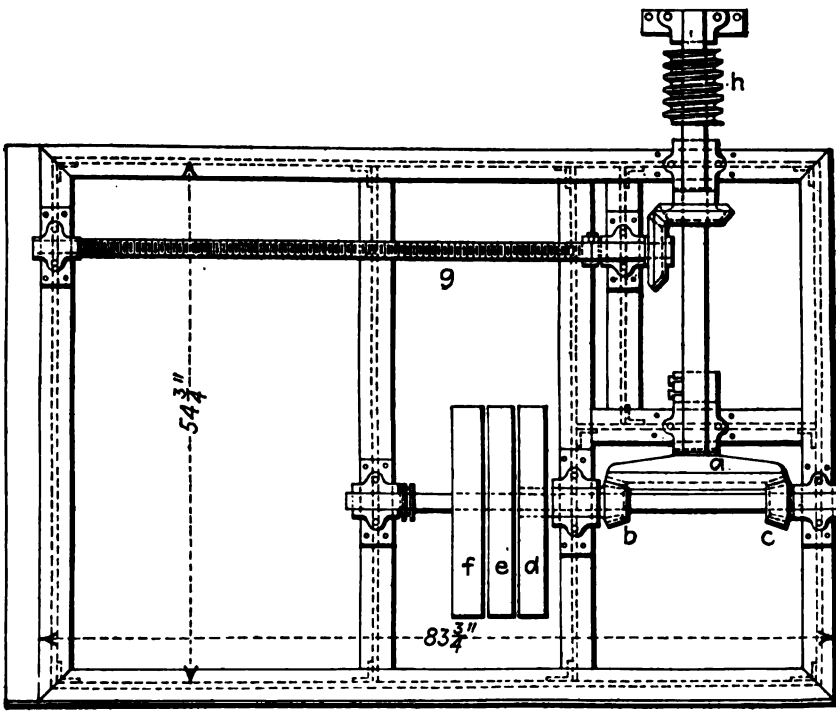


FIGURE 9.—Reversing-gear shift. *a*, Bevel gear; *b*, *c*, pinions; *d*, *e*, *f*, pulleys; *g*, threaded shaft; *h*, worm gear.

by trestles 6 feet high and is made of channel steel. Details of a support appear in figure 8. There is a support with a pillow block for each pair of buildings. Couplings are placed every 16 or 20 feet.

Over each support is a 13-tooth flanged pinion for engaging teeth in a rack or cog plate that is on the under side of an inverted tee steel beam connecting end trucks in opposite buildings. The rack is made of cast iron, contains 42 teeth and is about 62 inches long. Figure 7 shows the details. A stirrup of iron or roller is used to assure engagement of the rack and pinion. The entire table of channels and scrapers is moved by this rack and pinion, the channels having a straight-line reciprocating motion of 55 to 60 inches which takes 15 minutes. In a typical 60-barrel plant there is approximately 200 tons of iron and steel in the condensing buildings, not including the framework or sheet-iron covering of the buildings.

The conveyors for the carbon black are driven by a shaft belt connected to the main power shaft in the engine room. A 1-inch shaft lies on each side of the alley between the condensate buildings and transmits power to the conveyors within the buildings by means of bevel gears. The conveyor running along each side of an alley is chain driven by a sprocket wheel on the 1-inch shaft. These conveyors carry all of the black from the buildings to a chain and bucket elevator inclosed in a 16-gage galvanized sheet-iron box.

BOLTING MACHINES.

The grit, scale, and hard particles in the carbon black are removed by bolting machines, which vary greatly in design. The practice in removing particles from the black differs also. Operators at some factories pass the carbon through two bolters, some through one, and some factories are not equipped with bolting machines. At a few plants equipment includes coarse wire called a "scalper" for removing bolts, pieces of iron, and similar articles. The bolting machine may be of the horizontal or vertical type, the latter being more commonly employed.

Details of a machine often used are given in figure 10, and a view is shown in Plate IV, *B*. It is made of 20-gage galvanized iron. The steel screen used varies in size from 45 to 60 mesh, and is reinforced by a heavy wire. It is attached to a cylinder that can be removed through the drop door. A shaft having a spider with six arms, each of which carry two fiber brushes, forces the carbon black through the screen. The material not passing through the screen is discarded periodically.

STORAGE BIN AND PACKERS.

The storage bins are tapering-shaped hoppers located over the packers. They are made of galvanized iron and vary in size. Some operators use bins large enough to store two or three days' production in order to eliminate stoppage of work from trouble in the packing room, or to hold the carbon black made on Sunday, if the packers operate only six days per week. The storage bin is connected with the packers by a spout.

Packers for carbon black are similar to those used at sugar refineries. An auger inside of a tight sheet-steel tube presses the carbon black into a large paper bag. The auger is so designed as to avoid waste of the free-flowing product when the packer is stopped for changing the bags. The stock, when passing through the auger, keeps the hinged gates folded parallel to and against the top auger blades, but when the auger stops, coil springs force the gates downward against the carbon lodged between

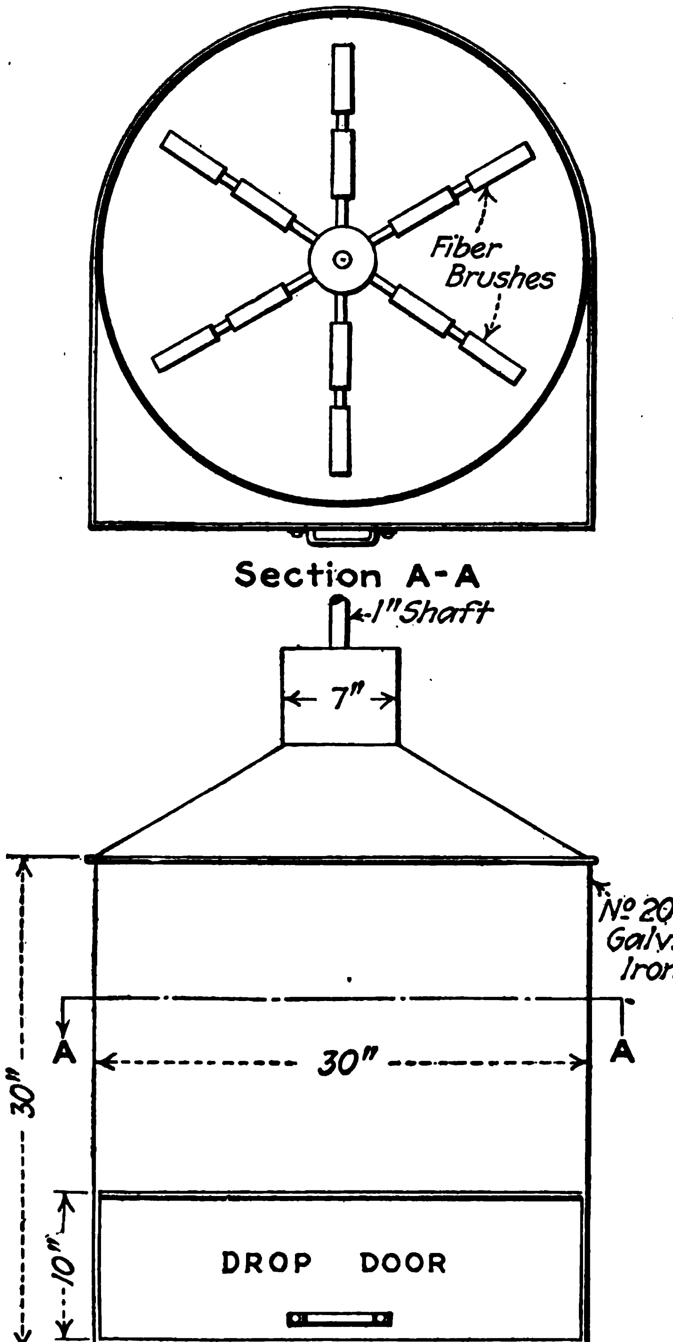
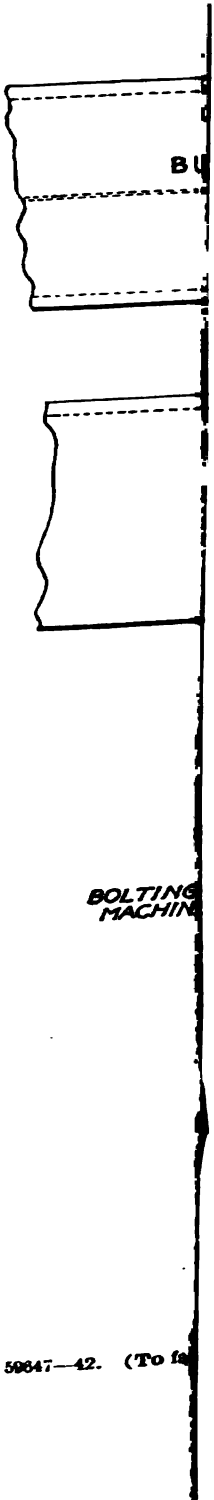


FIGURE 10.—Details of a bolting machine.



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the blades, and though they do not close the passageway completely, they confine the carbon enough to prevent leakage. The machine is gaged to pack in each bag a uniform amount, usually 12½ pounds or a quarter of a barrel. Some bags, especially those for export trade, contain 15 pounds. A simple movement of a lever causes the bevel gears to mesh and starts the packer, which stops automatically when the bag has been filled. Details of a packer are given in figure 11.

A 60-barrel plant usually is equipped with four packers that fill a bag in about 15 minutes. The inner shaft rotates slowly in order to

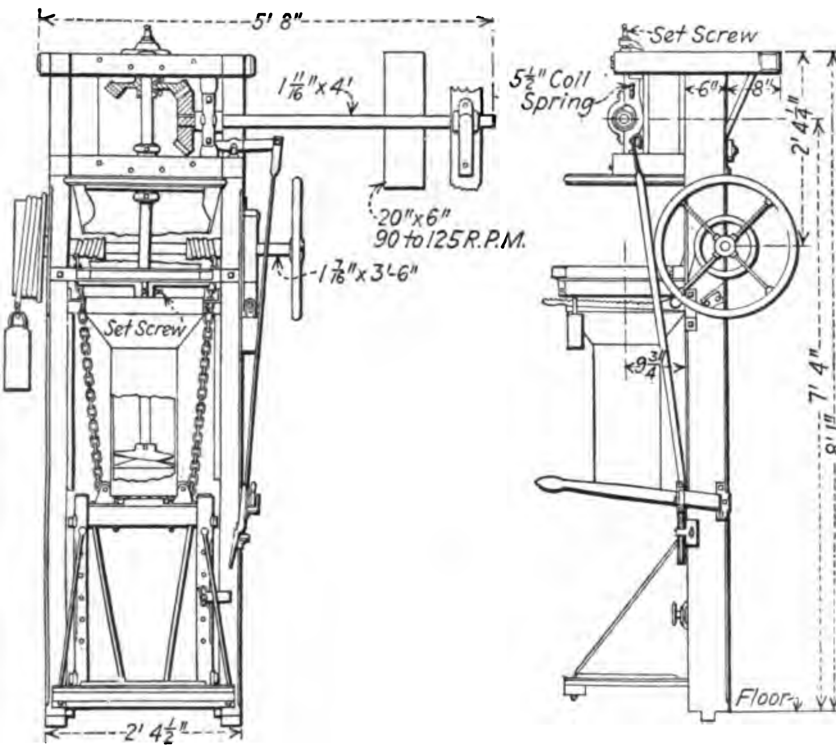


FIGURE 11.—Barnard-Moline packer of carbon black.

effect the proper separation of the carbon black from the air in which it floats or which it holds mechanically. The separation of the black from the air as far as is practicable commercially constitutes the chief problem of packing. The bags are tied, and at most plants are slightly compressed in a steel-plate box, in which travels a plunger, actuated by a crank shaftor eccentric. The sides of the bag are flattened to facilitate storage and transportation. After a bag is compressed. a second paper bag is placed over the package.

WAREHOUSE.

The bags of carbon black are removed by trucks from the packing building to the warehouse. If the black is intended for export it is packed in wooden boxes 3 by 3 by 2 feet each, holding from 12 to 15 bags. The warehouses are built on the main line of transportation or on a narrow-gage railroad having electric or gasoline engine-driven trucks to convey the product to a transfer point. The warehouses differ greatly in size. At one plant visited by the writer was stored a stock of 35,000 bags of black, and available spaces for as much more remained. Some warehouses are open, frame buildings, with corrugated sheet-iron roofs; some are completely inclosed sheet-iron buildings.

OPERATION OF CHANNEL PLANTS.

The channel process for packing carbon black and the construction of channel plants have been fully discussed. The operation of the channel plants may be briefly described as follows: The flames from the lava tips impinge against the under side of the traveling tables of channels, the draft being controlled by slide doors or slits at the base of the condensing buildings and by the chimneys at the ridge piece of the buildings. The gas burns with a uniform, luminous, and smoky flame. Table 3 contains analyses of gases formed in the incomplete combustion of the gas. The deposited carbon black on the under side of the channel is removed by the scrapers and falls.

TABLE 3.—*Analyses of flue gases.*[a]

	A. West Virginia.	B. West Virginia.	C. Louisiana.
	Per cent.	*Per cent.*	*Per cent.*
Carbon dioxide	1.10	3.4	2.51
Oxygen	19.60	15.0	14.30
Carbon monoxide	1.05	.1	1.36
Hydrogen	1.25	....	....
Nitrogen	77.00	81.3	81.83
Methane and ethane	....	.2	....

[a] None of the samples examined showed even a trace of formaldehyde or formic acid.

SMALL ROTATING-DISK PROCESS.

The small rotating-disk ring, or Blood process, invented by A. R. Blood in 1883, is used extensively at present. The disk upon which the carbon black is deposited is shown in Plate VI, *A*. It is made of cast iron, ranging in diameter from 36 inches to 42 inches and has a 50-inch face. The lava tips are set in a circular piece of ¾-inch standard pipe, which is about 28 inches in diameter and contains from 18 to 24 tips. The scraper for removing the carbon is continuously in contact with the disk and is set over a hopper radially with the disk. A driving gear is bolted on the disk, and a pinion meshing with the gear is attached to the drive shaft by means of a set screw. The teeth of the pinion are extraordinarily long in order to allow for the expansion and contraction of the entire length of the driving shaft. A shaft base or cap sets in the axis upon which the disk rotates, and acts as a guide and support for the driving shaft. It also stabilizes the pipe which rests on a concrete base and carries the weight of the disk. The gear and pinion actuate the disk, which makes one revolution in about 15 minutes. Figure 12 shows details of a wheel, driving gear and pinion, and shaft base. A gear and pinion, shaft base, and accessories is shown in figure 13; in this drawing the disk is not the same design, however, as that described above.

The disks are arranged in rows of 21 disks, with two or, usually, four rows per building. One unit plant has 16 to 20 buildings so

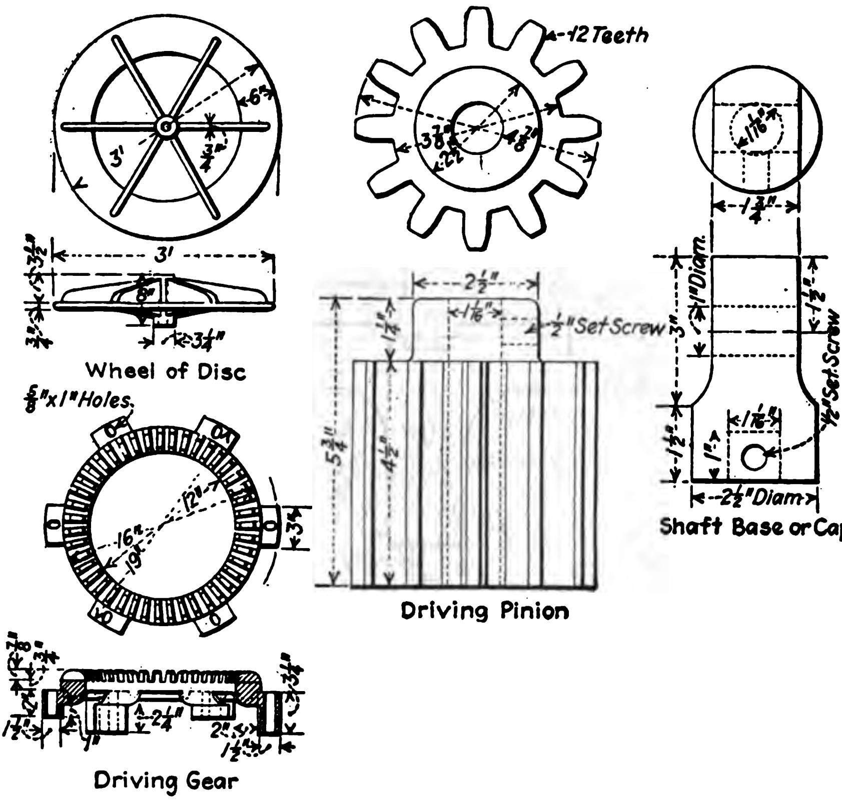


FIGURE 12.—Details of disk, driving gear and pinion, and shaft cap used in rotating-disk method.

that there are 84 disks per building and 1,532 disks in an 18-building factory. Each pair of rows has one conveyor and each row has a separate drive shaft extending the entire length of the building. The drive shafts are moved by a gear and pinion, power being transmitted by a 2-inch shaft in the alley. Plate VI, *B* shows how the power is transmitted to a building having four rows of disks.

The carbon black is delivered from the buildings as in the channel process. No gear-shifting machine is employed and the shafting is lighter than in the channel system, as the weight of the material in the condensing buildings of a typical plant using the rotating-disk method is about 150 tons.

The quality and yield of the carbon black made by the disk process is approximately the same as that made by the channel method.

THE PLATE OR CABOT PROCESS.

The plate system was invented by G. L. Cabot about 1892 and has two modifications. One method employs stationary plates 24 feet in diameter having beneath them revolving scrapers and burners; another method uses revolving plates 24 feet in diameter with stationary scrapers and burners. The first arrangement is the more widely used and is employed at a plant in West Virginia having until recently the largest output of any factory in the world. This

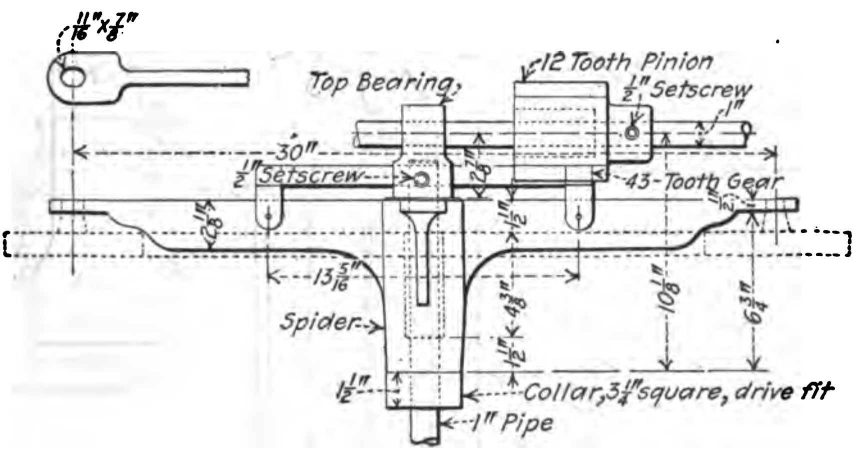
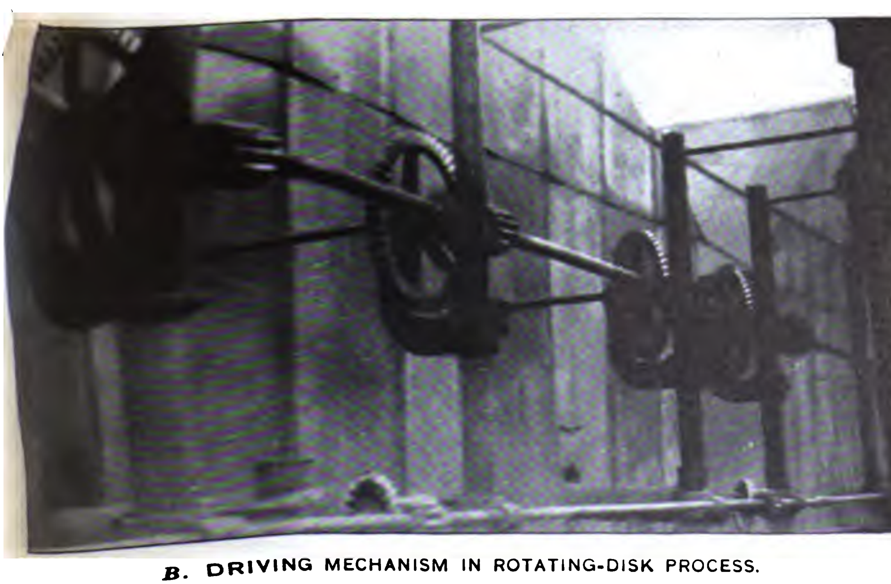


FIGURE 13.—Assembly of spider, gear, and pinion.

plant had 113 plates and is shown in Plate VII, *A*. The process is also used in Louisiana. (See fig. 14.)

The iron plates are made of 48 segments, 16 in the inner row and 32 in the outer row, the over-all diameter being 24 feet. The plates are perforated with ventilator holes to allow the products of combustion to escape and to afford a means of maintaining a draft. The plate is supported by guys screwed into a cap that is shaped like a broad truncated cone. This cap rests upon the top of a hollow mast, the joint between the cap and the mast being made gas tight with asbestos. A circular building, 26 feet in diameter, made of corrugated sheet iron, surrounds the plates. Above each plate is a roof made partly of triangular pieces of sheet iron and partly of four-sided sheets of corrugated iron extending about two-thirds of the distance up the 16-foot mast, leaving therefore, in the center,

A. DEPOSITING SURFACE FOR CARBON IN ROTATING-DISK PROCESS.



B. DRIVING MECHANISM IN ROTATING-DISK PROCESS.

A. CARBON-BLACK FACTORY IN WEST VIRGINIA USING THE PLATE PROCESS.

B. CYLINDER ON WHICH CARBON BLACK IS DEPOSITED IN ROLLER SYSTEM.

an open space having about one-third the diameter of the plate, through which the products of combustion can escape.

The mast stands in a bedplate; the upper surface of the bedplate carries a groove in which steel balls run as a bearing. Upon these

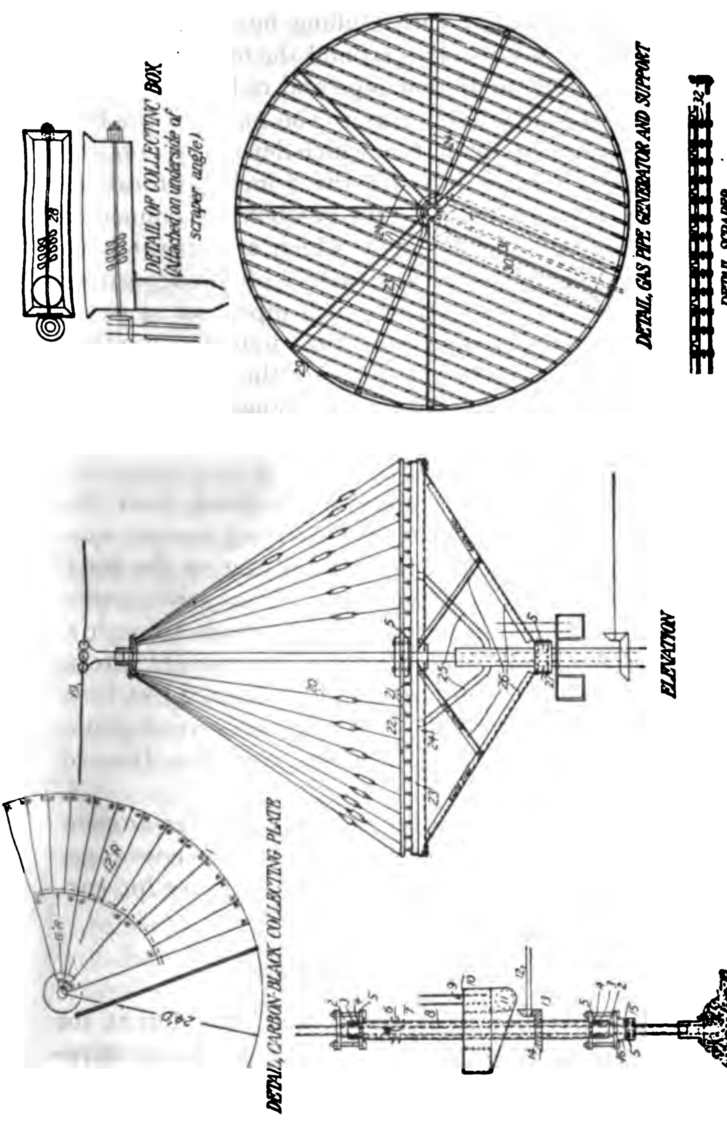


FIGURE 14.—Details of the plate or Cabot process of making carbon black.

1. Hole for attaching guys.
2. Stuffing box and gland.
3. Packing, 4 plugged.
5. Collar and set screw.
6. Tapped for gas.
7. Inner shaft plugged.
8. Openings, gas from inner tube to outer tube.
9. Carbon black.
10. Revolving cover plate.
11. Screw conveyor.
12. Driving shaft.
13. Pinion.
14. Gear.
15. Ball bearings.
16. Loose collar.
17. Concrete base.
18. Gas intake.
19. Cable support from one unit to other unit and to ground.
20. Guy wires or rods with tightening buckles.
21. 1½-inch gas pipes.
22. Cast-iron plates.
23. 4-inch gas pipe.
24. Angle irons.
25. Gas.
26. Angle-iron supports.
27. Stud bolts.
28. Screw or paddle conveyor.
29. Supporting and tie up angles.
30. Collecting box.
31. Angle scraper.
32. Attached rods and spring.

steel balls rests a casting having 8 arms that project outward and upward and fit into the lower ends of struts made of 2-inch pipe. On the outer end of these struts is an angle casting, into which the pipe fits, and a horizontal hole which accommodates a horizontal guy rod. Each horizontal guy is connected at the inner end to an octagonal plate that rotates with the burners and scrapers around the central mast. The burners fit in a gridiron of pipe lying on a circle of 4¼ by ¼-inch bar iron which is bolted to the vertical face of the angle castings. The lamp is fed by two ¾-inch holes in the central mast, which is incased in a gas box with stuffing boxes and glands above and below. This gas box revolves around the mast supported on the eight-horn casting with the burner pipe and radial black box.

The gas line from the regulators connects to the mast at the bottom; the mast is closed above by a cap from which depend the oblique guys. Slightly below the scraper box are the ¾-inch perforations that admit the gas into the gas box. To the gas box are connected two 1½-inch pipes feeding a 4-inch main in which are screwed the 1¼-inch burner pipe extending beneath the surface of the depositing plate. Each 4-inch pipe feeds over fifty 1¼-inch pipes, set at equal intervals and extending to the periphery of the circular depositing plate. The 1¼-inch pipes carry lava tips that are the same as those in the channel or disk process. The two center pipes have 60 lava tips each; and there are 1,265 tips under the entire plate. The burners make 1 revolution in 8 minutes.

Scrapers placed radially on the mast removed the black from the plates. Below the scrapers is a collecting box carrying a screw conveyor actuated by a gear and pinion, the gear sitting on the mast and the pinion on the end of the conveyor shaft. The carbon is carried to the inner end of the collecting box and descends through a vertical pipe into a circular box that discharges downward into a long conveyor running beneath the circular boxes and 2 feet from the center of the ring. Conveyors take the black from several plates to the packing house, where it is elevated to bins, and then dropped into the packing machines.

All the machinery at these plants moves so slowly that the amount of power used is surprisingly small. Only one 35-horsepower gas engine is necessary to operate 22 plates and furnish power for conveyors, packing, and bolting machinery.

ROLLER OR ROTATING-CYLINDER PROCESS.

The roller process was first used by E. R. Blood in 1883, but at the start proved unprofitable because of the small yield. Later, however, the details of operation were improved and a market for the product, which possesses valuable properties notwithstanding its inferior color, has been created. At present, this is the highest priced grade of carbon black and is utilized chiefly in making lithographic and embossing inks, and printing ink for half-tone engravings.

In the roller process the buildings or benches are 65 to 100 feet long and 25 to 35 feet wide; they are made of 24-gage straight or

V-crimped sheet iron and are wired to a small angle-iron framework. From four to ten buildings are connected to the same driving shaft or source of power.

A 1¾-inch pipe leads the gas to each set of rollers or cylinders. Some manufacturers place a small disk in the screw union in each distributing pipe before it is connected to the pipe carrying the lava tips, in order to regulate uniformly the flow of the gas under each roller. The burner pipe holding the lava tips is from 3 to 5 inches below the cylinders and usually is lower than in the channel system. The lava tips are round and have a round instead of a fishtail opening, hence the flame is cylindrical. Tips are separated ⅞ inch to 4 inches, as is shown in Plate VIII, *A*.

The rollers, 3 to 8 feet in length, have a spider bearing for a 1½-inch shaft. If made of cast iron they are about seven-sixteenths of an inch thick, 8½ inches outside diameter, and weigh approximately 100 pounds. (See Pl. VII, *B*.) The outside of each roller is machine faced. Some operators use ordinary extra-heavy well casing in 8 or 9 foot lengths and by countersunk rivets fix spider bearings in each end for the shafting. This arrangement is cheaper and makes the plant more independent of the local foundries, although the possibility exists that the cylinders may warp and throw the driving mechanism out of alignment. At a plant using casing, however, no difficulty from warping, distortion, or scaling by heat was experienced.

The scrapers for removing the deposited carbon black are placed at the top or near the top of the rollers, and run logitudinally the entire length. They are in direct contact with the rollers and scrape continuously. In one design, V-shaped blades are attached to the opposite ends of downwardly curved metal straps, one blade being positioned for contact with one roller and the other for another. The weight of the straps and blades, borne by the cylinders, brings the blades into close contact with the rollers and makes them scrape efficiently.

Over the cylinders is a removable sheet-iron hood; it protects the cylinders from drafts, and is provided with apertures to control the ventilation within the roller chamber. Below the cylinders is a trough-shaped hopper contracted at the bottom, designed to exclude air from the cylinders, and to collect the black scraped therefrom. A screw conveyor mounted in the bottom of the hopper carries the black to the bolting machines and hence to the storage bin over the packing machines. An angle-iron frame supports the hood, hopper, and conveyors. Under each hood are nine rollers, three rollers on each shaft. Where 4-foot rollers are used there are only two rollers on each shaft, and in some designs two sets of rollers to a hopper. Each building contains two rows of hoods and hoppers, and the

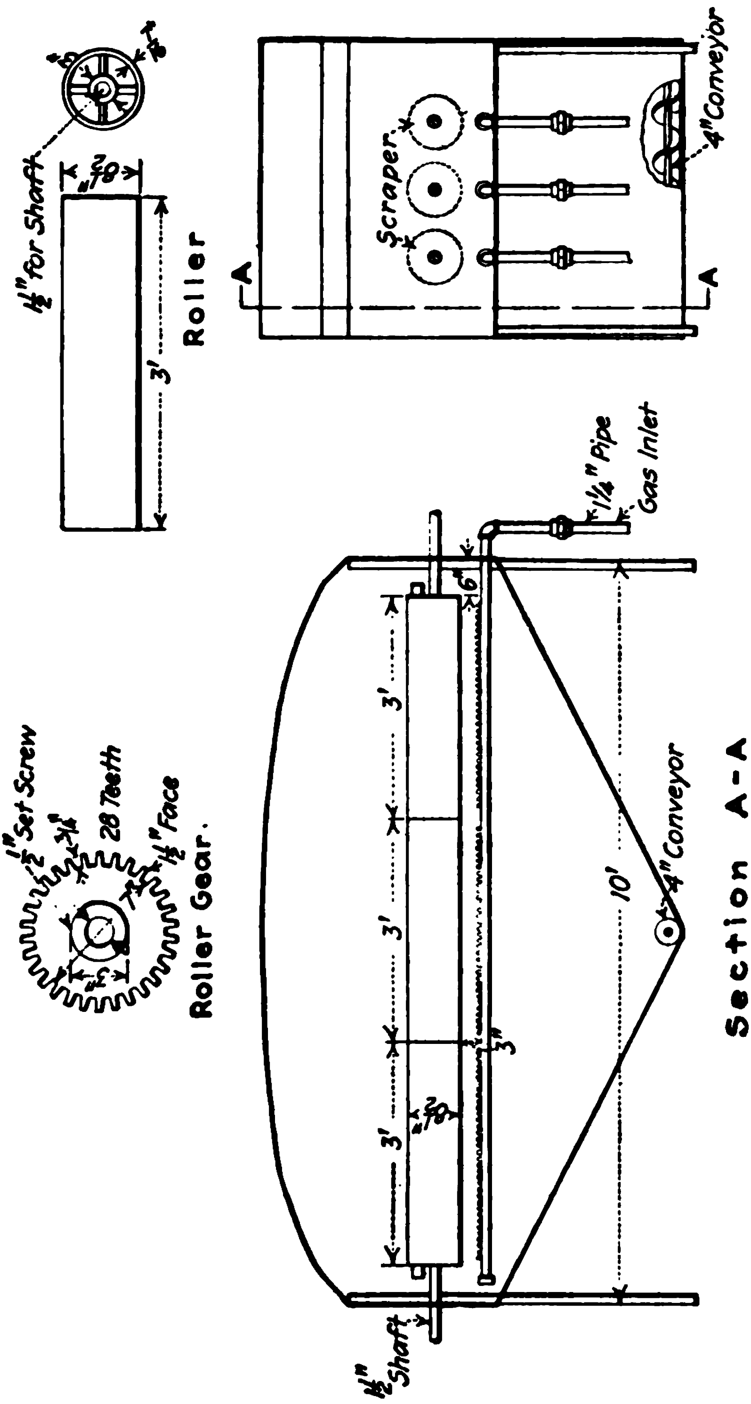


FIGURE 15.—Details of roller or rotating-disk cylinder process.

A. GAS BURNERS USED IN ROLLER PROCESS.

B. GEAR-ACTUATING CYLINDERS IN THE ROLLER PROCESS.

A. CHAIN TRANSMISSION USED IN ROLLER PROCESS.

B. A LOUISIANA CARBON-BLACK PLANT IN OPERATION.

shafting runs the entire width of the building; each shaft, therefore, actuates four or six rollers according to the length of the cylinders. Slits or slide doors in the building help to regulate the draft. A typical building has 196 to 288 rollers, 10,000 lava tips, about 24 to 32 hoods, and an equal number of hoppers.

On each shaft, which is made of hollow pipe, a worm gear with about 28 teeth and a pitch diameter of about 6 inches is attached by means of a set screw. This gear is actuated by a worm 3 or 4 inches in diameter having about 5 threads, and it makes one revolution every 15 to 45 minutes (see Pl. VIII, *B*). The grade of black determines the rate at which the cylinders revolve. The worm is mounted on a solid steel shaft that is moved by a chain and sprocket transmission from the main power line, as shown in Plate IX *A*. The conveyors, elevators, bolting machines, and packing machines are also connected to the main power shaft, which is actuated by a gas or expansion engine. Power requirements are about the same as in the channel method. Figure 15 shows details of the roller system.

GEARS USED IN CARBON-BLACK INDUSTRY.

The machinery at a carbon-black plant requires a large number of gears. Most of these are bevel gears as they are used to transmit power to the conveyors, although spur gears are used in transmitting power to bolters, scalpers, etc., and worm gears move the cylinders in the roller process, and also connect the reversing gear shift to the main drive shaft which actuates the rack and pinion in the channel system. (See fig. 16.)

Diametral pitch is the number of teeth to each inch of pitch diameter. The word diameter, when applied to gears, always means pitch diameter.

If the teeth are shaped properly, the linear velocities of the two wheels are equal, and the angular velocities or speeds of rotation are inversely proportional to the number of teeth and to the diameter. Thus a gear that has twice as many teeth as one mating with it will revolve just half as many times per minute.

In ordering standard gears and pinions it is only necessary to specify circular pitch, bore, face, and ratio of the number of teeth on the gear to the number of teeth on the pinion. Although there is no standard rule, the width of the faces of the teeth is generally made two or three times the circular pitch.

At carbon-black plants the temperature changes give rise to a special problem which is solved by using pinions whose facial dimensions are four or five times those of the gears so that should there be a sudden expansion or contraction in the shaft, the gear and pinions would still mesh. Should bevel gears be used, contraction might possibly prevent intermeshing, and expansion might break the teeth or force the shafting out of alignment, causing a waste of power and undue wear upon gears and bearings; in fact some bevel gears have worn away from this cause as much as three quarters of an inch. Frequently a device is resorted to which is not strictly mechanical, but which, nevertheless, gives good results under the conditions peculiar to this industry, namely, a bevel wheel is driven by a spur gear. The bevel is flat, perhaps five or six times the pitch diameter of the spur that drives it. Obviously the wear and tear on the cogs is uneven and greater than with a true bevel properly adjusted, but

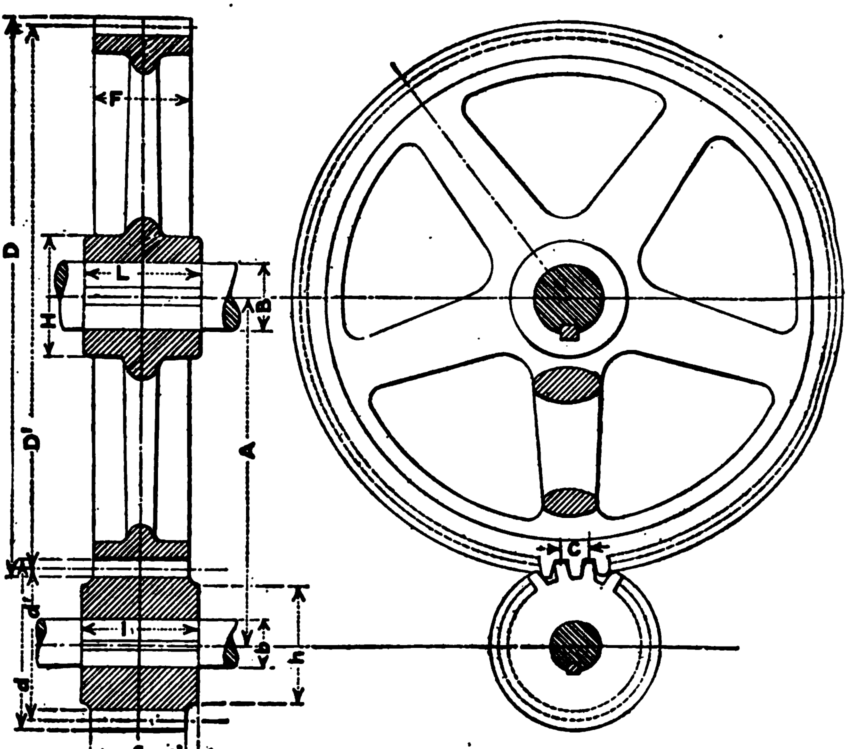


FIGURE 16.—Details of spur gear and pinion.

the arrangement has the great advantage that as the shaft carrying the spur gears expands and contracts, the long cogs on the spur wheels always engage the teeth of the bevel gear; as the power required is very small in proportion to the size of the gears and the motion is very slow, the extra wear and friction caused by this mathematically inaccurate method is of minor importance and far less injurious than the evils that might otherwise result from the expansion and contraction of the driving shaft. Some of the gears installed in carbon-black factories are not standard, but are "bastard" and are cast from special patterns. Tables 4 and 5 contain data of value in the construction of gears.

In the disk process especially gears are exposed to an intense heat that practically eliminates lubrication, and as a result wear and frictional losses are large. Maximum service may be obtained by the following procedure:

1. Gears and pinions should have ample strength, ductility, wearing surface, and hardness.
2. Installations should be properly made. Remember that badly worn gears will wear new pinions unduly, and that old pinions unduly wear new gears.
3. Gears should be kept in mesh on true centers in proper alignment. This necessitates proper maintenance of bearings.
4. Lubricate gears where possible.
5. Inspect gears at intervals.

If the care as specified above is not given the gears they soon fail to mesh accurately and serious evils result; power escapes in transmission; bearings wear unevenly, throwing the shifts out of line, and in turn causing gears, bearings, and other parts to wear faster; vibration produced in the gears causes increased wear and tear.

TABLE 4.—*Circular pitch of gears with its equivalent in diametral pitch, depth of space, and thickness of tooth.*

Circular pitch (inches).	Diametral pitch.	Thickness of tooth on pitch line.	Depth to be cut in gear.	Addendum.[a]
6	0.5236	3.0000	4.1196	1.9098
5	.6283	2.5000	3.4330	1.5915
4	.7854	2.0000	2.7464	1.2732
3½	.8976	1.7500	2.4031	1.1140
3	1.0472	1.5000	2.0596	.9550
2¾	1.1424	1.3750	1.8882	.8754
2½	1.2566	1.2500	1.7165	.7958
2¼	1.3963	1.1250	1.5449	.7162
2	1.5708	1.0000	1.3732	.6366
1⅞	1.6755	.9375	1.2874	.5968
1¾	1.7952	.8750	1.2016	.5570
1⅝	1.9333	.8125	1.1158	.5173
1½	2.0944	.7500	1.0299	.4775
1⅜	2.2848	.6875	.9441	.4377
1¼	2.5133	.6250	.8583	.3979
1⅛	2.7925	.5625	.7724	.3581
1	3.1416	.5000	.6866	.3183
15/16	3.3510	.4687	.6437	.2984
⅞	3.5904	.4375	.6007	.2785
13/16	3.8666	.4062	.5579	.2586
¾	4.1888	.3750	.5150	.2387
11/16	4.5696	.3437	.4720	.2189
⅝	5.0265	.3125	.4291	.1989
9/16	5.5851	.2812	.3862	.1790
½	6.2832	.2500	.3433	.1592
7/16	7.1808	.2187	.3003	.1393
⅜	8.3776	.1875	.2575	.1194
5/16	10.0531	.1562	.2146	.0995
¼	12.5664	.1250	.1716	.0796
⅛	25.1327	.0625	.0858	.0398
1/16	50.2655	.0312	.0429	.0199

[a] Distance from pitch line to top of tooth.

TABLE 5.—*Circular pitch of gears.*

[Circular pitch is the distance from the center of one tooth to the center of the next, measured on the pitch line.]

To find—	Having—	Rule.
Circular pitch	Diametral pitch	Divide 3.1416 by diametral pitch.
Do	Pitch diameter and number of teeth.	Divide pitch diameter by product of 0.3183 and number of teeth.
Do	Outside diameter and number of teeth.	Divide outside diameter by product of 0.3183 and number of teeth plus 2.
Pitch diameter	Number of teeth, circular pitch.	Multiply number of teeth by circular pitch, by 0.3183.
Do	Number of teeth and outside diameter.	Divide product of number of teeth and outside diameter by number of teeth plus 2.
Do	Outside diameter and circular pitch.	Subtract from outside diameter the product of circular pitch and 0.6366.
Do	Addendum and number of teeth.	Multiply number of teeth by addendum.
Outside diameter	Number of teeth and circular pitch.	Obtain continued product of number of teeth plus 2, circular pitch, and 0.3183.
Do	Pitch diameter and circular pitch.	Add to pitch diameter the product of the circular pitch and 0.6366.
Do	Number of teeth and addendum.	Multiply addendum by number of teeth plus 2.
Number of teeth	Pitch diameter and circular pitch.	Divide the product of pitch diameter and 3.1416 by the circular pitch.
Thickness of tooth	Circular pitch	One-half the circular pitch.
Addendum	Circular pitch	Multiply circular pitch by 0.3183.
Root	Circular pitch	Multiply circular pitch by 0.3683.
Working depth	Circular pitch	Multiply circular pitch by 0.6566.
Whole depth	Circular pitch	Multiply circular pitch by 0.6866.
Clearance	Circular pitch	Multiply circular pitch by 0.05.
Do	Thickness of tooth	1/10 thickness of tooth at pitch line.

THERMAL DECOMPOSITION.

Although several patents for cracking or thermal decomposition methods of producing carbon black from natural gas have been granted, at present only one company is operating such a process on a commercial basis. This plant decomposes the gas for the hydrogen and does not even collect the carbon formed.

The carbon black produced by this procedure contains hard particles, is grayish in color, and possesses a high apparent specific gravity. One sample the writer examined contained 5.38 per cent of matter that was soluble in chloroform and possessed only one-fifth the tinting strength of ordinary carbon black. Some of the product showed flakes of naphthalene and its utility in the rubber-tire industry was thereby much impaired. The product thus far made by thermal decomposition is almost unmerchantable, has been used successfully only in making cheap paints, and has sold for 1 to 2 cents per pound.

In one cracking process for petroleum a large pipe with walls 1½ inches thick is placed in a vertical position. The gas is introduced in the lower portion of the pipe and ejected from a side connection located near the top. A temperature of 1,500° F. is maintained by several circular rows of gas torches. The carbon deposited upon the inner walls of the pipe is released by a revolving mechanism that consists of a shaft to which are attached chains running the entire length of the furnace; the chains on revolving scrape the carbon from the inner wall of the pipe. The difficulty with this process is the rapid deterioration of the pipe and the large content of iron scales in the carbon black. Although a yield of from 8 to 10 pounds has been obtained per thousand cubic feet of gas, the product is of no commercial value.

In another process the cracking chamber is lined with fire brick, and by admitting at intervals a blast containing a mixture of air and gas, it is heated to 1,500° F. The carbon liberated is carried over by the blast of gas and is collected in separators or in bags.

COMPARISON OF DIFFERENT PROCESSES.

The channel, rotating-disk, and large-plate methods produce approximately the same yield of black per thousand cubic feet of gas. The roller system produces considerably less carbon than any of the other processes, but the resultant product is much more valuable and is utilized for special purposes. Table 6 shows the yield produced by various processes in different fields.

TABLE 6.—*Yield of carbon black in different fields.*

Plant number.	State.	Process.	Carbon black per 1,000 cubic feet gas.
			Pounds.
1	Louisiana	Channel, 2-table	0.78
2	....do	Channel, 1-table	.95
3	....do	....do	.80
4	....do	Large-plate	.80
5	West Virginia	....do	1.10
6	....do	Rotary-disk	.95
7	....do	Roller	.80
8	....do	Rotary-disk	1.00
9	....do	Channel, 2-table	1.12
10	....do	Channel, 1-table	1.30
11	....do	Rotary-disk	1.40
12	Oklahoma	Channel	1.20
13	Wyoming	....do	1.40

Plants of the channel system can be constructed almost entirely from standard forms; this feature simplifies the enlargement of the channel type of plant. The cost of construction is less than that of any other type of carbon-black factory. The large-plate method has the disadvantage of requiring special castings which are so large that a greater initial cost of construction is entailed than in other types. For a plant capable of producing a large output, however, the power requirements are less than for plants operated according to other methods. The rotating-disk process requires a special casting, but it has the advantage over the channel method that the plants are more flexible. Part of the disks in a condensing building may be out of order, yet the remaining rings will continue to operate, and it will not be necessary, as in the channel method, to eliminate an entire condensing building during repairs.

The roller system produces the smallest yield and requires the largest depositing surface per pound of black made and per thousand cubic feet of gas burned of any type of plant, as Table 7 indicates. The demand for black made by this process is small, and the present production can supply it. (See Plate IX, *A*.)

TABLE 7.—*Comparison of different methods of making carbon black.*

Plant number.	Location.	Method	Area of depositing surface per burner tip.[a]	Square feet per pound of carbon black.	Square feet per 100 cubic feet of gas burned.
			Sq. ft.		
1	Louisiana..........	2-table channel..........	0.21	4.87	3.75
2	.....do..........	1-table channel..........	.26	4.23	4.04
3	West Virginia......	Roller..........	....	9.10	7.33
4	.....do..........	Large-plate..........	....	6.55	7.16
5	.....do..........	2-table channel..........	....	5.05	6.75
6	.....do..........	Small-disk..........	....	3.10	2.90
7	Oklahoma..........	1-table channel..........	....	3.70	3.50

[a] Square feet of depositing surface.

VARIOUS FACTORS AFFECTING YIELD OF CARBON BLACK.

The various factors that affect the yield of carbon black are (1) the design of the plant, (2) weather conditions, (3) the pressure of the gas, and (4) the presence of salt water and oil in the gas. Factors of utmost importance in efficient recovery are the design of a plant, the kind of lava tip used, the distance from the depositing surface to the top of the lava tip, the arrangement for admitting air, and the rate of movement of the collecting surface. Provision should be made in construction for changing the height of burners, as different gases require different distances below the depositing surface. In West Virginia the lava tips are about 3 inches below the channels, but in Louisiana this distance is too great. By changing the position of the lava tips, one company in Louisiana increased its production of carbon black 20 per cent. If the tips are placed too near the collector, the flame tends to pass around the surface and loss of carbon black in flue gases increases. The rate of actuation of the depositing surface affects the quality of the carbon black manufactured more than it affects the quantity recovered. This factor, therefore, is determined by experiment; it is one of the flexible features, whereby various grades of black may be made by using the same method. The devices for admitting air are controlled by using as an index the color of the smoke issuing from the buildings, the superintendent having in mind the quality of black to be made and compensating losses in flue gas according to the quantity of black recovered.

Even at the most efficiently designed plant, the effects of weather conditions must be taken into consideration. A typical plant is

A. CARBON-BLACK PLANT EQUIPPED WITH WINDBREAK.

B. PLANT WHERE DRAFTS ARE CONTROLLED SO THAT LOSS OF FLOCCULENT CARBON IS AT A MINIMUM.

shown in Plate IX, *B*. Wind cuts down the yield by causing the flame to flicker and not lie quietly and smoothly against the surface of the iron. A company that was experiencing difficulty in obtaining efficient yields discovered its trouble was due to the sweep of the wind down a narrow valley toward the condenser building; the trouble was entirely eliminated by erecting a large wind break to protect the buildings, as shown in Plate X, *A*. (See also Plate X, *B*). Moist weather or light rains have little or no effect on the quality or the quantity of carbon black produced, but heavy rains tend to diminish the quantity and to injure the quality. Sometimes the water wets the black and cakes it, thus causing error in weighing the product in the packing room.

In considering the low recoveries of carbon black, persons not familiar with the industry usually think that relative efficiency may be increased merely by reducing the temperature of the collecting surfaces by means of air or water. G. L. Cabot,[10] for example, who has had a wide experience in cooling the surfaces on which carbon black is deposited, says on this point:

> The first factory that I ever owned, at Worthington, Pa., was originally built beginning in the year 1882, and carried water on the surface to keep the temperature down to the boiling point. We subsequently got much better yields without water cooling. Later on I tried the experiment of sprinkling the surfaces continuously with a lawn sprinkler device, and here again I immediately cut down the yield. Later on I bought a factory where black was condensed on hollow channels through which air was blown. We never were able to find that it perceptibly affected either the quality or quantity of black whether or not the air was blown through the channels.

Numerous difficulties on account of warping, expansion and contraction, corrosion, and rapid depreciation of equipment accompany the cooling of the depositing surface. The ordinary channel building when heated to the operation temperature expands 4 inches in a straight line; this expansion tends to force out of alignment the shafting, rack, gears, and other accessories. Expansion and contraction often warps the depositing irons to concave or convex surfaces and it then becomes difficult to remove the accumulated carbon; if the black is permitted to remain on the irons too long its quality is impaired by the formation of excessively heated gray particles called "grit." The forcing of air or water through or over the collecting surfaces leads to corrosion and increases depreciation. A 39-inch thermocouple inserted through the side of a carbon-black building, the stem projecting over the channel irons and about 10 inches above them, indicated, according to a standard pyrometer of the hot and cold junction type, that the temperatures of the different buildings varied from 650° F. to 800° F. The actual temperature of the channel ranged from 932° to 1,100° F.

[10] Personal communication.

The records of the factory show conflicting reports on results obtained in extremely cold or hot weather. The personal element may possibly be the determining factor at this point. Low yields in excessively hot or cold weather may result from the effect of temperature upon the men operating the factories who may not maintain the efficiency of the apparatus rather than from the effect of temperature upon the physical and chemical reactions in the manufacturing process.

Hippolyt Kohler [11] makes the following statement regarding lamp black:

> It follows with positive certainty that cooling of the flame for the purpose of producing lamp black is not necessary, since carbon does not separate with a low temperature flame, but on the contrary with the right high temperature. An object put in a flame can serve for the most part only as a trench which catches the evolved globules of soot and its heat-conducting property affects the production of carbon only inasmuch as it prevents too much burning of the carbon liberated in the flame.

Undoubtedly whenever the depositing surface is cooled below the reacting temperature, some of the hydrocarbons in the flame escape undecomposed. The flame must be neither extremely cold nor excessively hot, else the gas will not be decomposed completely, or too much carbon will be burned. A surface that is too hot collects less carbon black than a colder one, but a surface that is too cold chills the flame and less carbon is liberated.

Recovery of gasoline from natural gas before utilizing the gas for manufacturing carbon black is a large source of revenue. Stripping the gas of the gasoline vapors has no appreciable effect on either the quality or quantity of the carbon black produced. Each tenth of a gallon of gasoline recovered from each thousand cubic feet of gas reduces the volume of the gas three-tenths of a per cent; hence gasoline recovery does not change appreciably the carbon content of even a rich dry gas.

If the absorption process is used in recovering the gasoline from the gas, the gas may carry some absorption oil into the carbon black building. This oil would lower the quality of the black by increasing the volatile constituents, and the collection of the oil in low points in pipe lines would result in a fire hazard by the shutting off of the gas supply in some of the buildings. This condition can be eliminated completely by using absorbers of adequate size and by installing efficient drips on the discharge gas from the gasoline plants.

The presence of salt-water gas and a large percentage of sulphur have similar effects on the operation of a carbon-black plant. Salt crystallizes, and sulphur compounds accumulate on the lava tips causing the flame to "fork" so that it is not distributed evenly over the depositing surface, and the volume of the gas passing through

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[11] Kohler, Hippolyt, Das Fabrikation des Russes und der Schwarze, p. 105.

the burners is decreased. Where absorption gasoline plants are used in connection with carbon-black factories, difficulties from salt water are largely obliterated. If the flame becomes forked it is necessary to draw a thin knife through the tip and brush the "whiskers" from it. Some plants use only a brush to clean tips. In the Indiana gas field where the gas had a high sulphur content, the tips were cleaned every two weeks, whereas at some plants they are brushed but once a year.

The pressure of gas will in a measure affect not only the quality but also the quantity of the black produced. The pressure on distributing lines to burners varies from 0.2 inch to 1.5 inches water pressure. The use of kerosene or light lubricating oil in manometer tubes for determining pressure will eliminate in winter the trouble from water freezing in instruments exposed to the weather. With excessive pressures the yield of black usually is low.

SOURCES OTHER THAN NATURAL GAS FROM WHICH CARBON BLACK MAY BE MANUFACTURED.

Carbon black was first manufactured from artificial gas. The product is very glossy, has an intense color, and makes a high-priced printing ink. No black made from natural gas possesses all the qualities of that made from artificial gas. Carbon black, of course, could be manufactured from artificial, illuminating, blast furnace, producer, or coke-oven gases were it not for the prohibitive cost of the original gas. It has been made from coke-oven gas in England in recent years by Recketts & Sons, of Hull. Mr. G. L. Cabot says: "I have found illuminating gas and coke gas better than most natural gas for this purpose, except in price."

Several patents have been granted on processes in which carbon black is made by exploding mixtures of acetylene and air under pressure. The pressures vary from 50 to 100 pounds per square inch and the explosion shows that the acetylene is not merely oxidized but is dissociated. The acetylene is obtained from refuse calcium carbide—noncommercial grades too finely divided or having too low a content of carbide to be merchantable. Difficulties in this process are the rapid mechanical depreciation of the apparatus, the small output for invested capital, the inferior color and strength of the black compared with natural-gas black, and the uncertainty of the supply of refuse carbide. As it is a by-product, the price of commercial calcium carbide is prohibitive. Only a little black is made by this method, although the product is preferred for some purposes on account of its inherent bluish tinge. A small plant in Chicago burns acetylene, as in the manufacture of carbon black from natural gas. The collecting plate is cooled by circulating water with a rate of flow regulated by a thermostat. A yield of 11.6 pounds of black per thousand cubic feet of acetylene is obtained, which is a recovery of 17.3 per cent. Black made by burning acetylene is of better color than that made by explosion.

For some purposes, as for phonograph records, medical hard rubber, certain kinds of printers' ink, and black paint, it may be possible to substitute lampblack for carbon black, but for most purposes these two products are quite dissimilar in their physical properties and to date have proved unsuitable for substitution.

FIRE HAZARDS ACCOMPANYING THE HANDLING OF CARBON BLACK.

About 1890 a barrel of black shipped from a plant in Pennsylvania carried with it a spark of fire that entirely consumed the black and charred the lining of paper, but did not affect the barrel. Only two fires have occurred recently while carbon black was being transported. One was in 1914 at Baltimore, Md., in a car containing 200 wooden barrels of black; it resulted in the destruction of the car and contents, entailing a loss of $1,185. The other fire was in 1918, in a car loaded with 19,000 paper bags, each containing 12½ pounds of carbon black. The car was damaged only slightly, but the contents were entirely destroyed, resulting in a financial loss of $2,875.

G. L. Cabot [12] says, "these unexpected conflagrations led to the erroneous charge that carbon black is subject to spontaneous combustion."

The following experiment [13] was carried out: A water-jacketed oven was packed closely with carbon black and heated to a temperature of 100° C. for 72 hours without the temperature of the contents rising above 100° C. From this test and similar ones it is concluded that carbon black is not subject to spontaneous ignition.

A sample of carbon black was compressed, cooled to 0° C., and a vacuum pump applied. The gas liberated upon heating showed the following analysis:

Gases from carbon black.

	Per cent.
Carbon dioxide	0.32
Oxygen	21.20
Nitrogen	76.48

The ultimate analysis of another sample gave the following results:

Ultimate analysis of gas from carbon black.

	Per cent.
Hydrogen	0.5
Carbon	96.76
Nitrogen	.01
Oxygen	1.61
Sulphur	.12
Ash	.24

[12] Personal correspondence.

[13] Communication with Col. B. W. Dunn and C. P. Beistle, Bureau of Explosives.

It is evident that oxygen is selectively adsorbed and the slow mouldering of a spark in carbon black is due in a large measure to the occlusion of oxygen.

COST DATA.

The cost of constructing a carbon-black plant is usually given in dollars per barrel of fifty pounds of black. Previous to the war, a plant using the channel process could be constructed for $1,000 per barrel, but this figure has increased to $1,500 to $3,000 per barrel, depending on the size and the location of the factory. The following table gives construction costs of factories using the channel method:

TABLE 8.—*Cost of construction of channel plants.*

Date built.	Cost.	Capacity, pounds per day.	Cost, dollars per barrel.
1913	$116,000	6,000	$966
1916	40,000	1,000	2,000
1916	110,000	2,600	2,115
1917	608,000	19,000	1,600
1919	125,000	2,000	3,125

The cost of construction of a plant using the rotating-disk process is only slightly greater than that of a channel plant. No data are available on cost of erection of either roller or large-plate carbon-black plants.

The cost of operation, not including cost of gas, varies from 98 cents to $2 per hundred pounds of carbon black produced. This takes into account labor, sacking and resacking, depreciation, supplies, and repairs. The labor costs are notably low because most of the work is performed automatically by machinery. Table 9 shows the number of men employed at some of the plants:

TABLE 9.—*Comparison of number of men employed in different types of plants.*

Daily production.	Process.	Number of men employed.	Daily production per men employed.
Pounds.			*Pounds.*
2,600	Channel	7	371
1,000	Channel	4	250
6,000	Rotating-disk	13	461
300	Roller	3	100
12,000	Channel	16	750
8,000	Plate	18	440

The cost of gas ranges from 1.5 cents to 6½ cents per thousand cubic feet of gas, and is the largest expense and the most uncertain factor in the carbon-black industry. Most of the companies charge

10 per cent a year to depreciation, although one company charges off 12.8 per cent. This figure assumes to cover the hazard in the supply of gas. Depreciation of machinery is surprisingly small.

FUTURE PROSPECT OF INDUSTRY.

Attempts are made periodically to increase efficiency in the recovery of carbon black by enriching the gas with oil vapors. The amount of oil vapor held by the gas will depend upon (1) the relative temperature of the oil and gas, (2) the mechanical arrangement for bringing the oil and gas in contact with each other, and (3) the properties of the oil used. The oil usually employed is fuel or gas oil and ranges in gravity from 28° B. to 38° B. The oil vapor makes the color of the resulting product less intense, although the difference is not great enough to diminish the value of the black. It is doubtful whether this procedure is a commercial possibility or can be made profitable, especially as the field for the utilization of fuel oil is being so rapidly extended and its value trending upward.

The addition of chlorine to the burning gas has been tried in the laboratory, with the object of increasing the yield by the formation of hydrochloric acid and the liberation of carbon. The increased yield has not yet proved compensatory with the increased cost of apparatus and operation. One difficulty lies in the rapid deterioration of apparatus.

It is possible to augment the yield by catching the black that escapes from the condensing units, although the product that floats away in the air is relatively unimportant in bulk. Escaping black possesses an extremely low apparent specific gravity as compared with that deposited upon the irons. It may possibly have properties that would make its application especially useful for some purpose, but it resembles an inferior grade of lampblack and not carbon black. Undoubtedly this product could be collected by electrical precipitation. One company is installing a flue dust collector of the filter type. The yield of carbon black can be increased by diminishing the supply of air and by controlling the draft (see Pl. X, *B*), but the quality of the product is impaired. The maker of carbon black must work within a narrow range to obtain the best average results. Generally a burner that gives a heavy deposition of black on the cooling surface also increases the amount of black carried away in the flue gases.

Probably the most beneficial line of improvement of present commercial methods lies in changing the design of the plants so that the cost of construction will be diminished. The control of the supply of air should be regulated more efficiently and provision should be made in the design to render plants independent of weather conditions, especially of winds.

Thermal decomposition probably offers tne most promising method of increasing the quality of black from natural gas. The present methods are destructive to the apparatus—a defect that undoubtedly can be overcome—and the resultant product contains grit or adamantine carbon, is grayish, and contains some volatile matter.

ECONOMICS OF CARBON-BLACK INDUSTRY.

It is generally conceded that the most important use that can be made of natural gas is for domestic purposes. Whether gas is of greater economic value for the manufacture of carbon black than for other industrial purposes is a question that will depend on the conditions existing in each locality where a large supply of natural gas is available.

The policy of the Bureau of Mines in this regard is stated in Paragraph 34 of the resolutions adopted by the National Committee on Natural Gas Conservation, June 11, 1920, which reads:

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

At present there is considerable agitation for and against laws restricting the use of natural gas for the manufacture of carbon black. On February 24, 1919, the State of Wyoming enacted a law entitled "An Act for production and conservation of the supply of natural gas of the State of Wyoming prohibiting the waste and wasteful use of natural gas through the burning or consumption thereof for the manufacturing or producing of carbon or other resultant products therefrom, prohibiting the taking, using, sale, or other disposition of natural gas from gas wells for such purposes, and providing penalties for the violation of such Act." This law was still in force in 1920, having been held constitutional by the United States Supreme Court. The carbon-black industry has been established in Pennsylvania for over forty years, and in West Virginia for more than twenty years. The latter State still produces more than fifty per cent of the entire supply.[13] Neither of these States has ever passed any laws restricting the use of natural gas for this purpose.

During the past three years a number of carbon plants have been moved from West Virginia to Louisiana. The State authorities of Louisiana became alarmed at the situation and enacted a law[14] regulating the use of natural gas in industries. The Louisiana act does not prohibit the use of natural gas in making carbon black, and embodies essentially the following points: It shall be unlawful to permit the waste of natural gas, or to use natural gas for any purpose

[13] U. S. Geol. Survey, Carbon black in 1920.

[14] Thompson, J. W., Petroleum laws of all America: Bull. 206, Bureau of Mines, 1921, p. 645.

whatsoever in such manner as will threaten with premature exhaustion, extinction, or destruction the common supply or common reservoir from which natural gas is drawn.

The term waste as above used, in addition to its ordinary meaning, shall include:

1. Wantonly or willfully permitting the escape of natural gas in commercial quantities into the open air.

2. The intentional drowning with water of a gas stratum capable of producing gas in commercial quantities.

3. Underground waste.

4. Permitting any natural gas well to burn wastefully.

Additional information on the State laws dealing with conservation and use of natural gas may be found in Bulletin 206, Bureau of Mines.

The arguments most frequently heard against the use of natural gas for the manufacture of carbon black are: 1. Using natural gas for carbon black is depriving or will deprive domestic consumers of a supply; 2. Compared with other industries the industry uses an undue proportion of gas; 3. the value and the utility of carbon black are less than those obtainable by using the gas in other ways; 4. The methods used are carelessly inefficient and more efficient methods are at present available; 5. Utilizing gas for making carbon black threatens premature exhaustion of gas reservoirs.

On the other hand the carbon-black manufacturers claim that they use the best manufacturing processes that have been developed and that they produce a commodity of acknowledged utility. They have also provided a market for gas in isolated regions and in so doing have many times prevented conditions that would otherwise have resulted in waste. In certain isolated districts they have furnished small communities with natural gas whose consumption they assert was not sufficient to warrant the building of a pipe-line system.

The right of the domestic consumer to demand preference in the matter of the natural gas supply is not to be contested and where possible gas should be so utilized.

In view of the fact that carbon-black plants are ordinarily situated in the heart of gas fields, that the quantity of gas consumed is relatively constant throughout the year, and the pressure on the mains low, the amount of natural gas actually delivered to the carbon-black plant compares favorably with the amount actually delivered to domestic or industrial consumers where gas must be transmitted over long distances and under high pressures.

The value and utility of natural gas for carbon-black manufacture as compared to other uses depends almost entirely upon the local conditions surrounding the gas fields. For instance, if the gas burned for carbon black in Louisiana could be supplied to domestic consumers in Omaha, Nebr., or St. Paul, Minn., its exchange value would be greater than the carbon black made from it, and consequently if this exchange value was effective in the Louisiana field, the price of carbon black would either be commensurately increased or the manufacturers would automatically be forced out of the district by the prohibitive price they would have to pay for the gas. "The price is the universal barometer that indicates the changes in the demand for goods of all kinds."[15] Carbon-black plants operate until the price of gas rises on account of the supply being made available for domestic consumption by the construction or extension of pipe lines. Then the factories are dismantled and removed to more remote districts that have no other means for disposing of the gas. Thus the industry is necessarily migratory.

It is evident that location, in relation to market for gas for domestic and industrial consumption, is the largest economic factor affecting the value of gas and the carbon-black industry. This is true of a large number of our raw resources, such as coal in isolated districts in West Virginia, sand around the Great Lakes, or lumber in various districts of the Northwest.

Consumers of natural gas live in the gas-producing districts or at a reasonable distance therefrom, whereas users of carbon black are widely distributed. Consequently there is a conflict in interests between those who are in the radius of gas service from the field and those living a considerable distance from the field and benefiting by the use of carbon black.

The actual financial return accruing from the gas burned for carbon is usually larger than that from the sale of gas for industrial consumption from the same field. In Monroe, La., for example, gas is produced, piped, and delivered to the larger industrial users at a rate of 5 cents per thousand cubic feet. The carbon manufacturers pay 2 cents per thousand, and obtain from each thousand feet approximately one pound of carbon black, which sells for 8 cents per pound. Pipe-line companies because of a tenfold larger investment, unfavorable transportation conditions, such as high pressure and consequent leakage in the mains and the need for transportation facilities capable of handling gas during the period of maximum consumption, may find themselves at a disadvantage as compared to the carbon companies. The duration of the period of maximum consumption is probably only two weeks in the South, four months in Oklahoma, and six months in the East. Thus a gas distribution company in the eastern States must install equipment that is used only half of the time.

One gas concern in the Mid-Continent field delivers only 49 per cent of the gas collected in the field to the meter of the ultimate domestic

[15] Ely, R. T., Outline of economics, 1916, p. 29.

consumer. Four per cent is used to operate compressors, 4 per cent goes to main-line consumers, 10 per cent to main-line loss, and 33 per cent is lost in distributing plants. Mr. G. E. Taylor, assistant engineer of the public service commission of West Virginia, estimates that the loss by leakage in transporting gas in that State ranges from 5 to 30 per cent. Some authorities declare that the annual loss of natural gas from leakage is equal to the annual consumption.[16]

Three of the large industrial consumers of natural gas are zinc smelters, brick plants, and glass factories; Tables 10, 11, and 12 show the cost of gas and other factors of each of these.

TABLE 10.—*Value of gas used in manufacture of bricks.*

Brick plants, No.—	Quantity of gas used a day.	Cost of gas per M.	Bricks made a day, M.	Gas per M bricks.	Cost of gas per M bricks.
	M cubic feet.			*m.*	
1.	1,000	$0.10	50	20	$2.00
2.	860	.17	43	20	3.50

TABLE 11.—*Value of gas used by zinc smelters.*

Smelters, No.—	Quantity of gas a day.	Cost of gas per M.	Amount of spelter refracted a day.	Gas per pound of spelter.	Cost of gas per pound of spelter.	Spelter per M cubic feet of gas.
	M cubic feet.	*Cents.*	*Pounds.*	*Cubic feet.*	*Cents.*	*Pounds.*
1.	6,500	8	110,000	60	0.48	16.6
2.	3,625	11	69,050	53	.58	18.9
3.	3,000	8	48,500	63	.50	16.0
4.	2,760	4	60,000	46	.19	21.7
5.	2,530	8	76,900	33	.26	30.3
6.	1,442	10	28,400	51	.51	19.7
7.	5,400	11	102,000	53	.58	18.8
8.	5,100	11	108,000	47	.52	21.3
Average				50.7	.45	20.4

TABLE 12.—*Value of gas used in manufacture of window glass.*

Glass factories, No.—	Gas used weekly.	Cost of gas per M cubic feet.	Boxes [a] of glass per week.	Gas per box of glass.	Cost of gas per box of glass manufactured.	Glass per M of gas.
	M cubic feet.	*Cents.*		*Cubic feet.*	*Cents.*	*Boxes.*
1.	7,700	10	3,335	2,320	23	0.43
2.	13,500	11.6	6,000	2,250	26	.45
3.	8,400	12.5	3,600	2,340	29	.43
4.	8,500	13.5	3,000	2,840	38	.35

[a] Each box contains 50 square feet of glass having an average current value of $5.

Carbon black enters into the manufacture of printer's ink, automobile tires, paint, and other commodities and at present has no substitute. It is an economic good and possesses utility. It has been

[16] Wyer, S. S., Kansas Natural Gas Co. report.

said[17] that the fast-feeding newspaper printing press of to-day has been made possible only through the use of carbon black in the making of long inks. It would be improper to claim that carbon black is less useful than zinc, glass, or brick, as each serves a definite purpose and each is essential and necessary for certain specific uses.

In engineering, relative efficiency is really a comparison to an ideal or perfect standard. A perfect steam engine would be one that converted all of the energy latent in the coal used as fuel into mechanical power. The best steam engines, however, seldom convert more than 18 per cent of this energy, and the fuel efficiency of many steam engines is often as low as 1 per cent. Internal combustion engines using gasoline as fuel utilize approximately 20 per cent[18] of the total energy, as useful work, 35.8 per cent is lost in the cooling water, and 35.6 per cent is lost in exhaust gas and direct radiation of heat. The relatively low efficiency, 2.5 percentage of recovery, of present methods of producing carbon black is due to the waste of the resulting heat. In some districts, however, as in the Kanawha Valley of West Virginia, it might be feasible to utilize this heat in the evaporation of brines that yield sodium chloride and bromine. One company is doing some experimental work on dehydrating fruits and vegetables by the waste heat; such heat might be transformed into electrical energy for areas within carrying distance of the plants or might be used to electrify short railways.

It is pertinent that thus far the production of carbon black by thermal decomposition has given a product that can be utilized only in the making of cheap paints, and has sold as low as 2 cents per pound. As made by present methods it does not possess the valuable properties of the black made by the channel system, or by other commercial carbon-black processes. Inasmuch as the market for carbon black is more or less limited, it is obvious that if any process yielding 7 or 8 pounds of black per thousand cubic feet of gas by simple thermal decomposition can be made available, the older methods of manufacture will be abandoned.

Carbon-black factories utilize gas from low-pressure wells, casing-head gas from which the gasoline content has been removed, and gas that would otherwise be wasted. Formerly in Oklahoma one gas company broke its well connections when the rock pressure of the well decreased to 150 pounds. This is an exceptionally high pressure for abandoning a gas well. It should be mentioned, however, that gas at this pressure could easily be used in making carbon black as only a fraction of a pound pressure is necessary at the plant. In several localities gas is liberated into the atmosphere after the gasoline vapor has been extracted. It would seem possible in such localities to

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[17] Personal statement of A. E. Whiting, Shreveport, La.

[18] Stratford, C. W., Veedol, 1918, p. 8.

utilize the residual gas for carbon-black manufacture with reasonable confidence of a fair profit. Formerly, in developing a new territory the search was primarily for petroleum and a strike of gas was considered next to a failure, particularly if the district were remote from industrial centers. In such districts, the selling of gas to carbon-black manufacturers is entirely justifiable and may furnish the needed capital to continue drilling. Utilizing gas from such sources is really a measure of conservation.

WHY CARBON-BLACK MANUFACTURE ATTRACTS CAPITAL.

The manufacture of carbon black from natural gas is more inviting in some localities than the use of the gas for public utility service, for the reason that low pressure gas can be utilized, extensive transmission lines are unnecessary, the load is uniform, the field is near and installation is more elastic or is capable of being moved to another locality, and the necessary investment is smaller.

By utilizing low-pressure gas, the ultimate production of wells would be greater and wells with smaller potential capacities would be used; the line leakage would be smaller and the pipes to the gathering lines would cost less than high-pressure fittings and pipe connections. The gas utility company, on the other hand, would be forced to make an additional investment to install compressors, as it would require artificial pressure to transport low-pressure gas to the consumer.

Carbon-black factories are situated in the field or near the producing leases, so that only collecting lines to the wells are used; these lines are usually very short, and no compressors or high pressures are required. In consequence the cost of pipe is much less than with gas companies. A carbon-black plant uses approximately the same quantity of gas every day in the year, and hence can use its total equipment all the time. It can be situated in isolated fields where market facilities for other purposes are not available and consequently can obtain gas at lower rates. As mentioned before, a gas plant operating as a public utility can use its total equipment only during peak-load periods and is using its total capital only a fraction of the time.

Inasmuch as pipe-line investment covers chiefly gathering lines and the factories are of standard design and easily dismantled, a carbon-black plant can be moved from place to place with much more ease and less expense than can the equipment and installations of a natural-gas utility company. Large gas companies incur much of the initial expense in laying trunk lines, and when a gas field becomes depleted the expense of transferring the equipment to another field is much greater than for carbon-black plants. The hazards due to depletion of the gas supply are consequently less than for a public utility plant.

The investment necessary for each thousand cubic feet of gas handled will be about ten times[20] larger in a public utility plant than in a carbon-black factory. Carbon-black manufacturers do not carry a large reserve acreage, and hence need less capital. The investment necessary for transporting natural gas is greater than for any other utility service, assuming that the gas is collected in the field and delivered to the domestic consumer's meter. The cost is 50 per cent [21] greater than for ordinary manufacturing plants, and 300 per cent more than for electric plants.

SUMMARY.

The utilization in the manufacture of carbon black of low-pressure gas, of gas escaping into the air from natural-gas gasoline plants, gas in distinctly isolated districts, and gas in fields that have been abandoned by other gas companies on account of low pressure, is in reality often a conservation measure. It is preferable to the practice of letting the gas go to waste in the air or to plugging improperly the wells so that the gas sands can be damaged from flooding by water.

At present there is no more efficient process of making a product that has the properties of carbon black other than those methods described in the following pages. Thermal decomposition offers an interesting field for research as a possible means of increasing the relative efficiency of the industry. In the future it is probable that at some plants the waste heat will be utilized profitably.

Sufficient incentive to enterprise must be provided; to keep the gas in the ground for an indefinite period ties up money and resources. If the gas can be utilized and made to yield good to the State and profit to the individual, the public benefits accordingly, whereas if the gas remains in the ground where it can not be used and gives no returns on the investment, the loss to the State and to the individual may be gaged by the interest lost during the period of no returns. The question always arises whether it will in the end pay to hold the gas in the ground awaiting an unknown future period of use that will give greater returns than the present methods of utilization. Local conditions are the determining factor.

Probably the most beneficial use that can be made of gas is for domestic consumption and the Bureau of Mines does not recommend that gas be used for the manufacture of carbon black where an adequate market for the gas for domestic purposes is available.

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[20] S. S. Wyer, Natural gas, its production, service, and conservation: U. S. National Museum, Bull. 102, 1918, p. 61.

[21] West, F. H., Sale of natural gas carbon-black increasing: Gas Age, Dec. 16, 1918, p. 536.

PART II. CARBON BLACK—ITS PROPERTIES AND USES.

By G. St. J. Perrott.

INTRODUCTION.

The Bureau of Mines undertook an investigation of the carbon black industry as a result of economic issues arising during the World War. In the present methods of manufacture, carbon black is made by burning natural gas with a luminous flame against a metal surface and then collecting the liberated soot. This process produces from ½ pound to 2 pounds of black per 1,000 cubic feet of gas, or 1.5 per cent to 6.5 per cent of the total carbon in the gas. As the industry consumes about 40,000,000,000 cubic feet of gas annually, it seemed during the war that this seemingly wasteful utilization should be restricted and the gas saved to other industrial plants or to domestic consumers.

Little information was available, however, as to the methods of manufacture of carbon black, as to the feasibility of improving the existing methods, of substituting other more efficient methods for producing carbon black from natural gas, or of making it from some entirely different raw material. Data were needed also in regard to the industries using carbon black—how essential carbon black was to the various consumers, and which users could employ a substitute material.

In the spring of 1919 the Bureau of Mines began an investigation of the manufacture, properties, and uses of carbon black. Plants in Louisiana, Oklahoma, and West Virginia were studied by engineers of the bureau. Other processes for making carbon black were investigated, test methods studied, and microscopic and chemical analyses of a large number of blacks were made to explain the differences in behavior of different blacks.

This paper deals with the chemistry of the present methods of making carbon black, considers the possibilities of producing it by other methods, and describes in some detail the properties and uses of the product. The first part of this publication, by R. O. Neal, describes the design of plants for the present method of manufacture and discusses the economic aspects of the industry.

ACKNOWLEDGMENTS.

The writer wishes to express his appreciation of the valuable assistance and suggestions of A. C. Fieldner, supervising chemist, under whose supervision the work was carried out, and of the assistance of J. O. Lewis, chief petroleum technologist of the Bureau of Mines, and R. O. Neal, chemical engineer in the Bureau of Mines, who made it possible for the writer to visit carbon-black plants in Oklahoma and West Virginia.

Acknowledgment is made of the helpful cooperation of the following individuals and companies:

Binney & Smith, New York City, through whose courtesy several plants of the Columbian Carbon Co. in West Virginia were inspected, and who furnished information as to the uses of carbon black and samples of various blacks.

G. L. Cabot, Boston, Mass., who freely gave much valuable information, and who furnished gratis large amounts of different grades of carbon black.

G. H. Morrill Co., Norwood, Mass., who gave information as to testing methods and uses of carbon black, and furnished samples of black and printing ink.

J. V. Bassett, Hewitt Rubber Co., Buffalo, N. Y., who furnished information in regard to the use of carbon black in rubber, and samples of rubber articles containing carbon black.

J. P. Coe, U. S. Rubber Co., New York City, who furnished statistics in regard to the use of carbon black in the rubber industry.

Norman Underwood, Bureau of Engraving and Printing, Washington, D. C., who furnished information as to the uses of carbon black in the ink trade.

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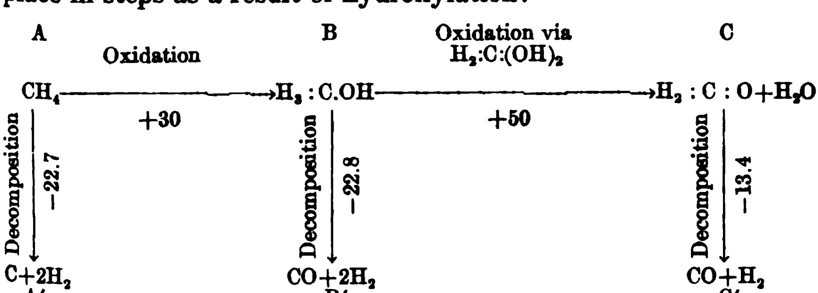
PRESENT METHODS OF MANUFACTURE.

Carbon black, as known to the American trade, is the fluffy, velvety-black pigment produced by burning natural gas with a smoky flame against a metal surface. In its physical characteristics it is entirely different from lampblack, which is made by burning oil or other carbonaceous material with insufficient air and collecting the smoke in settling chambers. Lampblack is gray in contrast to the deep black of carbon black, it often contains considerable quantities of empyreumatic matter, and a printing ink made from it has very different properties from one of similar composition made from carbon black. The process of manufacture most widely used at present is the so-called channel system, in which the black is deposited on the smooth undersurface of steel channels by lava-tip burners. The channel irons are usually built into tables of eight, sometimes 100 feet long. They are given a slow reciprocating motion that scrapes the black deposited on them into hoppers, from which it is carried by screw conveyors to the packing house, and there bolted and sacked.

The mechanism is inclosed in sheet-iron buildings in order that the amount of air may be regulated. Variation in the amount of air, in the speed of scraping, and in the pressure of the gas controls the quality of the product. The shape of the burner and the distance from the collecting surface also affect the quality of the black, but these factors are constant for any one plant. Other similar processes differ only in the nature of the collecting surface and the burners. G. L. Cabot, a pioneer in the manufacture of carbon black, has described the development of the industry.[22]

THEORY OF FORMATION OF CARBON BLACK.

When natural gas burns in an incomplete supply of air, the carbon is liberated not as a result of preferential combustion of hydrogen but as a direct decomposition of nuburned gas in the heat of the flame. According to Bone [23] and his coworkers, combustion takes place in steps as a result of hydroxylation:



[22] Cabot, G. L., Carbon black and lampblack: 8th Int. Cong. Applied Chem., vol. 12, 1912, p. 13.
[23] Bone, W. A., Gaseous combustion: Phil. Trans. Roy. Soc. London., vol. 215, 1915, pp. 275–315.

It is evident that the tendency is always to run from A to C. When the proportion of methane to oxygen is $CH_4 + O_2$ the reaction goes from A to B to C to C′. If the ratio is $2CH_4 + O_2$ or higher, only a part of the methane can be oxidized through the reaction A to C and part is decomposed at A by the heat evolved in the A to C reaction. The lowest per cent of oxygen in which a methane flame will burn is 15.6 per cent. Only in the inner part of the flame where the oxygen supply is low but where there is enough heat to break up the methane will carbon be evolved, and the percentage of carbon to be had by the incomplete combustion of methane is low; gases rich in ethane and the higher homologs give greater yields of carbon. Bone [24] in his experiments on the explosive combustion of hydrocarbons noted that the decomposition of methane was a surface effect and produced a hard gritty carbon, but the decomposition of ethane, ethylene, etc., took place throughout the whole mass of the gas and gave a soft carbon.

The function of the cold surface is to cool the liberated carbon in the flame enough to prevent its combustion. This procedure allows of a sufficiently hot flame to give carbon uncontaminated with empyreumatic matter, and produces a finely divided material which has been prevented from agglomerating by the sudden cooling. It is evident there must be an optimum temperature and an optimum position for the surface in the flame. Too cold a surface may prevent the maximum separation of carbon; too hot a surface will allow too much carbon to be burnt and may change the properties of the carbon that remains unburnt. The temperature of the channels in the present process is about 500° C.

The air supply must be regulated carefully. Admission of too much air will cause too large a percentage of the carbon to be burned in the flame and may even burn part of the carbon on the surface after it has been liberated. Insufficient air will give too cool a flame for the maximum yield of carbon and will produce a carbon contaminated with adsorbed intermediate products of combustion, as more of these intermediate products result at the lower temperature and as carbon has a greater power of adsorption at the lower temperature. The presence of these adsorbed impurities in carbon black for making ink is often desirable, the ink being of greater length than that from carbon blacks that are purer; hence manufacturers often sacrifice a high yield of black in order to obtain a product containing more volatile matter. This point is, on a later page, discussed in connection with the microscopic analysis of carbon blacks.

[24] Bone, W. A., Gaseous combustion: Phil. Trans. Roy. Soc. London, vol. 215, 1915, pp. 275–315.

OTHER METHODS OF MAKING CARBON.

Numerous methods for producing a larger yield of carbon from natural gas have been patented. In most of them the gas is broken up into carbon and hydrogen by passing through a retort filled with refractory material at a temperature of 1,200° C. or over. A much higher yield of carbon is produced in this way, sometimes as high as 40 per cent of the theoretical yield, but a salable grade has not yet been made on a large scale by this means.

PATENTS.

McTighe, United States patent 346,168, passes hydrocarbon vapor through a heated retort, decomposing the gas into flocculent carbon which is separated in depositing chambers.

Purtle and Rowland, United States patent 866,883, pass hydrocarbon gas at 10 pounds pressure into a closed retort heated to 800° C. and periodically remove the deposited carbon by means of a scraper.

Snee, United States patent 1,036,362, decomposes hydrocarbon gas in a retort heated electrically to 1,300 to 1,800° C. and deposits the liberated carbon on the bottom of the retort which is kept at a relatively lower temperature, thus preventing the coking of the carbon which occurs when the carbon deposits on surfaces heated to a high temperature.

Fernekes, United States patent 1,066,894, produces lampblack free from impurities such as naphthalene by passing methane through an alundum tube heated electrically to about 1,700° C. The gas is decomposed into carbon and hydrogen without formation of intermediate products.

Szarvasy, United States patent 1,199,220, produces retort carbon from methane by passing the gas over particles of carbon heated to glowing temperature. The necessary temperature is maintained by supplying hydrogen and air or oxygen before introducing the methane.

Brownlee and Uhlinger, United States patents 1,168,931 and 1,265,043, produce carbon black and hydrogen by passing natural gas or other hydrocarbon under pressure through a tower containing highly heated refractory material. The material is heated by surface combustion, air being intermittently added to the gas.

Bacon, Brooks, and Clark, United States patent 1,220,391, pass a hydrocarbon through a tube made up of graphite rings heated electrically to a temperature above 1,200° C. Carbon black and hydrogen are produced simultaneously and the gas pressure developed removes the carbon while still in suspension in the hydrogen.

McCourt and Ellis, United States patent 1,276,385, produce gas black and hydrogen by passing methane through a highly heated bed of granular refractory material at sufficient speed to prevent deposition of carbon on the refractory material. The treating tube filled with refractory material is surrounded by a heating tube containing refractory material that is heated by surface combustion of the hydrogen produced in the process.

Garner [25] claims to make a good grade of carbon black from natural gas, obtaining several times the yield of the present process presumably by cracking the gas in presence of a catalyst. Other proposed methods of making carbon black from natural gas are chlorination to hydrochloric acid and carbon (Mott, U. S. 1,259,121; Averill, U. S. 1,238,734), explosion at elevated temperature, and pressure with a "priming charge" of acetylene (Machtolf, U. S. 872,949), explosion with CO or CO_2 (Gollmert, German patent No. 212,202, Nov. 1, 1907), and electrical deposition of lampblack from a flame on a wire screen (Thieme, German patent No. 256,675, Jan. 11, 1912).

Several patents have been granted for making carbon black by the explosion or thermal decomposition of acetylene (Morehead, U. S., 779,728, 986,489; Pictet, British, 24,256, Oct. 19, 1910; Wegelin, German, 201,262, Jan. 9, 1907; Bosch, German, 270,199, Feb. 8, 1913), and in Europe considerable quantities of black were made from acetylene from carbide waste. This black is said to have a bluish tinge, to be very free from impurities, and to be of considerable value in making certain kinds of ink. No quantity of black made by this process has ever been on the American market.

Other patents describe the manufacture of carbon black from hull bran (Hershman, U. S., 1,188,936); from peat (Smith, U. S., 916,049); by incomplete combustion of petroleum vapor in a closed chamber (Frost and Nix, U. S., 977,000); from coal tar by treatment with alkali and naphtha (Evans, U. S., 1,175,732; French, 480,487, Aug. 9, 1916; German, 291,727, Feb. 3, 1914); from oil by decomposing a thin film on a disk by playing upon it an electric arc or gas flame (British, 124,557, Mar. 22, 1918); by reducing CO or CO_2 over finely divided carbon (Tamp, Canadian, 175,937, Mar. 27, 1917).

DISCUSSION OF POSSIBLE SUBSTITUTE METHODS.

The process of Brownlee and Uhlinger has been put into commercial operation for producing hydrogen, but thus far no market has been found for the carbon produced, which is usually gray and contains particles of grit that may be agglomerates of carbon or may be particles of the refractory material. It seems highly possible, how-

[25] Garner, J. B., The chemical possibilities of natural gas: Proc. Nat. Gas Assoc. of America, vol. 10, 1918, pp. 136–169.

ever, that carbon suitable for use in rubber might be made by this method, or better, by a modification of the method in accordance with the ideas expressed in the patents of Snee and of Bacon, Brooks, and Clark. The ink makers would be harder to satisfy.

The carbon after being formed must not be allowed to stay in the heated zone long enough to become agglomerated and changed into the gray variety of amorphous carbon. In the method of Snee a cold surface is provided for collecting the carbon immediately after liberation, while Bacon, Brooks, and Clark rely on the rapid expansion of the decomposing gases to sweep the carbon out of the hot zone.

It seems probable that a raw material of simple composition, such as natural gas or a pure organic substance, will be more susceptible of decomposition to a good grade of carbon black than a complex mixer, such as tar oil or crude petroleum. The difference between carbon black and ordinary lampblack may be due partly to the fact that lampblack is made from a complex mixture of compounds each with its own optimum temperature of decomposition. A uniform product from such a mixture is less likely to be expected than from a simpler raw material.

Explosion of hydrocarbon vapors with CO, CO_2, O_2 or their mixtures might be worthy of investigation, and there is a possibility of utilizing the gases from oil-cracking processes.

Microscopic examination of carbon black shows that the particles are smaller than 0.2 microns. It is hardly possible to hope to approach any such fineness of subdivision by grinding charcoal or other carbonaceous material. G. A. Hulett,[26] in experiments on the true density of charcoal, ground coconut charcoal in a ball mill through which a slow current, about 5 c. c. per minute, of air was passing. The fine dust carried along with the air was precipitated electrically. A sample of it showed only one-third the tinting strength of carbon black, although the true density of the ground charcoal was but 5 per cent greater.

At present most substitute processes of manufacture are impracticable for economic reasons. As carbon black in 1920 sold as low as 9 cents a pound, it is cheaper than ordinary lampblack. The author knows of no process that has produced on a commercial scale a product with properties similar to those of the carbon black now being made.

Probably the most promising line of attack in the search for a substitute process is the cracking of gas or oil in a heated retort provided with suitable means for getting the liberated carbon away from the heated zone immediately after liberation. If such a process

[26] Private communication.

were perfected to make a satisfactory carbon black, the material could be sold at a low price on account of the large yield and the value of the hydrogen produced. The hydrogen may be compressed in tanks and used for cutting flames, or for the hydrogenation of oils. This process is one of the cheapest ways of producing hydrogen for the latter purpose. It might be impracticable to make use of the hydrogen on account of difficulties in transportation, but the black could still be made at least as cheaply as at present if engineering difficulties could be overcome.

USES OF CARBON BLACK.

The uses of carbon black, in the order of their importance, are as follows: (1) Printer's ink, (2) rubber, (3) black and gray paint and enamel, (4) stove polish, (5) other products such as phonograph records, carbon paper, crayons, typewriter ribbons, black and gray paper, glazed paper, tarpaulins, black leather, bookbinders' board, marking and stenciling inks, rubber sheeting and clothing, hard rubber, artificial stone, and black tile, Chinese and india inks, insulating materials, and case hardening. The amounts used by these industries during 1918 were approximately as follows: Printer's ink, 10,000,000 to 12,000,000 pounds; rubber, 20,000,000 pounds; stove polish, 4,000,000 to 5,000,000 pounds; all other uses, 1,000,000 pounds. Besides this in normal times probably 10,000,000 pounds are exported.

DISCUSSION OF IMPORTANT USES.

PRINTER'S INK.

Lampblack has been used as a pigment for printer's ink ever since the invention of the printing press, and until 1864 it was used almost exclusively. For printing requiring an extremely fine-grained ink great trouble was taken to purify the black. After the advent of carbon black in 1864, and its diminished cost after 1880, lampblack was less and less used in printer's ink; only a little is used at present time, and that only to impart certain qualities to an ink already containing carbon black.

According to Circular No. 53 of the United States Bureau of Standards—[27]

> The history of ink making shows that the development of the industry followed the improvement of inks, to gain the desired consistency, along the following lines: (1) The ink must have a certain body; (2) it must have a certain cohesion or flow (long or short); and (3) a certain adhesion or tack. An ink varnish is "long" when a drop falls away from a spatula with a long hairy string or thread; it is "short" when the drop is cut off sharply, with a very small tail.

Carbon black is peculiarly suited to the needs of present methods of printing, the fast-running presses and half-tone illustrations.

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[27] The composition, properties, and testing of printing inks, U. S. Bureau of Standards, Circ. 53, 1915.

Certain carbon blacks give a short ink; that is, an ink of buttery consistency which does not flow rapidly. This is especially desirable in lithographic and offset work, in slow-speed presses, and for most half-tones. Lampblack does not give the right consistency and is too gray. Certain other carbon blacks are used because for fast-running presses they make a fluid long ink which has opacity enough to give a black letter. Ink manufacturers and users believe that carbon black is absolutely essential to their business.

USE OF CARBON BLACK IN RUBBER.

Prior to 1914 carbon black was used by the rubber industry in small amounts for coloring. Little distinction was made between carbon black and lampblack, the two compounds being used indiscriminately. At the present time, partly on account of the stimulus afforded by the rising price of zinc oxide, carbon black is used in large amounts as a filler for rubber, with a correspondingly decreased amount of zinc oxide. Many rubber men claim unusual properties for rubber so compounded. Carbon black is used in rubber in quantities of 3 per cent to 20 per cent by weight, and is said to increase the tensile strength greatly and to give increased toughness and resistance to abrasion. Some authorities believe that the life of the rubber and its capacity to carry loads are increased. Other rubber chemists are more conservative and do not admit that carbon black possesses any properties that make it irreplaceable.

Carbon black is much cheaper than zinc oxide. In 1919 carbon black, specific gravity 1.8, suitable for compounding in rubber, could be procured for 9 cents a pound and zinc oxide, specific gravity of 5.8, cost at least as much. On a volume basis carbon black evidently cost one-third as much as an equal volume of zinc oxide. In practice, however, a greater volume of carbon black is used than of zinc oxide, therefore the resulting mix with carbon black contains less rubber per unit volume than the corresponding zinc-oxide mix.

Theoretically carbon black should be an ideal filler for rubber, owing to its extremely fine state of division and to the correspondingly large surface energy developed by mixing intimately with the gum rubber. It also serves to protect the rubber substance from the effects of light and it may retard oxidation. Whatever the exact facts may be as to the irreplaceability of carbon black in rubber, a large amount is now consumed by the rubber companies for automobile tires and other articles, probably 20,000,000 pounds annually besides 10,000,000 pounds exported in normal times. See also page 8.

USE OF CARBON BLACK IN PAINT.

Carbon black is coming into extensive use in paints. It has a higher tinting strength than any other black; a given weight will obscure a greater area of surface. Carbon black is acknowledged superior for varnishes and enamels. It is much used in making black and gray paints for general purposes. The United States War Department requires the use of carbon black in black enamels and in various black and gray paints. Some authorities [28] consider lampblack superior to carbon black and it is probably true that in certain gray tints lampblack is superior on account of its bluish-gray tones.

OTHER USES.

Other consumers of carbon black use the material because of its low cost and high coloring power. In phonograph records it produces a smooth surface for recording, although lampblack may also be employed. Carbon black makes a carbon paper that will produce opaque letters on a great many copies.

TESTING METHODS.

The suitability of a black for a given purpose is finally determined by actually trying out its working qualities. In making rubber a sample mix is prepared and the finished piece is tested for tensile strength, percentage of elongation, toughness, and resistance to abrasion. In ink manufacture a sample batch of ink is made up and the suitability of the black determined by an actual run on the press, the working qualities of the ink and the amount used for a given number of impressions being noted.[29]

A number of laboratory tests are useful in matching a standard sample. The tests most commonly employed are for tinting strength, color, and grit. It is also desirable to determine moisture, ash, and acetone extract.

PHYSICAL TESTS.

TINTING STRENGTH.

According to the American Society for Testing Materials, tinting strength is "the power of coloring a given quantity of paint or pigment selected as a medium or standard for estimating such power." Tinting strength, then, as applied to carbon blacks is the measure of the ability of the black to impart a color to a definite weight of standard white. It depends on the size of the particles and on the specific gravity of the black. In testing, the black is always compared with a standard black.

In making the test, weigh out accurately on a sensitive balance 0.100 gram of the black to be tested and 10.0 grams of a standard

[28] Maire, Frederick, Modern pigments and their vehicles, 1908, p. 226. Toch, Maximilian, The chemistry and technology of paints, 1916, p. 366.

[29] For a detailed discussion of printing inks, *see* The chemistry and technology of printing inks, Norman Underwood and John V. Sullivan, 1915; The composition, properties, and testing of printing inks, U. S. Bureau of Standards, Circ. 53, 1915.

zinc white kept especially for the purpose. Transfer to a glass or marble slab and add from a burette exactly 3.5 c. c. refined linseed oil. Mix with a palette knife and rub out thoroughly with the palette knife, or better with a glass muller, until no streakiness or difference of color is observed when successive small portions are spread on a clean piece of window glass and viewed from the upper side. It is important that the rubbing out be thorough; 10 minutes is usually time enough for it. Follow the same procedure with the standard black. Then spread a small amount of each mix side by side on a clean glass, as a microscope object glass. Examination of the samples from the other side of the glass, particularly at the line where they overlap, will show the difference in tinting strength.

To make a quantitative estimation of the tinting strength of the sample as compared to the standard, more white is added to the stronger mix until the colors match. A new sample of the stronger black is then weighed out, using the calculated amount of zinc white, and the process is repeated until mixes of the same color are obtained. If, for example, it was necessary to mix 15 grams of zinc white with 0.1 gram of the standard to match a mixture of 10 grams zinc white and 0.1 gram of the sample, then the sample has 66⅔ per cent the strength of the standard.

COLOR.

By the term color is meant the relative blackness of the material when mixed in oil. In making the color test, take 0.3 gram of each of the blacks to be compared and add 1.3 c. c. of refined linseed oil from a burette. Mix thoroughly with the palette knife, spread side by side on a slip of glass, and compare the relative color by viewing from the upper side of the glass.

GRIT.

Presence of gritty matter is determined by rubbing a portion of the black under the finger or by placing a small amount on the tongue and rubbing it between the tongue and palate.

HIDING POWER.

In tests of paint pigments *hiding power* and *spreading rate* are often determined. Carbon blacks made by the present process as a rule vary so little among themselves in these two properties that testing by the present methods is probably of little value. A brief description of the two terms may, however, be of interest.

Hiding power is the ability of a pigment when mixed in oil to obscure a surface on which it is painted. In making the tests, equal weights of each pigment and equal quantities of oil are mixed together. The mixes are then spread on a prepared board marked off in black and white squares so that the squares are just obliterated.

The brush is weighed before and after painting. The smaller the weight used for a given area, the greater the hiding power of the paint

Dr. A. H. Pfund, of Johns Hopkins University, has designed an instrument, the cryptometer, for determining the hiding power of white pigments and paints that might be modified for use with carbon blacks. Briefly the principle of the instrument is as follows:

> Granting that an infinitely thick layer of paint will "hide" a given background completely, it is desired to find the least thickness of layer which will hide the background as effectively as does the infinitely thick layer. This purpose is accomplished by means of the cryptometer, which yields numerical values of the hiding power of the pigment in terms of the number of square centimeters which 1 gram of the pigment will cover and hide, as well as of the hiding power of a paint, expressed in square feet per gallon.[30]

SPREADING RATE.

The spreading rate of a paint is the ability of the paint to coat a surface. The American Society for Testing Materials thus illustrates the term:

> The paint when spread on a planished iron surface at the rate of 600 square feet to the gallon will not sag or run when placed in a vertical position at 70° F.

The test is performed in a manner similar to the testing of hiding power.

CHEMICAL TESTS.

It is occasionally desirable to make a few quantitative chemical tests of carbon black. A black containing more than 0.2 per cent ash is probably adulterated with mineral black or charcoal. An acetone extract over 0.1 per cent indicates adulteration with a poorly calcined lampblack. Too great a percentage of moisture is undesirable. Certain blacks will absorb as much as 15 per cent of their weight of moisture, making a total moisture content of 20 per cent or more. Most blacks for making ink contain from 2 to 4 per cent of moisture, although certain blacks may contain as high as 7 per cent.

MOISTURE.[31]

A 1-gram sample of the black is placed in a weighed porcelain crucible and heated for one hour at 105° C. in a constant temperature oven in circulating dry air. The crucible is then removed from the oven, covered, and cooled in a desiccator over sulphuric acid. The loss in weight multiplied by 100 is recorded as the percentage of moisture.

ASH.[31]

The crucible containing the residue from the moisture determination is heated gradually with a Meker burner, or better in a muffle furnace,

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[30] A. H. Pfund, personal communication.

[31] For details of method see Tech. Paper 8, Bureau of Mines, "Methods for analyzing coal and coke," by F. M. Stanton and A. C. Fieldner.

to about 750° C. or to a cherry red. Ignition is continued until all the particles of carbon have disappeared. The crucible is then cooled in a desiccator and weighed, after which it is heated again for 15 minutes, cooled, in a desiccator, and reweighed. If the change in weight is more than 0.0002 gram, the process is repeated until successive weighings are constant to this figure. The weight of the crucible and ash minus the weight of the crucible is taken as the weight of the ash.

ACETONE EXTRACT.

A 2-gram sample is weighed into an alundum or paper extraction thimble of 20 c. c. capacity and the extraction carried out for one hour, using any standard apparatus of the Soxlet type. The weight of the residue after evaporation of the acetone is taken as the acetone extract. The extract for a pure carbon black is usually zero.

Carbon blacks vary in color and tinting strength. As a rule, the less volatile matter a carbon black contains, the blacker is its color. Tinting strength of carbon blacks high in volatile matter is usually higher than that of the carbon blacks which are purer carbon. This may be due to the fact that blacks containing more volatile matter are more dispersed and hence more effectively hide the zinc-white particles.

SPECIFICATIONS.

The bureau has received a great many inquiries in regard to tests that a carbon black must meet to be suitable for use in printing ink or rubber. The following specifications represent an attempt to gather the requirements adopted by the trade. No hard and fast specifications for carbon black exist and the test on which a black stands or falls is the practical test:

PRINTING INK.

CHEMICAL TESTS.		PHYSICAL TESTS.	
Moisture	less than 5.0 per cent.	Color	must match standard.
Ash	less than 0.1 per cent.	Tinting strength	must equal standard.
Acetone extract	less than 0.1 per cent.	Grit	none.

PRACTICAL TESTS.

The black when made into ink must have satisfactory working qualities as determined by an actual run on the press for which the ink is intended. The ink must have satisfactory transfer, tack, drying properties, color, and must print a sufficient number of pages per pound. The oil must not separate from the pigment and there must be no offset or smutting.

TESTING METHODS.

Chemical and physical tests are performed as previously described. Practical tests are to be made on the press for which the ink is intended. Specifications for tests of halftone black ink, taken from the set of requirements and tests formulated by the Government Printing Office, are given below. A slightly different set of requirements must be satisfied for other kinds of ink.[32] The requirements for a satisfactory test are as follows for halftone black ink:

1. *Nonseparation of oil from pigment.*—The oil or varnish should not separate from the pigment either on the face of the type or cuts, or in the fountain, but should be short enough to break up readily in the distribution and not "string."

2. *Transfer.*—In transferring from type or cuts to paper the ink should leave the face of the type or cuts reasonably clean.

3. *Hardness.*—Ink should dry hard on the paper in eight hours to admit of easy handling without damage or injury to the work, and should not pull the coating or the face from the paper, nor the face from the roller.

4. *Drying.*—Ink should not dry on the form, rollers, or distribution so that it may not be easily removed therefrom.

5. *Offset or smutting.*—The ink must be able to carry sufficient color to print clean and sharp, without offset or smut on sheets falling on top from the press fly or in piling the work.

6. *Color.*—The ink must dry a deep, solid carbon (not aniline) black, and not turn gray nor have a metallic sheen or luster, nor blister the face of the paper.

7. *Quantity required.*—The weight of the amount used must be noted and averaged on a basis of 5,000 printed pages.

METHODS TO BE USED IN MAKING THE PRACTICAL TESTS.

1. The practical test of halftone black ink shall be made on the flat-bed presses in use in the Government Printing Office.

2. The test shall be made on coated book paper of the size, weight, and quality in general use in the Government Printing Office.

3. The type or cut forms shall be previously "made ready" and the press otherwise in good condition to make a satisfactory run.

4. The form, rollers, distribution, and ink fountain shall then be thoroughly washed and cleaned. The ink to be tested shall be weighed before being placed in the fountain. The quantity to be tested should be sufficient to run not less than three hours, and preferably a run of five hours should be made.

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[32] See Report on ink test, Form S-888, Government Printing Office, Press Division, or The composition, properties, and testing of printing inks, Bureau of Standards, Circ. 53, 1915.

5. Ink that will separate the oil or varnish from the pigment on the face of the form or in the fountain will not be accepted.

6. To be satisfactory ink under the impression should transfer from the face of the type or cuts to the paper, leaving the face of the type or cuts reasonably clean. It should be heavy in body, should feed well, and have sufficient "tack" to dry on the paper rapidly enough while printing to avoid the necessity of using slip sheets; but it should dry hard on the paper in eight hours, so that the work can be handled easily without damage or injury to the printing. It must not pull the face or coating from the paper and leave it on the face or form, or pull the face from the rollers. It should be removed easily from the form, rollers, and distribution, must be able to carry sufficient color without offset or smut, and print clean and sharp.

7. The ink to be satisfactory must dry a deep, solid carbon (not aniline) black, and not turn gray, nor have a metallic sheen or luster, nor blister the face of the paper.

After the test has been made, the remaining quantity of the ink shall be removed from the fountain and weighed, a reasonable allowance being made for the ink necessarily left in the fountain, on the rollers, and distribution, in order to determine the number of copies a given quantity of ink will print.

RUBBER.

CHEMICAL TESTS.		PHYSICAL TESTS.	
Moisture	Less than 4 per cent.[33]	Grit	None (should completely pass through a 100-mesh sieve and feel as an impalpable powder when rubbed under the finger).
Acetone extract	Less than ½ per cent.	Tinting strength	Not less than 90 per cent the strength of standard.
Ash	Less than 0.25 per cent.		

PRACTICAL TESTS.

Rubber mixes are made up containing equal weight of the sample to be tested and of the standard. Mixes are cured under exactly the same condition. The finished sheet is tested for tensile strength, per cent elongation, toughness, and resistance to abrasion.

PAINT.

CHEMICAL TESTS.		PHYSICAL TESTS.	
Moisture	Less than 5 per cent.	Tinting strength	Not less than 95 per cent the strength of standard.
Ash	Less than 1.25 per cent.		

[33] Some rubber chemists place this figure as low as 2½ per cent.

PRELIMINARY WORK ON OTHER LABORATORY TESTS.

Some attention has been given to the possibility of devising tests that will predict in a quantitative way the performance of the black when made into ink, and preliminary work has been done on the problem.

Tests that suggest themselves are: Measurements of (1) viscosity, (2) cohesion, and (3) adhesion of mixtures of black and oil. Determination of these three properties should throw light on the probable performance of the black in use.

VISCOSITY.

Attempts to measure the viscosity of mixtures of black and linseed oil in a Saybolt viscosimeter were unsatisfactory because an extremely dilute mixture was necessary. Accordingly it was decided to try out the MacMichael torsion viscosimeter,[34] which is used in the petroleum laboratory at the Pittsburgh station for determining the viscosity of heavy oils. In this instrument a brass disk connected to a graduated torsion head is suspended from a piano wire in a rotating cup containing the liquid to be tested. Deflection is proportional to viscosity at any given rate of revolution. By use of a suitable wire, liquids of very high viscosity can be tested. The apparatus is calibrated with a liquid of known viscosity. Mixtures of equal weights of various blacks with the same amount of raw linseed oil were made up and the viscosity determined by means of the MacMichael apparatus. It was found that carbon blacks prized by ink makers on account of their "length" gave a lower reading on the viscosimeter than other blacks.

At this time the author's attention was drawn to a paper by Bingham[35] on measurements of the mobility and "yield value" of paint. Bingham distinguishes between the viscosity of true liquids and the rigidity of plastic solids. Measurements of the flow through a capillary when different pressures are applied to the liquid show that the curve of pressure against the volume flowing through in unit time is different for true liquids and for plastic solids. In a true liquid the curve passes through the origin; for a plastic solid, the curve cuts the pressure axis at some distance on one side of the origin. This distance Bingham calls the yield value or force that must be applied to the plastic solid before any deformation takes place. It appeared possible to obtain similar curves using the torsion viscosimeter by measuring the deflection at different speeds of rotation, the speed of rotation corresponding to the volume flowing through the capillary, and the deflection corresponding to the

[34] MacMichael, R. F., A new direct reading viscosimeter: Jour. Ind. Eng. Chem., vol. 7, 1915, pp. 961-3. Bureau of Mines Reports of Investigation No. 2201.

[35] Bingham, E. C., and Green, Henry. Paint, a plastic material and not a viscous liquid: Preprint Am. Soc. Test. Mat., 22d Ann. Meeting, June 24 to 27, 1919.

pressure. Mixes of several blacks were made up, using 10 grams of black to 100 c. c. of raw linseed oil. These were run at different speeds in the torsion viscosimeter at a temperature of 80° F. Curves are shown in figure 17.

It will be noticed that at the higher speeds the points lie on a straight line and the extrapolation of this line back to zero revolutions per minute does not pass through zero deflection. These curves are similar to those obtained by Bingham with the capillary method. It is possible to obtain a relative figure for the rigidity or

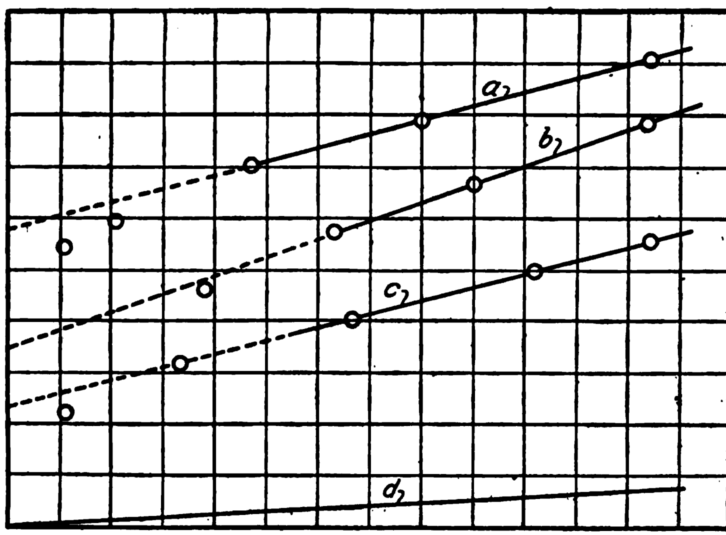


FIGURE 17.—Curve showing the viscosity of mixture of carbon black and linseed oil: *a*, Short carbon black; *b*, lampblack; *c*, long carbon black; *d*, linseed oil.

mobility and the yield value from these data. Relative rigidity is obtained from the following relationship:

$$R_{rel}=t\,(d_t-d_t\,\infty)$$

Where t is the time of one revolution in seconds, d_t the deflection, and $d_t\infty$ the deflection at zero revolutions per minute. Data and calculated relative rigidity and mobility are given in the following table:

TABLE 13.—*Viscosity of mixtures of carbon black and lampblack with linseed oil.*

SHORT CARBON BLACK.

Revolutions per minute.	Deflection.	Time of 1 revolution, seconds.	Relative rigidity.	Relative mobility.
124	90	0.48	15.4	0.0650
80	79	.75	15.7	.0637
47	70	1.28	15.4	.0650
21	59	2.86	....	....
11	54	5.45	....	....

Yield value=58.

TABLE 13.—*Viscosity of mixtures of carbon black and lampblack with linseed oil*—Con.

LAMPBLACK.

Revolutions per minute.	Deflection.	Time of 1 revolution, seconds.	Relative rigidity.	Relative mobility.
124	78	0.48	20.6	0.0486
90	66	.67	20.8	.0481
63	57	.95	20.9	.0478
38	46	1.58	17.4	.0575

Yield value=35.

LONG CARBON BLACK.

Revolutions per minute.	Deflection.	Time of 1 revolution, seconds.	Relative rigidity.	Relative mobility.
124	55	0.48	15.4	0.0650
102	49	.59	15.3	.0654
67	40	.90	15.2	.0658
33	31	1.82	14.6	.0685
11	22	5.45	....	....

Yield value=23.

RAW LINSEED OIL.

Revolutions per minute.	Deflection.	Time of 1 revolution, seconds.	Relative rigidity.	Relative mobility.
124	7	0.48	3.4	0.0194
70	4	.86	3.4	.0194

Yield value=0.

SUMMARY.

	Relative rigidity.	Relative mobility.	Yield value degrees deflection.
Short carbon black plus linseed oil	15.0	0.067	59
Long carbon black plus linseed oil	15.3	.065	23
Lampblack plus linseed oil	22.0	.046	33
Raw linseed oil alone	3.4	.019	0

DISCUSSION OF RESULTS.

It is at once seen that the difference between the long and short blacks tested is a difference principally in yield value, and that the mobilities of the two mixtures are nearly the same. This relation is also seen at once by inspection of the curves that show the same slope for the two blacks. The lampblack with a steeper slope has a lower mobility and a yield value intermediate between the long and short blacks.

The yield value is apparently the resistance, probably because of attractive forces between the particles of black, that the mixture offers to deformation when the load is applied above a certain rate. If the load is applied slowly, a different condition obtains as shown by the falling off of the curve from a straight line at the lower speeds of revolution. If the rotation of the cup is stopped while a mixture is being tested, the deflection drops back quickly to a point near the yield value and then slowly decreases nearly to zero over a period of several minutes. It is hoped to continue work with the torsion viscosimeter and to compare results as obtained with it to the results obtained by the capillary method. Results are of course empirical, but might nevertheless be of practical value.

COHESION.

Cohesion is defined as the attraction between the particles of the same substance. It is the resistance a substance offers to deformation. An ink with low cohesion is a long ink, that is, it allows itself to be changed in shape and easily drawn out into strings. One with higher cohesion offers greater resistance to deformation and breaks off when an attempt is made to draw it out into a string with the palette knife. Cohesion may be measured by determining the force necessary to draw a flat circular plate away from the surface of the liquid on which it is resting. In order to get duplicable results with a mixture such as ink, the force must be applied quickly. If the force is applied slowly, the same indefinite results are obtained as in the viscosity determinations at the lower speeds, probably owing to slippage. Results of a few measurements of this character with long and short black mixtures show long blacks to have lower cohesion.

ADHESION.

The molecular attraction between the surface of bodies in contact is called adhesion. When a liquid wets a solid the adhesion between the liquid and solid is more powerful than the cohesion of the liquid, as is shown in the method of determining the force of cohesion. When the plate is pulled from the liquid, the plate is wet with the liquid showing that the cohesion of the liquid has been overcome but its adhesion for the plate has not been overcome. The adhesion of an ink for the type and paper must influence its working qualities, and constitutes what the printer calls "tack". Adhesion of a liquid may be measured by dipping a weighed metal plate in the liquid, allowing it to drain at a constant temperature, and reweighing. For a plastic material, such as ink or paint, the value for the adhesion so obtained would probably be modified by the yield value of the mixture.

In making any tests of mixtures of carbon or lampblack in oil, care must be taken that the black is thoroughly incorporated with the oil if duplicable results are to be obtained. The mixture should be thoroughly ground in a paint mill or in a three-roller ink mill. An inert mineral oil would probably be better than linseed oil for testing purposes.

COMPLETE CHEMICAL ANALYSES OF CARBON BLACKS.

In the course of the work, complete proximate and ultimate analyses and determination of true density of a number of different carbon blacks on the market have been made. Analyses were made under the direction of W. A. Selvig, analytical chemist. The standard procedure used at the Bureau of Mines for coal analyses was followed.[36]

Analyses of lampblacks and several other blacks were made for the sake of comparison and the results are set down in the following tables:

TABLE 14.—*Analyses of carbon black.*

	Long black No. 1.	Long black No. 2.	Long black No. 3.	Short black No. 1.	Short black No. 2.	Short black No. 3.
PROXIMATE ANALYSIS.						
Moisture	3.56	7.13	5.30	2.25	3.02	3.12
Volatile matter	11.99	13.41	10.40	5.60	5.48	5.58
Fixed carbon	84.40	79.44	84.16	92.13	91.47	91.22
Ash	.05	.02	.14	.02	.03	.08
ULTIMATE ANALYSIS (AS RECEIVED).						
Hydrogen	1.19	1.82	1.11	.74	.88	1.06
Carbon	88.17	84.56	87.98	94.78	93.50	93.63
Nitrogen	.04	.04	.08	.09	.04	.05
Oxygen	10.54	14.00	10.68	4.37	5.25	5.19
Sulphur	.01	.06	.01	.00	.30	.00
Ash	.05	.02	.14	.02	.03	.08
ULTIMATE ANALYSIS (MOISTURE FREE).						
Hydrogen	.82	.57	.55	.50	.52	.72
Carbon	91.42	91.05	92.91	96.96	96.41	96.64
Nitrogen	.04	.04	.08	.09	.04	.05
Oxygen	7.66	8.26	6.30	2.43	2.69	2.51
Sulphur	.01	.06	.01	.00	.31	.00
Ash	.05	.02	.15	.02	.03	.08
True specific gravity	1.80	1.78	1.88	1.85	1.80	1.78

TABLE 15.—*Lampblacks and other blacks.*

	Lampblack.		Bone black.	Vine black.	Willow char-coal.	Wood pulp black.	Carbon from cracking of methane.	
	No. 1.	No. 2.					No. 1.	No. 2.
PROXIMATE ANALYSIS.								
Moisture	0.39	3.12	3.88	9.58	3.24	6.42	0.02	1.25
Volatile matter	2.26	17.38	10.92	29.54	14.66	9.78	.78	6.40
Fixed carbon	97.35	79.44	2.68	40.50	80.23	78.84	98.36	92.11
Ash	.00	.06	82.52	20.38	1.87	4.96	.84	.24
ULTIMATE ANALYSIS (AS RECEIVED).								
Hydrogen	.52	1.51	.88	2.44	2.74	1.60	.45	1.26
Carbon	97.62	87.84	8.64	51.65	85.04	83.20	98.70	96.76
Nitrogen	.11	.00	1.06	.80	.16	.17	.01	.01
Oxygen	1.18	9.95	6.84	24.41	10.11	9.59	....	1.61
Sulphur	.57	.64	.06	.32	.08	.48	.05	.12
Ash	.00	.06	82.52	20.38	1.87	4.96	.84	.24
ULTIMATE ANALYSIS (MOISTURE FREE).								
Hydrogen	.48	1.20	.47	1.53	2.46	.95	.45	1.13
Carbon	98.00	90.67	8.99	57.12	87.89	88.91	98.72	97.99
Nitrogen	.11	.00	1.10	.88	.17	.18	.01	.01
Oxygen	.84	7.41	3.53	17.58	7.47	4.15	....	.51
Sulphur	.57	.66	.06	.35	.08	.51	.06	.12
Ash	.00	.06	85.85	22.54	1.93	5.30	.02	.24
Acetone extract	.165	6.50	....	....	....	....	.02	.16

[36] Stanton, F. M., and Fieldner, A. C., Methods of analyzing coal and coke: Tech. Paper 8, Bureau of Mines, 1913. Fieldner, A. C., Notes on the sampling and analysis of coal: Tech. Paper 76, Bureau of Mines, 1914.

TABLE 16.—*Complete record of analyses of carbon blacks, lampblacks, and other blacks.*

Brand.	Manufacturer.	Method of manufacture.	Laboratory No.	Condition.[a]	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Ultimate: Sulphur.	Calorific value: Calories.	Calorific value: B. t. u.	Real specific gravity.
G Elf carbon black	G. L. Cabot	24-foot plates, large burners, Grantsville, W. Va.	31522	1	2.76	10.49	86.64	0.11	1.02	91.97	0.02	6.86	0.02	7,578	13,640	....
				2	......	10.79	89.10	.11	.73	94.58	.02	4.54	.02	7,793	14,027	....
P N Elf carbon black.	....do	3-foot plates, large burners, Spencer, W. Va.	32384	1	2.58	8.37	89.04	.01	1.14	92.20	.07	6.17	.41	7,592	13,666	....
				2	......	8.59	91.40	.01	.87	94.64	.07	3.99	.42	7,793	14,027	1.74
New Vulcan carbon black.	....do	3-foot plates, average size lava tips, Grantsville, W. Va.	32380	1	3.12	5.58	91.22	.08	1.05	93.63	.05	5.19	.00	7,651	13,772	....
				2	......	5.76	94.16	.08	.72	96.64	.05	2.51	.00	7,897	14,215	1.78
Monarch carbon black.	....do	Channels, medium size lava tips, Glasgow, W. Va.	32379	1	2.34	6.16	91.50	.00	.78	92.90	.08	6.22	.02	7,596	13,673	....
				2	......	6.31	93.69	.00	.53	95.13	.08	4.24	.02	7,778	14,000	1.86
Kalista carbon black	....do	Cylindrical rollers, cylindrical burners, Creston, W. Va.	32381	1	5.30	10.40	84.16	.14	1.11	87.98	.08	10.68	.01	7,106	12,791	....
				2	......	10.98	88.87	.15	.55	92.91	.08	6.30	.01	7,504	13,507	1.88
Auk carbon black	....do	Channels, medium size lava tips, Glasgow, W. Va.	32383	1	2.64	7.06	90.30	.00	.86	92.53	.06	6.55	.00	7,570	13,626	....
				2	......	7.25	92.75	.00	.59	95.04	.06	4.31	.00	7,775	13,995	1.85
Long carbon black	Binney & Smith	Probably cylindrical roller system.	32266	1	7.13	13.41	79.44	.02	1.32	84.56	.04	14.00	.06	6,817	12,271	....
				2	......	14.44	85.54	.02	.57	91.05	.04	8.26	.06	7,341	13,214	1.78
Short carbon black	....do	Probably channel or 3-foot disk.	32265	1	3.02	5.48	91.47	.03	.88	93.50	.04	5.25	.30	7,618	13,712	....
				2	......	5.65	94.32	.03	.52	96.41	.04	2.69	.31	7,855	14,139	1.80
Rubber carbon black.	....do	....do	32267	1	3.02	5.33	91.62	.03	1.02	93.82	.02	5.06	.05	7,778	14,000	....
				2	......	5.50	94.47	.03	.70	96.74	.02	2.46	.05	8,020	14,436	1.81
No. 54 carbon black	....do	Unknown	31984	1	2.48	8.07	89.43	.02	.99	92.74	.03	6.20	.02	7,660	13,788	....
				2	......	8.27	91.71	.02	.73	95.10	.03	4.10	.02	7,855	14,139	1.82
Sample from a rubber company carbon black.	....	....	31985	1	2.74	7.81	89.42	.03	.78	92.86	.03	6.29	.01	7,635	13,743	....
				2	......	8.03	91.94	.03	.49	95.48	.03	3.96	.01	7,850	14,130	....
Triangle carbon black.	Eastern Carbon Co.	3-foot disks, Shrewsbury and Barren Creek, W. Va.	32006	1	2.25	5.60	92.13	.02	.74	94.78	.09	4.37	.00	7,706	13,871	....
				2	......	5.73	94.25	.02	.50	96.96	.09	2.43	.00	7,883	14,189	1.87
Bull's-eye carbon black.	....do	Unknown	32007	1	3.56	11.99	84.40	.05	1.19	88.17	.04	10.54	.01	7,212	12,982	....
				2	......	12.43	87.52	.05	.82	91.42	.04	7.66	.01	7,478	13,460	1.80
Germantown lampblack.	Patton Co	Incomplete combustion of oil, probably "dead oil."	32547	1	.39	2.26	97.35	.00	.52	97.62	.11	1.18	.57	7,986	14,375	....
				2	......	2.27	97.73	.00	.48	98.00	.11	.84	.57	8,017	14,431	1.70
Lampblack	Binney & Smith	....do	31983	1	3.12	17.38	79.44	.06	1.51	87.84	.00	9.95	.64	7,386	13,295	....
				2	......	17.94	82.00	.06	1.20	90.67	.00	7.41	.66	7,624	13,723	....
Do	L. Martin Co	....do	32548	1	2.47	14.66	82.77	.10	1.76	88.94	.10	8.34	.76	7,484	13,471	....
				2	......	15.03	84.87	.10	1.53	91.19	.10	6.30	.78	7,673	13,811	....
Black from cracking natural gas.	....	Heated retort, Carbo-Hydrogen Co., Coraopolis, Pa.	32545	1	.02	.78	98.36	.84	.45	98.70	.01	......	.05	7,948	14,306	....
				2	......	.78	98.38	.84	.45	98.72	.01	......	.05	7,950	14,310	1.72
Do	....	By turning pure gas into a hot surface combustion furnace.	32546	1	1.25	6.40	92.11	.24	1.26	96.76	.01	1.61	.12	8,102	14,584	....
				2	......	6.48	93.28	.24	1.13	97.99	.01	.51	.12	8,205	14,769	....

[a] The form of analysis is denoted by number as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

TABLE 16.—*Complete record of analyses of carbon blacks, lampblacks, and other blacks*—Continued.

Brand.	Manufacturer.	Method of manufacture.	Laboratory No.	Condition.	Proximate.				Ultimate.					Calorific value.		Real specific gravity.
					Moisture.	Volatile matter.	Fixed carbon.	Ash.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Calories.	B. t. u.	
Bone black	Binney & Smith		31986	1	3.88	10.92	2.68	82.52	0.88	8.64	1.06	6.84	0.06	668	1,202	....
				2	......	11,36	2.79	85.85	.47	8.99	1.10	3.58	.06	695	1,251	....
				3	......	80.28	19.72	....	3.32	63.53	7.77	24.96	.42	4,912	8,842	....
Vine black	do		31987	1	9.58	29.54	40.50	20.38	2.44	51.65	.80	24.41	.32	4,079	7,342	....
				2	......	32.67	44.79	22.54	1.53	57.12	.88	17.58	.35	4,511	8,120	2.02
				3	......	42.18	57.82	....	1.98	73.74	1.14	22.69	.45	5,824	10,483	....
Willow charcoal	do		31988	1	3.24	14.66	80.23	1.87	2.74	85.04	.16	10.11	.08	7,514	13,525	....
				2	......	15.15	82.92	1.93	2.46	87.89	.17	7.47	.08	7,766	13,979	....
				3	......	15.45	84.55	....	2.51	89.62	.17	7.62	.08	7,919	14,254	....
Wood-pulp black	do		31989	1	6.42	9.78	78.84	4.96	1.60	88.20	.17	9.59	.48	6,973	12,551	....
				2	......	10.45	84.25	5.30	.95	88.91	.18	4.15	.51	7,451	13,412	....
				3	......	11.04	88.96	....	1.00	93.89	.19	4.38	.54	7,868	14,162	....

DISCUSSION OF ANALYSES.

Analyses show that carbon blacks are by no means pure carbon; some of them contain as low as 91 per cent carbon on a moisture-free basis. It will be noted that the blacks classified as long blacks are higher in volatile matter, oxygen, and moisture than the short blacks. True specific gravity varies from 1.78 to 1.88. This determination is made on the moisture-free sample. Apparent specific gravity varies from 0.15 to 0.20, depending partly on the amount of pressure put on the black in packing. If the blacks are placed in a tube and centrifuged at a high rate of speed, the apparent specific gravity is increased to 0.25.

Carbon made by cracking methane in a heated retort, if made at a very high temperature, is usually nearly pure carbon. See No. 1 in Table 15. When made at a lower temperature, considerable amounts of polymerization products, as naphthalene, may be present in the material. See No. 2 in Table 15. Unless well calcined, lampblack usually contains considerable empyreumatic matter that shows up in the analysis as a high figure for volatile matter and acetone extract. See lampblack No. 2 in Table 15; lampblack No. 1 is a calcined material. The true density of the lampblacks analyzed was about 1.70, a figure that is probably low on account of the difficulty of wetting the material with water. For an accurate determination of the true density of lampblacks, another liquid should be used, such as benzol. The apparent density of the lampblacks was about 0.09. The true specific gravity of the other blacks varies from 1.7 for wood-pulp black to 2.02 for vine black. Apparent specific gravity for wood-pulp black is 0.28 and for vine black 0.75.

ADSORBED GASES.

Carbon black contains considerable quantities of carbon monoxide, carbon dioxide, and oxygen. The oxygen is probably present as "fixed oxygen," that is, in some kind of combination with the carbon. Through the cooperation of Dr. G. A. Hulett and H. E. Cude, of Princeton University, the nature and amount of the adsorbed gases were determined. The apparatus used was that designed by Dr. Hulett to determine the nature of the adsorbed gases in gas-mask charcoal. The gases are pumped off at any desired temperature by means of a Topler pump and are analyzed, the water being caught on a bulb containing solid carbon dioxide.

The composition of the gases which can be pumped off at room temperature is practically that of air, and the volume approximately that of the voids and capillary spaces. At 445° C. a larger volume usually comes off, consisting chiefly of CO_2, CO. Carbon dioxide may be present in as large an amount as 1 per cent of the weight of the moisture and the gas-free black, oxygen about 0.01 per cent, CO, 0.1 to 0.2 per cent, methane and hydrogen, a trace, nitrogen 0.05 to 0.2 per cent. An insufficient number of samples was analyzed to allow conclusions to be drawn in regard to the relation between the adsorbed gases and the physical and chemical properties. At the temperatures investigated, none of the hydrogen indicated by the ultimate analysis was pumped off. The carbon dioxide evolved would account only for part of the oxygen shown by the ultimate analysis to be present. (See tables 17, 18, and 19.)

TABLE 17.—*Adsorbed gases in carbon black.*

[True density of blacks and volume of adsorbed gases.]

Labratory No.	Material.	Weight, gas and moisture free.	Water, per cent original material.	Density, grams, per c. c.	Volume of gas pumped off.[a]	
					Room temperature, c. c.	445° C. c. c.
32006	Short black No. 1	3.2841	3.15	1.871	15.40	23.02
32265	Short black No. 2	2.4206	3.88	1.872	15.25	9.95
32007	Long black No. 1	3.1805	6.84	1.893	13.55	25.80
32266	Long black No. 2	2.8370	9.49	1.952	16.75	19.45

[a] Corrected to 0° C. and 760 mm.

TABLE 18.—*Analysis of gas pumped off at room temperature.*

Volume.	Short black No. 1, 15.40 c. c.	Short black No. 2, 15.25 c. c.	Long black No. 1, 13.55 c. c.	Long black No. 2, 16.75 c. c.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
CO_2	0.7	1.4	1.3	0.8
O_2	20.2	19.1	18.6	22.1
CO	0	.2	.1	.2
CH_4	.2	.1	.2	.0
H_2	.0	.0	.0	.0
N_2	78.9	79.2	79.8	76.9
Total	100.0	100.0	100.0	100.0

TABLE 19.—*Analysis of gas pumped off at 445° C.*

Volume.	Short black No. 1, 23.02 c. c.	Short black No. 2, 9.96 c. c.	Long black No. 1, 25.80 c. c.	Long black No. 2, 19.45 c. c.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
CO_2	67.2	51.9	64.19	73.5
O_2	.9	2.7	.62	1.2
CO	26.2	30.0	12.22	15.9
CH_4	.0	1.2	.41	.5
H_2	.0	0.5	.07	.2
N_2	5.7	13.7	22.49	8.7
Per cent of black by weight.[a]				
CO_2	.924	.418	1.020	.990
O_2	.009	.016	.007	.010
CO	.230	.154	.124	.140
CH_4	.000	.004	.002	.002
H_2	.000	[b] .000	.000	[c] .000
N_2	.050	.070	.228	.074

[a] Gas and moisture free. [b] Probably .0002. [c] Probably .0001.

HYGROSCOPICITY.

Carbon blacks absorb moisture when exposed to damp air and too large a moisture content is detrimental to the working qualities of the black in ink. Blacks containing a high percentage of volatile matter, as long blacks, are as a rule more hygroscopic than are those containing a lesser amount of volatile matter. Inasmuch as any considerable percentage of moisure is detrimental to the working qualities of the black, it is important that original packages of carbon black be kept unbroken in a dry room until ready for use. The following table shows results of exposing weighed amounts of different blacks over water and over sulphuric acid at a temperature of about 25° C. The blacks when initially weighed were in equilibrium with a humidity of about 60 per cent at 25° C.

TABLE 20.—*Hygroscopicity of carbon black.*

	Per cent loss in weight over H_2SO_4.		Per cent gain in weight over H_2O.		Moisture at 105° C.
	24 hours.	72 hours.	24 hours.	72 hours.	
Long black No. 1	3.9	4.2	4.9	10.3	3.6
Long black No. 2	6.2	6.9	7.0	14.1	7.1
Short black No. 1	2.4	2.6	3.1	6.7	2.3
Short black No. 2	2.2	2.5	3.6	7.7	3.0

MICROSCOPIC EXAMINATION.

The photomicrographs of carbon black were taken by Dr. Reinhardt Thiessen, of the Pittsburgh station, and the following discussion of the bearing of the photomicrographs on the properties exhibited by carbon black in ink was written in collaboration with Dr. Thiessen.

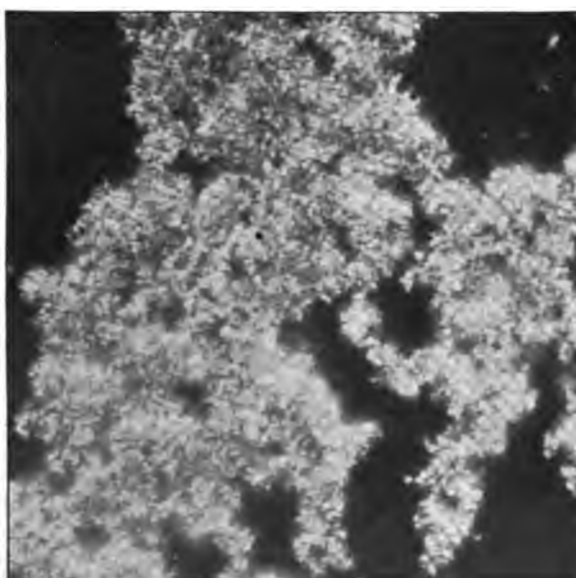
According to the ink manufacturers, various grades of carbon black show very different properties when made into ink. Underwood [37] says:

> There is a wide range in the behavior of different carbon blacks, a wider range than there is any apparent cause for. They vary from making short tacky inks to making inks of great natural length and decided flow, while some carbon blacks which we have had experience with were absolutely useless for making any kind of ink, even news ink.

The terms "length" and "shortness" are explained by Underwood as follows:

> If a pigment when mixed with a large quantity of oil still remains stiff or can not be drawn out into a string between the fingers but breaks, it is said to be short. While there are some classes of work that require ink of a certain degree of shortness, as a general rule pigments that show this quality are not suited for making inks.

[37] Underwood, Norman, and Sullivan, J. V., The chemistry and technology of printing inks, 1915.



SHORT BLACK TWO HOURS AFTER PREPARATION ON SLIDE. MAGNIFIED 2,000 DIAMETERS.

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[37] Underwood, Norman, and Sullivan, J. V., The chemistry and technology of printing inks, 1915.

An ink that flows well must also have the property of being drawn out into a string between the fingers, and this is called length. Thus each of these terms suggests or includes the other; they are both sometimes spoken of under the name viscosity.

Apparently a pigment that gives a long ink is one that affects the original properties of the vehicle to a less extent than does an equal weight of a short pigment. To a large extent this question is probably one of fineness of subdivision, although the tendency of the particles of the pigment to form agglomerates may also affect it.

The particles are extremely small, below the resolving power of the microscope. Indications are that the average size of the particles of carbon black is about 100 millimicrons. Microscopic examination indicates that the particles of long blacks are slightly larger than those of short blacks, although the apparent difference in size may be due to the effect of diverse surface conditions on the diffraction of light. Exact measurements of the size of the particles have not been made; they would involve the counting of the number of particles in a small volume containing a known weight of black of known density, the measurement of the deflection in an electric field, and other measurements.

Dark ground illumination with the ultracondenser has proved to be the most satisfactory method of examination for most purposes. Examination by transmitted light in the ordinary manner does not distinguish between single particles and small agglomerates of particles; it is of advantage in showing up large agglomerates or particles of grit, and serves to show the relative opacity of the blacks. In general the higher the percentage of carbon in a black the blacker it looks under the microscope. Well-calcined lampblacks are more opaque than carbon black or than lampblacks containing much volatile matter.

Under the microscope freshly prepared mixtures of thin lithographic varnish with short and with long carbon black at first appear precisely similar. They consist of ultraparticles, or of agglomerates of two or three particles. After a few minutes, however, a decided difference is apparent. The short black has begun to agglomerate into groups of 20 or 30 particles, and in an hour over a hundred may be grouped together. These agglomerates are held loosely together and may be dispersed by pressing down on the cover glass, but they come together again in a few minutes.

The long black on the contrary remains completely dispersed after several hours. Plate XI, *A*, shows a short black 18 minutes after preparation on the slide, Plate XI, *B*, shows the same black after 2 hours. Plate XII is the same as Plate XI, *B*, but magnified 2,000 diameters. *A* and *B*, Plate XIII, show a long black after several hours, magnifications 500 and 2,000, respectively. The concentra-

HYGROSCOPICITY.

Carbon blacks absorb moisture when exposed to damp air and too large a moisture content is detrimental to the working qualities of the black in ink. Blacks containing a high percentage of volatile matter, as long blacks, are as a rule more hygroscopic than are those containing a lesser amount of volatile matter. Inasmuch as any considerable percentage of moisure is detrimental to the working qualities of the black, it is important that original packages of carbon black be kept unbroken in a dry room until ready for use. The following table shows results of exposing weighed amounts of different blacks over water and over sulphuric acid at a temperature of about 25° C. The blacks when initially weighed were in equilibrium with a humidity of about 60 per cent at 25° C.

TABLE 20.—*Hygroscopicity of carbon black.*

	Per cent loss in weight over H_2SO_4.		Per cent gain in weight over H_2O.		Moisture at 105° C.
	24 hours.	72 hours.	24 hours.	72 hours.	
Long black No. 1	3.9	4.2	4.9	10.3	3.6
Long black No. 2	6.2	6.9	7.0	14.1	7.1
Short black No. 1	2.4	2.6	3.1	6.7	2.3
Short black No. 2	2.2	2.5	3.6	7.7	3.0

MICROSCOPIC EXAMINATION.

The photomicrographs of carbon black were taken by Dr. Reinhardt Thiessen, of the Pittsburgh station, and the following discussion of the bearing of the photomicrographs on the properties exhibited by carbon black in ink was written in collaboration with Dr. Thiessen.

According to the ink manufacturers, various grades of carbon black show very different properties when made into ink. Underwood [87] says:

> There is a wide range in the behavior of different carbon blacks, a wider range than there is any apparent cause for. They vary from making short tacky inks to making inks of great natural length and decided flow, while some carbon blacks which we have had experience with were absolutely useless for making any kind of ink, even news ink.

The terms "length" and "shortness" are explained by Underwood as follows:

> If a pigment when mixed with a large quantity of oil still remains stiff or can not be drawn out into a string between the fingers but breaks, it is said to be short. While there are some classes of work that require ink of a certain degree of shortness, as a general rule pigments that show this quality are not suited for making inks.

[87] Underwood, Norman, and Sullivan, J. V., The chemistry and technology of printing inks, 1915.

An ink that flows well must also have the property of being drawn out into a string between the fingers, and this is called length. Thus each of these terms suggests or includes the other; they are both sometimes spoken of under the name viscosity.

Apparently a pigment that gives a long ink is one that affects the original properties of the vehicle to a less extent than does an equal weight of a short pigment. To a large extent this question is probably one of fineness of subdivision, although the tendency of the particles of the pigment to form agglomerates may also affect it.

The particles are extremely small, below the resolving power of the microscope. Indications are that the average size of the particles of carbon black is about 100 millimicrons. Microscopic examination indicates that the particles of long blacks are slightly larger than those of short blacks, although the apparent difference in size may be due to the effect of diverse surface conditions on the diffraction of light. Exact measurements of the size of the particles have not been made; they would involve the counting of the number of particles in a small volume containing a known weight of black of known density, the measurement of the deflection in an electric field, and other measurements.

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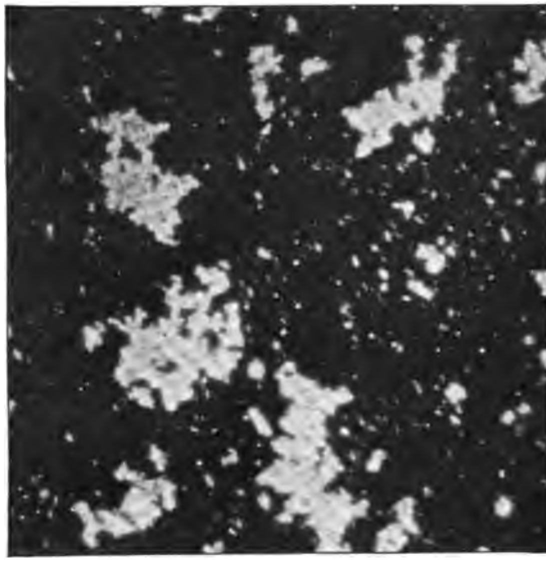
Long blacks are usually made with cylindrical burners and a cool flame, a method that tends to produce a black high in volatile matter. It seems probable that these absorbed impurities prevent the carbon particles from agglomerating. In support of this conclusion, it has been found that if a long black be treated with steam at 500° C. so that the occluded matter is burned off, the black forms a distinctly thicker mixture in oil and is seen to be agglomerated under the microscope. Conversely, if a definite quantity of a short black is treated with a dilute alcoholic solution of tannin and mixed with oil after the alcohol has evaporated, it makes a much more fluid mixture than an equal amount of untreated black.

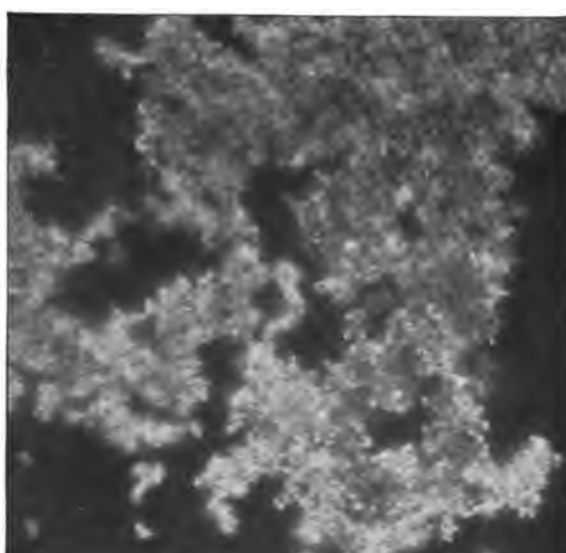
The tendency to agglomerate is modified materially by the character of the vehicle in which the blacks are suspended. In a thick viscous varnish no agglomeration is noticeable after several hours. Small amounts of metal soaps in a thin varnish tend to cause agglomeration even in the long blacks. Lampblack shows the tendency to agglomerate fully as much as do short carbon blacks, yet lampblacks as a rule make long inks. It is evident, therefore, that the tendency to agglomerate does not entirely explain the difference in the behavior of different blacks; surface forces between the vehicle and the particles of black probably play a part, and of course the size of the particles must be of importance. Measurement should be made of the size of particles of various carbon blacks and lampblacks.

Under the microscope lampblack and the different grades of carbon black look much alike. Lampblack is sometimes a little blacker, more opaque than the carbon black, probably according to the amount of carbon in the particle. Some blacks have a larger percentage of coarse material than others, but the divergence in properties is probably due to a difference in the constitution of the ultra particles, possibly a difference in size, in attraction between the particles, and in surface energy at the oil-black interface. In carbon blacks the difference in surface condition is apparently due to the presence of adsorbed gases and combined oxygen. In lampblacks a similar condition obtains. Calcining a lampblack at too high a temperature and removing too much of the empyreumatic matter and adsorbed gases produces a black that makes a short ink. Plate XIV, *A* and *B*, shows lampblack at 500 and 2,000 diameters, respectively.

Blacks which give long ink then probably consist of slightly larger particles than those which make a shorter ink, hence exposing less surface per unit weight and requiring less oil to form a mixture of a given consistency. Furthermore, difference in surface conditions,



A. LAMPBLACK, MAGNIFIED 500 DIAMETERS.



B. LAMPBLACK, MAGNIFIED 2,000 DIAMETERS.

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Long blacks are usually made with cylindrical burners and a cool flame, a method that tends to produce a black high in volatile matter. It seems probable that these absorbed impurities prevent the carbon particles from agglomerating. In support of this conclusion, it has been found that if a long black be treated with steam at 500° C. so that the occluded matter is burned off, the black forms a distinctly thicker mixture in oil and is seen to be agglomerated under the microscope. Conversely, if a definite quantity of a short black is treated with a dilute alcoholic solution of tannin and mixed with oil after the alcohol has evaporated, it makes a much more fluid mixture than an equal amount of untreated black.

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Blacks which give long ink then probably consist of slightly larger particles than those which make a shorter ink, hence exposing less surface per unit weight and requiring less oil to form a mixture of a given consistency. Furthermore, difference in surface conditions, due to the fact that long blacks contain a high percentage of adsorbed gases, probably influences the properties of the mixture of the black with oil. Microscopic examination of dilute mixtures of black and oil shows one effect of this difference in surface conditions, in the tendency of the blacks containing little adsorbed impurities to agglomerate, while the blacks containing large amounts of volatile matter remain dispersed.

This discussion of the properties of mixtures of carbon black and oil has been speculative and little experimental evidence has been presented; but it is hoped that the discussion will stimulate interest in the problem and further investigations.

SUMMARY.

It has been pointed out in this paper that the present process of making carbon black recovers only a small percentage of the carbon in the gas, yet no other process in practical operation produces a material with properties similar to carbon black. Inability to secure carbon black would deal a serious blow to the printing industry, and would probably inconvenience rubber manufacturers and others. On account of the diminishing supply of natural gas, developmental work should be conducted on more efficient methods of manufacture and production from other materials. The problem is not an easy one, and developmental work should probably not endeavor to improve the present process but should investigate entirely new methods, as for example, the decomposing of gas or of other hydrocarbons in the absence of air. The uses of carbon black have also been discussed, testing methods have been explained, and a brief account has been given of preliminary work on microscopic and chemical differentiation of blacks giving "long" and "short" inks.

SELECTED BIBLIOGRAPHY.

This bibliography was compiled in March, 1919. Additional references were later secured from a bibliography on lampblack by the Carnegie Library of Pittsburgh.

In abridgments of specifications of English patents in the English patent office for the periods 1855–66, 1867–76, 1877–83, 1884–88, 1889–92, 1893–96, 1897–1900, 1901–04, 1905–08, lampblack is covered by class 90.

1844—1874.

Bottenberg, J. H. Apparatus for the manufacture of lampblack. U. S. patent 153234, July 21, 1874. Has a revolving, water-cooled cylinder with burners on interior.

Clark, Edward. Improvement in the manufacture of lampblack and colophane. U. S. patent 6001, Jan. 2, 1849. Manufactures lampblack and colophane by heating resin.

Child, R. S. Utilization of coal tar. U. S. patent 32753, July 9, 1861.

Farrar, Alonzo. Apparatus for the manufacture of carbon black. U. S. patent 154467, August 25, 1874. Has a rotary water vessel with a stationary scraper.

HOWARTH, JOHN. Manufacture of carbon black from natural carburetted hydrogen gas (natural gas). U. S. patent 131446, Sept. 17, 1872. Reissue 6937, Feb. 22, 1876. A pan of water is placed upon a soapstone slab to reduce the temperature of the carbon black that is deposited.

LUNDGREN, J. E. Mode of pulverizing and preparing for use, coal, etc. U. S. patent 42257, April 5, 1864. Production of a substitute for lampblack by pulverizing carbonaceous material by means of a ball mill.

MATLACK, MAHLON. Improved apparatus for the manufacture of lampblack. U. S. patent 75943, Mar. 24, 1868.

MILLOCHAU, ADOLPH. Manufacture of lampblack. U. S. patent 72068, Dec. 10, 1867. Condenses carbonaceous vapors upon a surface that is directly over a flame and is kept cool by artificial means.

——— Manufacture of lampblack. U. S. patent 84131, Nov. 17, 1868. Lampblack is placed in a vessel containing oil to be burnt, and a wick is not used as it often becomes gummed from collection of tar.

MINI, J. G. Improvement in making lampblack. U. S. patent 3824, Nov. 13, 1844.

PERLEE, R. N. Manufacture of lampblack. U. S. patent 72078, Dec. 10, 1867. Introduces a current of air from pump to burner in which oil is burned.

PRENATT, AUGUSTUS. Improvement in the manufacture of lampblack. U. S. patent 50493, Oct. 17, 1865.

ROGERS, JOHN. Improvement in apparatus for making lampblack. U. S. patent 146951, Jan. 27, 1874.

ROTH, J. A. Making lampblack. U. S. patent 17519, June 9, 1857.

TAIT, A. H. Manufacture of carbon black for pigment. U. S. patent 148778, Mar. 17, 1874. Carbonization of sugar, starch, etc.

1875—1884.

BLOOD, E. R. Machine for making carbon or gas black. U. S. patent 269378, Dec. 19, 1882. A scraper curved to conform more or less to a peripheral section of the cylinders and attached by its middle to a crosshead adapted to be moved back and forth between the cylinders.

See also Hallock, J. K.

CORNELL, J. M. Improvement in lampblack apparatus. U. S. patent 210672, Dec. 10, 1878.

DINGLER'S POLYTECHNISCHES JOURNAL. Ueber die Gewinnung von Lampenschwarz aus natürlichen Kohlenwasserstoffen. Bd. 231, 1878, pp. 177-178.

DYSART, J. T. Apparatus for manufacturing carbon black. U. S. patent 266953, Oct. 31, 1882. Uses a depositing surface that consists of a metallic surface faced with asbestos.

FALCONER, WILLIAM. Machine for the manufacture of carbon black. U. S. patent 277472, May 15, 1883. Consists of stationary burners, rotating horizontal table perforated for ventilation, stationary sectional scraper, receptacle for receiving black, and conveyor for removing carbon black from receptacle.

FALES, L. S., and NEFF, PETER. Manufacture of lampblack. U. S. patent 160759, March 16, 1875. Made from acid sludge by treating first with steam to remove acid and subsequently burning recovered oils by the use of wicks.

GENTELE, J. G. Lehrbrech der Farbenfabrikation. 1880. 661 pp.

HALLOCK, J. K. Machines for making lampblack. U. S. patent 195709, Oct. 2, 1877. A circular depositing plate and revolving burners are inclosed in a hood for regulating the supply of air to burners.

HALLOCK, J. K., and BLOOD, E. R. Machines for making lampblack. U. S. patent 205955, July 16, 1878. A revolving cylinder arranged above burners so that the flame will impinge upon the exterior surface of the cylinder and deposit carbon.

HEUMANN, R. Presence of carbon particles in the flame. Ann. Chem., vol. 181, 1876, p. 129; vol. 182, 1876, p. 1; vol. 183, 1876, p. 102; vol. 184, 1876, p. 206.

HOWARTH, JOHN. Apparatus for the manufacture of lampblack. U. S. patent 161039, March 23, 1875. Uses soapstone tile as deposition surface for carbon, movable burners, and moving scrapers.

MALLET, J. W. Lampblack from natural gas, 1880. United States Centennial Commission, International exhibition 1876. Reports and awards group, vol. 4, p. 111.

NEFF, PETER, and FALES, L. S. Improvement in apparatus for the manufacture of carbon or lampblack. U. S. patent 159440, Feb. 2, 1875.

———. Manufacture of lampblack. U. S. patent 160786, Mar. 16, 1875. The combined burning of carbonaceous gases and crude petroleum or dead oils.

———. Improvement in gas burners for the manufacture of lampblack. U. S. patents 160787 and 160789, Mar. 16, 1875.

———. Manufacture of lampblack. U. S. patent 160788, Mar. 16, 1875. The carbon black burners are placed in cells, the bells or domes of which are enveloped with a wire gauze.

———. Improvement in apparatus for manufacture of lampblack. U. S. patents 162492 and 162679, Apr. 27, 1875; 163027, May 11, 1875; 166936, Aug. 24, 1875.

———. Lampblack apparatus. U. S. patent 162679, April 27, 1875. Relates to the installation of funnel-shaped hoods above burners that are connected to a bag house to catch flocculent carbon black that is carried away by fumes.

———. Lampblack apparatus. U. S. patent 166936, Aug. 24, 1875. Apparatus having a convex depositing surface, with burners located beneath which are adjustable in order to facilitate the removal of black.

———. Apparatus for making lampblack. U. S. patent 163027, May 11, 1875. The use of condensing domes located over carbon black burners whereby the surface is always maintained cool.

———. Apparatus for manufacture of lampblack. U. S. patent 162492, April 27, 1875. Consists of a suitable burning chamber that is connected to a water tank containing two or more flues.

———. Gas burners for the manufacture of lampblack. U. S. patent 160787, March 16, 1875. Describes an improvement in a gas burner used in making carbon black.

———. Gas burners for the manufacture of lampblack. U. S. patent 160789, March 16, 1875. Relates to burner employed in the manufacture of carbon black.

——— Manufacture of lampblack. U. S. patent 172046, Jan. 11, 1876. Description of a new design of gas burner used in making carbon black.

——— Scrapers for lampblack apparatus. U. S. patent 176476, Apr. 25, 1876. A number of stiff inflexible metallic scrapers attached at one extremity to a rigid body.

——— Scrapers for lampblack apparatus. U. S. patent 176477, Apr. 25, 1876. Describes a vertical spring-pressed metallic scraper having flanged working extremities and loosely hinged to opposite sides of the cross bar.

——— Improvement in the manufacture of lampblack, No. 172046, Jan. 11, 1876; improvement in scrapers for lampblack apparatus, U. S. patents 176476, Apr. 25, 1876; 176477, Apr. 25, 1876; 176478, Apr. 25, 1876.

——— Scrapers for lampblack apparatus. U. S. patent 176478, Apr. 25, 1876. Overlapping metallic scrapers, flexible and elastic in themselves, and curved upward from a rigid bearing.

——— Machinery for making lampblack. U. S. patent 197395, Nov. 20, 1877. The depositing surface is attached to a car or vehicle whereby it may be moved relative to burners.

——— Apparatus for the manufacture of lampblack. U. S. patent 221417, Nov. 11, 1879. A compartment provided with adjustable openings in floor to regulate the passage of air.

See also Fales, L. S.

NEFF, PETER, and FALES, L. S. Apparatus for the manufacture of carbon or lampblack. U. S. patent 159440, Feb. 2, 1875. A series of rooms communicating by openings alternately near top and bottom. Each room has a suspended hinged apron for intercepting and collecting the soot.

PLUMBLY, F. K. Apparatus for the manufacture of lampblack. U. S. patent 301518, July 8, 1884. Gas is burned under revolving pans containing water. Each pan is arranged with a separate hood to which is connected an exhaust fan.

ROGERS, JOHN. Improvement in processes and apparatus for making lampblack, U. S. patent 186498, Jan. 23, 1877.

SANTOS, J. R. Analysis of lampblack made from the natural hydrocarbon gas of the Ohio petroleum region. Chem. News, vol. 38, 1878, pp. 94–95.

SEYMOUR, M. J. Process of and apparatus for manufacturing lampblack. U. S. patent 278749, June 5, 1883. Consists in forcing the smoke from burning hydrocarbons through a suitable liquid or a moist vapor and then evaporating the liquid or condensing the vapor to recover the finely divided carbon.

SHOEMAKER, G. G. Apparatus for the manufacture of carbon black. U. S. patent 292696, Jan. 29, 1884. Lampblack is deposited on interior surface of a conical steel apparatus which is water cooled. The lampblack is automatically scraped from the cone.

WINSLOW, H. B. Improvement in apparatus for the manufacture of lampblack, U. S. patent 222337, Dec. 2, 1879.

1885–1894.

ANDES, L. E. Die Fabrikation der Stiefelwichse und der leder Conservirungsmittel. 1893. 366 pp.

BINNEY, EDWIN. Apparatus for the manufacture of carbon black. U. S. patent 453140, May 26, 1891. Consists of a furnace, cylindrical chamber, and conveyor for removing the carbon black located at bottom of chamber.

BLOOD, E. R. Lampblack machine. U. S. patent 480990, Aug. 16, 1892. Has circular plates as the depositing surface with an opening between edges and gas burners below opening.

BLOOD, A. R., BLOOD. B. H., and BLOOD, E. R. Apparatus for manufacture of lampblack. U. S. patent 387487, Aug. 7. 1888. Consists of a number of horizontal rotating deposit rings, with an annular row of gas burners, arranged centrally under the deposit ring, and scrapers operating to remove the black automatically from the ring.

BLOOD, E. R., and WENSTRAU, S. P. Lampblack machine. U. S. patent 403174, May 14, 1889. A deposition plate for carbon black having a vent directly over flame for the escape of the products of combustion, with a secondary plate supported over the vent.

—— Process of making lampblack. U. S. patent 478268, July 5, 1892. A perforated plate for catching carbon black is used.

CABOT, G. L. Apparatus for the manufacture of lampblack. U. S. patent 468510, Feb. 9, 1892. Apparatus provided with rotating burners, fixed collecting plate, and radial trough traveling under the plate and surrounding the scrapers for removing the accumulated black.

—— Manufacture of lampblack. U. S. patent 491923, Feb. 14, 1893. Gas is enriched with oil and the mixture superheated before being burned under plates for collecting the carbon.

CABOT, SAMUEL, jr. Apparatus for the manufacture of lampblack. U. S. patent 388475, Aug. 28, 1888. A revolving multiburner lamp is provided with an external ring of angle iron braced to a central standard, with burner tubes supported thereto, and an endless driving chain resting in the angle of the external ring and encircling the pulley of a suitable motor.

DIETRICH, TOBIAS. Lampblack machine. U. S. patent 431881, July 8, 1890. A machine for preparing carbon black is in an inclosed chamber in which an endless metallic belt is arranged as the depositing surface.

DREYER, ROBERT. Apparatus for the manufacture of lampblack. U. S. patent 444315, Jan. 6, 1891. Manufactures carbon black with the simultaneous generation of steam.

DYSART, J. T. Apparatus for manufacturing carbon black. U. S. patent 343446, June 8, 1886. Introduces gas into a carbonaceous liquid through a series of small openings, then conducts gas to burners, and carbon black is deposited on condensing surfaces.

ESTER, G. L. Lampblack machine. U. S. patent 507220, Oct. 24, 1893. A machine having two accumulator wheels arranged in a common horizontal plane, and each having toothed edges. Wheels are moved by a worm gear that simultaneously intermeshes with toothed peripheries of both wheels.

ESTER, H. J. C. Lampblack machine. U. S. patent 486097, Nov. 15, 1892. The carbon is deposited upon the inside and outside of the rim of a revolving wheel.

IRVINE, ROBERT. Condensation of carbon particles in smoke. Jour. Soc. Chem. Ind., vol. 9, 1890, pp. 1110–1112.

JAMES, J. E. Lampblack or carbon-black machine. U. S. patent 521797, June 26, 1894. Apparatus with a collecting plate having an air vent opening and a damper for governing opening that is automatically controlled by the scraper.

KOHLER, HIPPOLYT. Die Fabrikation des Russes und der Schwarze, 1889. 105 pp.

LANGVILLE, L. S. Carbon product. U. S. patent 475062, May 17, 1892.

MCNUTT, L. J. Hydrocarbon-gas-black machine. U. S. patent 481240, Aug. 23, 1892. The carbon is deposited upon moving channel irons, which are automatically scraped.

MCTIGHE, J. J. Apparatus for manufacturing lampblack. U. S. patent 346168, July 27, 1886. Comprises a depositing chamber, with means of cooling same in combination with a retort wherein hydrocarbon vapors may be decomposed.

——— Manufacturing carbon black. U. S. patent 346169, July 27, 1886. Producing carbon black from gas by the action of intense heat without combustion of gas.

NEFF, PETER. Apparatus for manufacturing lampblack. U. S. patent 314706, Mar. 31, 1885. Stationary burners are used and a horizontally rotating table, the under surface of which is concave.

——— Apparatus for manufacturing lampblack. U. S. patent 314707, Mar. 31, 1885. Gas is burned under a horizontal rotating turntable mounted on flanged wheels that travel on a circular track.

——— Apparatus for manufacturing lampblack. U. S. patent 319604, June 9, 1885. The apparatus is provided with a horizontally rotating surface constructed to form an inverted chamber for the reception of carbon dioxide.

——— Apparatus for the manufacture of lampblack. U. S. patent 319605, June 9, 1885. The machine is equipped with a revolving black collector mounted on a hollow shaft, which is provided below collector with lateral openings and is used as a ventilating chimney.

——— Apparatus for the manufacture of lampblack. U. S. patent 319606, June 9, 1885. Relates to a machine in which a collector is mounted on a hollow standard that revolves around an upright stationary column.

OPPLER, T. Die Unfallverhutungs-Austellung in Berlin in ihrer Bedeutung für die chemische Industrie: Chem. Ind., vol. 12, 1889, p. 532; (Lampblack manufacture)—abstract—Jour. Soc. Chem. Ind., vol. 9, 1890, p. 272.

REEDON, P. F. Hydrocarbon-gas-black machine. U. S. patent 523945, July 31, 1894. The machine has deposit rings having a semicircular underface, and an annular groove around the periphery of the top. The rings have ratchet teeth in the bottom of the groove.

RHODES, S. L. Lampblack machine. U. S. patent 497686, May 16, 1893. The machine has a concave depositing surface and a reciprocating carriage supported in proper relation to surface and to burners mounted on carriage.

SALBERG, SWAIN. Apparatus for making lampblack. U. S. patent 486127, Nov. 15, 1892. The depositing surface is V-shaped for collecting the carbon.

SCHERMERHORN, D. M., SCHERMERHORN, P. V., and SCHERMERHORN, S. P. Apparatus for the manufacture of gas black. U. S. patent 489332, Jan. 3, 1893. Carbon black is deposited upon a T-shaped beam. The scraper box moves along this depositing surface, but both beams and burners are stationary.

SMITHELLS, ARTHUR. Note on the structure of luminous flames. Jour. Chem. Soc., vol. 61, 1892, pp. 217–226.

SMITHELLS, ARTHUR, and INGLE, HARRY. The structure and chemistry of flame. Jour. Chem. Soc., vol. 61, 1892, pp. 204–216.

WAGNER, RUDOLPH VON. Manual of chemical technology, 1892, 968 pp.

WILSON, JOHN. Apparatus for manufacturing lampblack. U. S. patent 346973, Aug. 10, 1886.

1895–1904.

BERSCH, JOSEF. The manufacture of mineral and lake pigments. 476 pp., 1901.

CABOT, SAMUEL. Process of recovering flocculent carbon. U. S. patent 581391, Apr. 27, 1897. Consists in treating the carbonaceous residues from the manufacture of prussiates with an aqueous solution of a mineral acid.

FRANK, ADOLPH. Process of making carbon pigment. U. S. patent 682249, Sept. 10, 1901. Consists in reacting on a carbide of a metal with an oxide of carbon.

HOUZE, LUC, and DHÉ, CHARLES. An apparatus for making lampblack. U. S. patent 668045, Feb. 12, 1901. An apparatus with a combustion chamber, a collecting plate in the chamber being provided with a damper for controlling the air.

HUBON, E. Le noir d'acetylene et ses derives, 1900. Mém. Soc. Ing. Civ. France, 1900, pt. 1, p. 680.

HUBOU, L. J. E. Process of making lampblack. U. S. patent 671672, Apr. 9, 1901. Consists in exploding acetylene under pressure out of contact with air by means of an electrical, chemical, or calorific source of energy.

—— Process of making lampblack. U. S. patent 673185, Apr. 30, 1901.

JAUBERT, G. F. Acetylene and the manufacture of mineral black. Scientific Am. Supp., vol. 48, 1899, p. 19905.

MANN, J. H. Apparatus for making carbon black. U. S. patent 706430, Aug. 5, 1902. The apparatus has a horizontally disposed shaft and carbon-collecting wheels that have wedge-shaped peripheries.

—— Machine for making lampblack. U. S. patent 754471, Mar. 15, 1904. The apparatus has a reversible plate on a pivotal support. Both sides of the plate form depositing surfaces.

MANN, J. L. Lampblack machine. U. S. patent 654171, July 24, 1900. The apparatus has as the depositing surface a corrugated roller that is exposed to a flame, and has means for scraping rollers.

—— Lampblack apparatus. U. S. patent 706429, Aug. 5, 1902. The machine is made up of a horizontal series of members mounted to rotate in individual parallel vertical planes, that are separated by vertical interspaces, each member being arranged with its peripheral edge over the flame.

OGILEZ, D. J. Process of producing lampblack. U. S. patent 706001, July 29, 1902.

PARRY, E. J., and COSTE, J. H. The chemistry of pigments, 280 pp., 1902.

PORSCH, F. W. Apparatus for the manufacture of carbon black. U. S. patent 726341, Apr. 28, 1903. A machine provided with a depositing-plate comprising two rings, each having beveled faces and the outerlying ring elevated above the inner ring.

REARDON, P. F. Apparatus for making lampblack. U. S. patent 663395, Dec. 4, 1900. A machine having horizontal revolving deposit plates arranged in two rows provided with burners and scrapers. A hopper extending the entire length of the rows carries away accumulated carbon.

SANDERS, J. F. Apparatus for making lampblack, U. S. patent 660973, Oct. 30, 1900. Production of lampblack. Sci. Am. Supp., vol. 48, 1899, p. 19800.

THALWITZER, R. Manufacture of soot by combustion of a mixture of gases with hydrocarbon vapors. British patent 22567, Nov. 11, 1899.

WEGELIN, GOTTFRIED. Apparatus for manufacturing lampblack, U. S. patent 664916, Jan. 1, 1901. Apparatus for making lampblack, U. S. patent 688215, Dec. 3, 1901.

——— Process of making lampblack. U. S. patent 673185, Apr. 30, 1901. Consists in compressing a column of flame to a smaller cross section, by means of an annular radial current of air applied against the flame.

——— Process of making lampblack. U. S. patent 680093, Aug. 6, 1901. A process of manufacturing lampblack and controlling the specific gravity of the product which consists in controllably abstracting heat from the flame of combustion by passing the flame through a restricted cooling flue that is cooled externally at determined points varying with the quality of product desired.

WILLIAMS, J. J. Automatic lampblack machine. U. S. patent 601389, Mar. 29, 1898. A machine having a frame, a series of depositing plates, each provided with a cooling chamber on its upper surface, a series of collectors movably mounted under plates, and a conveyor for removing accumulated carbon.

1905–1914.

ACHESON, E. G. Method of treating amorphous bodies and product thereof. U. S. patent 1082386, Dec. 23, 1913.

AMERICAN GASLIGHT JOURNAL. Lampblack—a composite paper by several members. Vol. 87, 1907, p. 620.

ANDES, L. E. Treatment of paper for special purposes, 1907.

ARSEM, W. C. Transformation of other form of carbon into graphite. Trans. Am. Electro-chem. Soc. vol. 20, 1911, p. 105. Chem. Eng. vol. 14, 1911, p. 400. Jour. Ind. Eng. Chem. vol. 3, 1911, p. 799.

BONE, W. A. Gaseous combustion. Chem. News, vol. 97, 1908, pp. 196–8, 212–5; vol. 102, 1910, pp. 271–73, 284–6, 297–8, 309–11, 323–5; vol. 112, 1915, pp. 211–7, 223–5. Trans. Royal Soc. London, vol. 215, 1915, pp. 273–318. Jour. Chem. Soc. vol. 87, 1905, p. 910, 1236, vol. 89, 1906, p. 652, 660, 939, 1614.

BOSCH, K. Manufacture of lampblack from hydrocarbons or their mixtures by decomposition, German patent 268291, July 14, 1911. Method of obtaining soot from hydrocarbons such as acetylene, German patent 270199, Feb. 8, 1913.

BUTLER, D. B. Lampblack production and uses. Min. and Eng. World, vol. 35, 1911, pp. 864–865.

CABOT, G. L. Lampblack and carbon black. Eighth Internat. Cong. of App. Chem., vol. 12, p. 13–31, 1912. On the preparation of carbon blacks from natural gas in America. Jour. Soc. Chem. Ind., vol. 13, 1894, pp. 128–130.

DAVEY, C. W. B. et al. Treatment of brine at low temperatures and manufacture of lampblack. British patent 5685, Mar. 13, 1908.

DAVIS, W. H. Lampblack machine. U. S. patent 859750, July 9, 1907. A machine having a cylinder as the depositing surface. Air is forced through the cylinder and discharged into a combustion chamber.

DIFFENBACH, O., and MOLDENHAUER, W. Improving lampblack by means of oxidizing agents. German patent 263292, Feb. 18, 1912.

DOYLE, H. L. Collodial suspension of graphite. Jour. Phys. Chem., vol. 17, 1913, p. 390.

FARADAY SOCIETY. Colloids and their viscosity. A general discussion, including papers by Wolfgang Ostwald, Victor Henri, Wolfgang Paule, H. Freundlich, and Emil Hatschek. Transactions, vol. 9, 1913, p. 34–107.

FERNEKES, GUSTAVE. Method of producing carbon or lampblack. U. S. patent 1066894, July 8, 1913. Consists in subjecting methane to a temperature of not less than 1,300° C.

FRANK, ADOLF. Gewinnung von Russ und Graphit aus Acetylen und Metallcarbiden. Chem. Ztg., vol. 29, pt. 2, 1905, p. 1044. Abstract translation, Jour. Soc. Chem. Ind., vol. 24, pt. 2, 1905, p. 1117.

FROST, W. H., and JOSHUA J. NIX. Process for the production of carbon black together with combustible gas, U. S. patent 977000, Nov. 29, 1910.

GOLLMERT, MAX. Process of manufacturing finely divided or amorphous carbon from mixtures of hydrocarbons and CO or CO_2. German patent 212202, Nov. 1, 1907.

HERMAN, E. Breaking down light hydrocarbons with exclusion of air. German patent 290883, Oct. 23, 1914.

HURST, G. H. Painters' colors, oils, and varnishes. 1913. 519 pp.

JOURNAL OF GAS LIGHTING. Influence of surface decomposition of hydrocarbons. Vol. 106, 1909, pp. 300.

——— Methane equilibrium. Vol. 117, 1912, p. 21.

KOPPERS. Process of separating carbon from hydrocarbons by passing through heated retorts. French patent 356,351, July 24, 1905.

LAMPBLACK, LTD. Lampblack from incomplete combustion of oil. British patent 17223, July 14, 1912.

MACHTOLF, JOSEF. Apparatus for manufacturing soot from hydrocarbons by rupture with electric sparks. British patent 14601. 1906.

——— Process for the production of amorphous carbon. U. S. patent 872949, Dec. 3, 1907. Heating an explosive mixture of hydrocarbon gases to their ignition temperature.

——— Apparatus for producing carbon. U. S. patent 872950, Dec. 3, 1907. Igniting an explosive mixture of hydrocarbons. A conduit connects the decomposition chamber with the collecting compartment.

——— Apparatus for making lampblack from hydrocarbons by rupture with electric sparks. German patent 194301. 1908. Apparatus for making amorphous carbon by decomposition of hydrocarbons. German patent 207520. 1909. Process of making lampblack with very valuable properties. German patent 194939. 1908.

——— Carbon and hydrogen by explosion of hydrocarbons. British patent 13685, 1909.

MAIRE, FREDERICK. Modern pigments and their vehicles. 266 pp. 1908.

MAISER, Franz. Apparatus for making oil-fuel lampblack. German patent 203711. 1909.

——— Lampblack. German patent 288990, Mar. 10, 1914.

MANN, J. L. Apparatus for making lampblack. U. S. patent 865603, Sept. 10, 1907. A machine with a carbon collecting member having a continuous surface, the different portions of which are exposed successively to a flame and provided with flanges forming a flame guard.

MAYER, M., and ALTMAYER, V. Synthesis of methane with calcium hydride. Ber. Deut. chem. Gesell., Jahrg. 41, 1908, pp. 3074–3080.

MOREHEAD, J. M. Process of making lampblack from acetylene. U. S. patent 779728, Jan. 10, 1905. Consists in exploding mixture of acetylene and oxygen that has been compressed.

——— Process of dissociating acetylene. U. S. patent 986489, Mar. 14, 1911.

OGILVY, D. J. Process of producing black or dark carbonaceous pigments. U. S. patent 785696, Mar. 21, 1905. Impinging carbonaceous flames produced by a moving source on the surface of water in a stationary condition.

——— Process of producing carbonaceous pigments. U. S. patent 813911, Feb. 27, 1906. Impinging carbonaceous flames, produced by a moving source on water in a state of motion.

PLAUSEN, H. Pure finely divided carbon from coal or wood charcoal. British patents 17729, 17731, 17732, 1913.

PICTET, R. P. Preparation of hydrogen and lampblack from acetylene. German patent 255733, Oct. 22, 1909.

——— Continuous production of hydrogen and carbon from acetylene. British patent 24256, Oct. 19, 1910.

PURTLE, A. D., and ROWLAND, I. E. Process of making carbon black. U. S. patent 866883, Sept. 24, 1907. Subjects gas under pressure in closed retort heated to 800° C. until the gas is decomposed and carbon is deposited in a flocculent condition on the interior walls of the retort.

——— Apparatus for producing carbon black. U. S. patent 877596, Jan. 28, 1908. For the thermal decomposition of gas in which the hydrogen is utilized in heating the decomposition chamber.

REDWOOD, BOVERTON. Petroleum, 1906. Discusses lampblack, p. 698.

RÜTGERSWERKE, AKT-GESELL. Process of manufacturing lampblack from mineral coal tar. German patent 208600, May 24, 1908.

SADTLER, S. P. Industrial organic chemistry, 601 pp., 1912. Discusses lampblack, p. 31.

SALBERG, SWAIN. Apparatus for making lampblack. U. S. patent 801743, Oct. 10, 1905. A series of annular pans, each with a ring of gear teeth around its upper end; the teeth of one pan matching with teeth of another so that when the driving mechanism is connected to one pan it will be transmitted throughout the series.

SHARTS, T. P. Apparatus for producing carbon. U. S. patent 819606, May 1, 1906.

SIEMENS & Co. Production of lampblack. German patent 295517, 1914.

——— Société Anon. des combustibles industriels. Pure carbon from hydrocarbons such as coal tar, tar oil, etc. German patent 291727, Feb. 3, 1914.

SMITH, J. E. Process for obtaining carbon black from peat. U. S. patent 916049, Mar. 23, 1909.

SNEE, J. A. Method of producing carbon black. U. S. patent 1036362, Aug. 20, 1912. Consists in passing a stream of hydrocarbon gas horizontally through a highly heated flame-excluded zone with a lower temperature at the bottom than at the upper part.

STEWART, G. W. Resistance temperature coefficient and the coefficient of expansion of lampblack. Phys. Rev., vol. 26, 1908, p. 333.

STUTLER, B. B. The largest lampblack factory, Oil and Gas Jour., vol. 10, pt. 1, 1911, p. 2.

SWEENY, J. M. Machine for making carbon black. U. S. patent 836948, Nov. 27, 1906. Has a horizontal plate upon which gas flames are directed at an acute angle.

THIEME, BRUNO. Electric production of lampblack. Ztschr. Elektrochem., vol. 18, 1912, p. 131.

——— Electrical deposition of lampblack from flame on a wire screen. German patent 256675. Jan. 11, 1912.

THOMPSON, G. W. Coating-power and hiding-power of paints, Proc. Eighth Int. Cong. Appl. Chem., vol. 25, 1912, p. 795.

—— Scientific preparation and application of paint. Jour. Ind. Eng. Chem., vol. 2, 1910, p. 87.

THORPE, EDWARD. A dictionary of applied chemistry, ed, 1912–13. Lampblack, vol. 1, pp. 664–665.

WEGELIN, GOTTFRIED. Apparatus for making lampblack. U. S. patent 807646, Dec. 19, 1905. The oil is agitated by a mechanical stirrer and air current in the combustion chamber.

—— Utilizing power from explosion of acetylene (in manufacture of lampblack). German patent 201262, Jan. 9, 1907.

—— Apparatus for making lampblack. U. S. patent 897439, Sept. 1, 1908.

ZERR, GEORGE, and RUBENCAMP, R. Treatise on color manufacture, 605 pp. Griffin, 1908. Discusses lampblacks (soot pigments), pp. 415–425.

1915—1919.

ACHESON, E. G. Method of deflocculating solid materials. U. S. patent 1223350, Apr. 24, 1917.

ANDES, L. E. Oil colors and printers' inks. 1918. 212 pp.

AVERILL, C. C. Lampblack and hydrochloric acid, U. S. patent 1238734, Sept. 4, 1917.

BACON, R. F., BROOKS, B. T., and CLARK, HUGH. Manufacture of carbon black and hydrogen. U. S. patent 1220391, Mar. 27, 1917. A method of making lampblack and hydrogen by injecting a jet of liquid hydrocarbons into a zone heated to a temperature sufficient to flash hydrocarbons into their elements.

BONE, W. A. *See* under 1905–1914.

BROWNLEE, R. H., and UHLINGER, R. H. Process for the manufacture of hydrogen and carbon black. U. S. patent 1168931, Jan. 18, 1918. Methane is decomposed by bringing it into contact with a highly refractory material in vacuum at pressure. Carbon black is then separated from hydrogen.

BLARDONE, G. G., NICHOLS, C. W., and BRUQUIERE, FAURIE. Substitute for lampblack, U. S. patent 1156742, Oct. 12, 1915.

BRIGGS, T. R. The tinting strength of pigments. Jour. Phys. Chem., vol. 22, 1918, p. 216.

BROWNLEE, R. H., and UHLINGER, R. H. Apparatus for manufacture of hydrogen and carbon black. U. S. patent 1265043, May 7, 1918. Apparatus for decomposing methane by bringing it into contact with a highly heated refractory material in the absence of air.

CABOT, G. L. Apparatus for making carbon black. U. S. patent 1162131, Nov. 30, 1915. A machine having laterally spaced, parallel, depositing-cylinders.

DAVIS, W. H. Lampblack machine. U. S. patent 1160862, Nov. 16, 1915. A flat perforated plate above ordinary rings collects the carbon black usually lost in flue gases.

DOWLING, D. B. Utilizing natural gas. Bull. Canadian Mining Inst., June 1918, pp. 525–528. Describes gasoline absorption plant and carbon black plant in Wyoming.

ENGINEERING. X-Rays and the structure of amorphous carbon. Vol. 104, 1917, pp. 594–596.

EVANS, A. C., WICK HAMPTON, and MITCHELL, P. J. Method of manufacturing finely divided carbon and by-products from coal pitch, U. S. patent 1175732, Mar. 14, 1916.

FISHER, H. A. Warns against crowding carbon-black industry, Nat. Pet. News, vol. 10, 1918, p. 64.

GARNER, J. B. The chemical possibilities of natural gas, Proc. Nat. Gas. Assoc. of America, vol. 10, 1918, p. 136–169, Nat. Gas and Gasoline Jour., vol. 12, 1918, pp. 319–330; Gas Age, vol. 41, 1918, pp. 555–560; Am. Gas. Eng. Jour., vol. 108, 1918, pp. 489–495, 505–508; Chem. Eng., vol. 26, 1918, pp. 245–254.

GEER, W. C. Compounding rubber with lampblack, U. S. patent 1245700, Nov. 6, 1917.

GERARD, J. M. Process for the manufacture of carbon black and lampblack. U. S. patent 1278137, Sept. 10, 1918.

HAMILTON, W. R. Trap for saving gas at oil wells. Tech. Paper 209, Bureau of Mines, 1919, p. 21.

HERSHMAN, P. R. Comminuted carbon and process of making same, U. S. patent 1188936, Jan. 27, 1916.

HIRT, L. E. Manufacture of carbon or lampblack. U. S. patent 1264796, Apr. 30, 1918. Making carbon black by enriching burning gas with oil vapors.

HUTCHINS, T. W. S. Manufacture of lampblack. U. S. patent 1309070, July 8, 1919. Making lampblack from tar or oil.

LEWIS, G. C. Method of treating finely subdivided material. U. S. patent 1263082, Apr. 16, 1918.

MALISOFF, W., and EGLOFF, G. Methane. A very complete review of the literature. Jour. Phys. Chem., vol. 22, 1918, pp. 529–575.

MCCOURT, C. O., and ELLIS, C. Gas black and hydrogen from methane. U. S. patent 1276385, Aug. 20, 1918.

MITCHELL, C. A., and HEPWORTH, T. C. Inks, their composition and manufacture, 1916. 266 pp.

MOTT, W. R. Process of manufacturing lampblack. U. S. patent 1259121, Mar. 12, 1918. Process of producing carbon black by heating a mixture of methane gas and carbon tetrachloride.

——— Process of purifying lampblack and making carbon articles. U. S. patent 1303362, May 13, 1919. Lampblack is heated in the presence of carbon tetrachloride.

NATIONAL PETROLEUM NEWS. Carbon-black plants follow discovery of gas in Morehouse Parish, La. June 11, 1919. p. 1/m.

OGILVY, D. J. Carbon pigment base and process of making same, U. S. patent 1268142, June 4, 1918.

OIL AND GAS JOURNAL. Carbon-black industry is opposed by Smith, vol. 16, 1918, p. 32.

——— Gas wasted in production of carbon black, vol. 17, 1918, p. 48.

PIKE, R. D. Lampblack refuse purification. Canadian patent 181082, Dec. 18, 1917.

——— Carbon and method of manufacturing same. U. S. patent 1262251, Apr. 9, 1918. Method of purifying lampblack refuse by washing, roasting, and pulverizing.

——— Carbon and method of recovering same from the waste product of oil cracking. U. S. patent 1285363, Nov. 19, 1918. Recovering lampblack from refuse product of oil-gas manufacture by washing, roasting, and pulverizing.

SCHWEIZER, V. The distillation of resins and the preparation of resin products, resinates, lampblack, printing inks, etc., 1917. 212 pp.

SLATER, W. E. Influence of different surfaces on the decomposition of methane. Jour. Chem. Soc., vol. 109, 1916, pp. 160–164.

SNELLING. W. O. Lampblack. U. S. patent 1213915, Jan. 30, 1917. Apparatus for making carbon black by projecting a flame upon a depositing surface that is maintained at a temperature slightly above 100° C.

SZARVASY, E. Retort carbon by dissociation of methane. U. S. patent 1199220, Sept. 26, 1916.

TARUP, P. Process for production of finely divided carbon. Canadian patent 175937, Mar. 27, 1917.

TARCYZYNSKI, S. Collodial carbon and dissociation of organic liquids by the electric arc. Ztschr. Elektrochem., vol. 22, 1916, pp. 252–254; Jour. Soc. Chem. Ind., vol. 35, 1916, p. 889.

THIEME, B. Modern production of lampblack. Ztschr. Elektrochem., vol. 20, 1914, pp. 61–63.

THORP, F. H. Outlines of industrial chemistry, 1917, 665 pp.

TOCH. M. The chemistry and technology of paints, 1916. 366 pp. Discusses lampblack, pp. 98–99; carbon black, p. 100.

UNDERWOOD, N., and SULLIVAN, J. V. The chemistry and technology of printing inks, 1915.

UNITED STATES BUREAU OF STANDARDS. Composition, properties, and testing of printing inks. Circular 53. 1915.

WARTENBURG, VON. The methane equilibrium, Ber. Deut. chem. Gesell., vol. 40, 1907, p. 2134.

WEST, F. H. Sale of natural-gas carbon black increasing. Gas Age, vol. 42, 1918, pp. 535–536.

WYER, S. S. Natural-gas: Its production, service, and conservation. Smithsonian Institution, U. S. Nat. Mus. Bull. 102, part 7, 1918, pp. 59–62.

ZIMMERS, D. F., JESSOP, E. N., KOENIG, W. J., and GARNER, J. B. Process of manufacturing carbon black. U. S. patent 1307430, June 24, 1919. The black is made from natural gas.

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Bulletin 193

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ALBERT B. FALL, SECRETARY

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H. FOSTER BAIN, DIRECTOR

ANALYSES OF MINE AND CAR SAMPLES OF COAL COLLECTED IN THE FISCAL YEARS 1916 TO 1919

BY

ARNO C. FIELDNER, WALTER A. SELVIG
and J. W. PAUL

WASHINGTON
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ANALYSES OF MINE AND CAR SAMPLES OF COAL COLLECTED IN THE FISCAL YEARS 1916 TO 1919.

By ARNO C. FIELDNER, WALTER A. SELVIG, and J. W. PAUL.

SAMPLING AND ANALYTICAL METHODS.

By ARNO C. FIELDNER.

INTRODUCTION.

Many mine samples of coal are analyzed each year in the laboratories of the Bureau of Mines. The analyses are made in connection with investigations relating to fuels belonging to or for the use of the United States Government, the causes of accidents in coal mines, the geologic relations of coal beds, and the quality and the value of the coal and lignite in the public lands. The systematic collection and analysis of such samples in connection with fuel investigations was begun in 1904 at the Government fuel-testing plant at the Louisiana Purchase Exposition, and was under the direction of the United States Geological Survey for six years. Descriptions of the coal samples collected between the beginning of this work, July 1, 1904, and the transfer of the fuel-testing and mine-accident investigations to the Bureau of Mines, July 1, 1910, were compiled and published in Bureau of Mines Bulletin 22.[1] Descriptions and analyses of samples collected during the fiscal years 1911 to 1913 were published in Bureau of Mines Bulletin 85.[2] Descriptions and analyses of samples collected during the fiscal years 1913 to 1916 were published in Bureau of Mines Bulletin 123.[3]

The present bulletin presents analyses and descriptions of samples collected during the fiscal years 1916 to 1919. In order that the material in this bulletin may be used to supplement that presented in Bulletins 22, 85, and 123, the same plan of geographical classi-

[1] Lord, N. W., and others, Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910: Bull. 22, Bureau of Mines, 1912, 1,200 pp. (In two parts.)

[2] Fieldner, A. C., and others, Analyses of mine and car samples of coal collected in the fiscal years 1911 to 1913: Bull. 85, Bureau of Mines, 1914, 444 pp.

[3] Fieldner, A. C., and others, Analyses of mine and car samples of coal collected in the fiscal years 1913 to 1916: Bull. 123. Bureau of Mines, 1918, 478 pp.

fication has been followed, the analyses and descriptions of the samples being grouped in alphabetical order according to the State, county, and town near which the mines or prospects sampled are situated.

ACKNOWLEDGMENTS.

Special acknowledgment is due to G. O. Smith, Director of the United States Geological Survey, and to M. R. Campbell, geologist in charge of the economic geology of fuels, for furnishing field descriptions of those samples collected by the geologists of the Survey.

A number of the mine samples from Maryland were collected under the direction of E. B. Mathews, director of the Maryland Geological Survey.

A number of the mine samples from Illinois were collected under the direction of F. W. De Wolf, director of the Illinois Geological Survey.

The collection of samples by the fuel-inspection section of the Bureau of Mines was under the direction of G. S. Pope, engineer. Samples designated by the letter W preceding the laboratory number were analyzed in the Washington laboratory of the bureau under the direction of J. D. Davis, chemist, and H. M. Cooper, chemist.

The collection of mine samples and the gathering of mine data by the field engineers of the Bureau of Mines were under the direction of G. S. Rice, chief mining engineer of the bureau, who also reviewed the description of the method of field sampling. The descriptions of the mines and the sections of the coal beds were compiled by J. W. Paul, chief coal-mining engineer of the bureau, assisted by Hattie R. Sondheim, clerk, and Samuel Sanford, engineer. The chemical analyses were made under the direction of A. C. Fieldner, chemist, and W. A. Selvig, assistant chemist, who were assisted by F. D. Osgood, assistant chemist; V. C. Allison, L. E. Ashim, C. L. Boyle, O. C. Brown, W. R. Collette, C. W. Davis, H. A. Depew, L. R. Eckman, I. S. Guest, S. A. Harris, H. H. Hill, Wm. Hoffman, B. B. Kaplan, C. R. Locke, G. H. Mengel, G. E. Postma, J. I. Prest, C. S. Purcell, W. C. Ratliff, and B. B. Wescott, junior chemists; W. E. Surbled, laboratory assistant; and A. D. Bauer, Morris Block, W. E. Demby, M. D. Gladstein, J. B. McGrael, J. Schlesinger, and P. D. Watson, laboratory helpers. The assistant and junior chemists and laboratory helpers were analyzing coal samples for varying lengths of time, ranging from one month to three years. The computing of the analyses at the Pittsburgh laboratory was under the direction of R. A. Wood, assistant engineer.

COLLECTION OF SAMPLES.

Samples designated by the letter A in the table of analyses were collected by representatives of the Bureau of Mines, in connection with the investigation of fuels belonging to or for the use of the Government, and with investigations of accidents in coal mines.

The samples designated by the letter B in the table of analyses were collected by the United States Geological Survey in connection with the study of the geologic relations of the coal beds and the classification of public lands. Under this designation are also included a number of samples collected by the State geological surveys of Illinois and Maryland.

METHOD OF MINE SAMPLING FOLLOWED BY BUREAU OF MINES.

The method of collecting mine samples by the Bureau of Mines involves selecting a representative face of the bed to be sampled; cleaning the face; making a cut across it from roof to floor, and rejecting or including impurities in this cut according to a definite plan as they are included or excluded in mining operations; reducing this gross sample, by crushing and quartering, to about 3 pounds; and immediately sealing the 3-pound sample in an air-tight container for shipment to the laboratory.[4]

COLLECTION OF CAR SAMPLES.

The carload lots of coal shipped to Pittsburgh for test were sampled by taking definite quantities of coal at regular intervals from a car as it was unloaded, and by reducing to convenient size (about 50 pounds) the gross sample thus obtained. The method of collecting and reducing car samples is given in detail in Bureau of Mines Bulletin 116.[5]

METHOD OF SAMPLING FOLLOWED BY THE UNITED STATES GEOLOGICAL SURVEY.

In collecting mine samples the Geological Survey followed essentially the same method of sampling as that used by the Bureau of Mines. However, in sampling outcrops and prospect holes or country banks when mining is not in progress, the geologist can not imitate the miner in rejecting or including impurities in the sample, and hence the sample from the cut across the bed includes all partings or bindings less than three-eighths of an inch thick and every concretion or "sulphur ball" having a maximum diameter of less than 2 inches and a thickness of less than one-half inch. All other impurities in the bed are excluded from the sample. Obviously an

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[4] Holmes, J. A., The sampling of coal in the mine: Tech. Paper 1, Bureau of Mines, 1911, 18 pp.

[5] Pope, G. S., Methods of sampling delivered coal, and specifications for purchase of coal for the Government: Bull. 116, Bureau of Mines, 1916, 64 pp.

arbitrary and uniform system of rejecting impurities is necessary for sampling outcrops, prospects, and undeveloped mines.

RELATION OF MINE SAMPLES TO COMMERCIAL SHIPMENTS.

In comparing analyses of mine samples and those of coal shipped from a mine due allowance must be made for the larger proportion of impurities that may be included in the commercial operation of the mine. It is difficult in taking a mine sample to reject impurities exactly as the miner rejects them. The practice of different miners varies, especially if rigid inspection at the tipple is not enforced. In some mines, for instance, where the coal bed has friable partings or has a soft, flaky roof or floor, the inclusion of some foreign matter is unavoidable. Hence the analysis of the mine sample usually indicates a better grade of coal as regards ash content and heating value than the actual commercial shipments, and for this reason the mine sample should be considered as representing the coal that can be produced only under the most favorable conditions of mining and preparation.

In commercial shipments that are sampled at their destination, the moisture content may be either more or less than that in the mine samples, the relative proportions depending on the amount of bed moisture, the size of the coal, and the weather conditions during transit.

Coals containing 5 per cent or more of moisture tend to lose moisture while in transit, provided no rain or snow falls. Slack coal usually contains more moisture than the mine sample. Low-moisture coals shipped in open cars may gain or lose moisture, according to the weather conditions.[6]

The calorific value, referred to moisture-free and ash-free coal, of samples taken from shipments at destination, tends to be slightly lower than that of the fresh mine samples from the same mine. The deterioration is caused mainly by absorption of oxygen from the air by the freshly exposed surfaces of coal. The rate of deterioration varies with the different types of coal and depends on a number of factors, chief of which are: (1) Size of coal, (2) proportion of surface exposed to circulating air, (3) duration of exposure, (4) temperature and humidity.

It is therefore difficult to assign any definite values for deterioration of coal while in transit.[7] A number of mine and car samples tested

[6] For a comparison of the moisture, ash, and sulphur contents of mine and car samples tested at the United States fuel-testing plant, St. Louis, Mo., see Burrows, J. S., The importance of uniform and systematic coal-mine sampling: U. S. Geol. Survey Bull. 316, 1907, pp. 490–560. For a discussion of moisture in coal deliveries, see Pope, G. S., Sampling coal deliveries: Bull. 63, Bureau of Mines, 1913, p. 12.

[7] For data on deterioration of coal, see Porter, H. C., and Ovitz, F. K., Deterioration and spontaneous combustion of coal in storage, a preliminary report: Tech. Paper 16, Bureau of Mines, 1912, 14 pp.; Porter, H. C., and Ovitz, F. K., Deterioration in the heating value of coal during storage, Bull. 136, Bureau of Mines, 1917, 36 pp.; Parr, S. W., and Wheeler, W. F., The weathering of coal: University of Illinois Eng. Exp. Station Bull. 38, 1909.

by the United States Geological Survey and the Bureau of Mines showed the following average losses:

Average loss in moisture-free and ash-free calorific value of car sample as compared with that of mine sample.

Kind of coal.	Per cent.
Semibituminous, New River, and Pocahontas	0.1
Bituminous, Appalachian field	.3
Bituminous, Illinois, Indiana, and Missouri	.8
Subbituminous and lignite	1.3

ANALYTICAL METHODS.

The methods of analysis and the details of apparatus used by the Bureau of Mines in analyzing coal are fully described in Technical Paper 8[8] of the Bureau of Mines. They are briefly summarized here, and certain changes in minor details, which are fully discussed in Technical Paper 76,[9] are described.

PREPARATION OF LABORATORY SAMPLES.

Immediately after the sealed 3-pound can in which the sample is received at the laboratory has been opened, the contents are transferred to a weighed sheet-metal pan, spread out to a depth of 1 inch, and at once weighed. The pan containing the sample is placed in a large drying oven in which a temperature of 30° to 35° C. is maintained. Through this oven a current of warm air is made to flow by means of an ordinary desk fan mounted on top of the oven, and the sample is dried until the loss in weight between two successive weighings, made 6 to 12 hours apart, does not exceed 0.5 per cent. The total loss of weight is reported as "air-drying loss."

Immediately after the last weighing has been made the entire sample is quickly pulverized to 10-mesh size by being passed through a roll crusher. After having been mixed, the 10-mesh material is reduced with a riffle sampler to 500 grams. This 500-gram part is at once transferred to the porcelain jar of an Abbé ball mill, which is sealed air-tight and rotated at the rate of 60 revolutions per minute until the coal is pulverized to 60-mesh size.

This 60-mesh coal is emptied on a one-half-inch screen, which is vigorously shaken to detach the coal from the pebbles. The sample (approximately 500 grams) is then reduced to the final laboratory sample of approximately 60 grams by successive halvings with a small riffle sampler. The final sample is put through the 60-mesh sieve, and at once transferred to a 4-ounce wide-mouthed bottle, which is securely closed with a well-fitting rubber stopper. Any

[8] Stanton, F. M., and Fieldner, A. C., Methods of analyzing coal and coke: Tech. Paper 8, Bureau of Mines, 1913, 42 pp.

[9] Fieldner, A. C., Notes on the sampling and analyses of coal: Tech. Paper 76, Bureau of Mines, 1914, pp. 14-58.

particles of coarse material remaining on the sieve are carefully rubbed down to 60-mesh size on a bucking board and are thoroughly mixed with the sample in the bottle.

This air-dried sample is used in all analytical determinations.

DETERMINATION OF MOISTURE.

The residual moisture in the air-dried sample is determined by heating 1 gram in a shallow porcelain capsule, seven-eighths of an inch deep and 1¾ inches in diameter, for one hour at 105° C. in a constant-temperature oven through which a current of dry preheated air is rapidly passing. The air is dried by being passed through concentrated sulphuric acid. The covered capsule is cooled in a desiccator over sulphuric acid and then weighed. The loss in weight is called "moisture at 105°" in the air-dried coal.

ASH DETERMINATION.

The same sample is used for determining ash as was previously used for determining moisture. A porcelain capsule containing the sample is placed in a cool muffle and the temperature is gradually raised to approximately 750° C. The ignition in the muffle is continued, with occasional stirring of the ash, until all particles of carbon have disappeared. After the capsule containing the ash has been cooled in a desiccator it is weighed, and ignition is repeated until constant weight (0.0005 gram or less) has been attained.

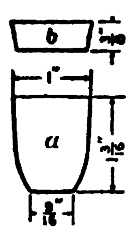

FIGURE 1.—10-c. c. platinum crucible for determining volatile matter.

The ash content as determined by this method represents the ignited mineral residue or "uncorrected ash."

DETERMINATION OF VOLATILE MATTER.

METHOD.

A 1-gram sample of the fine (60-mesh) coal is weighed into a bright, well-burnished, 10-gram (10 c. c.) platinum crucible, *a* (fig. 1), with a close-fitting capsule cover, *b*. The crucible and contents are heated to a temperature of 950° C. in a specially designed electric furnace of the vertical type (fig. 2). After having been heated exactly seven minutes the crucible is removed from the furnace, cooled, and weighed. The loss in weight minus the weight of moisture determined at 105° C. times 100 equals the percentage of volatile matter.

MODIFIED METHOD FOR LIGNITES AND SUBBITUMINOUS COALS.

Lignites and coals high in moisture are heated at a low temperature with a flame until all the moisture is driven out in order to avoid mechanical losses from material thrown out of the crucible by

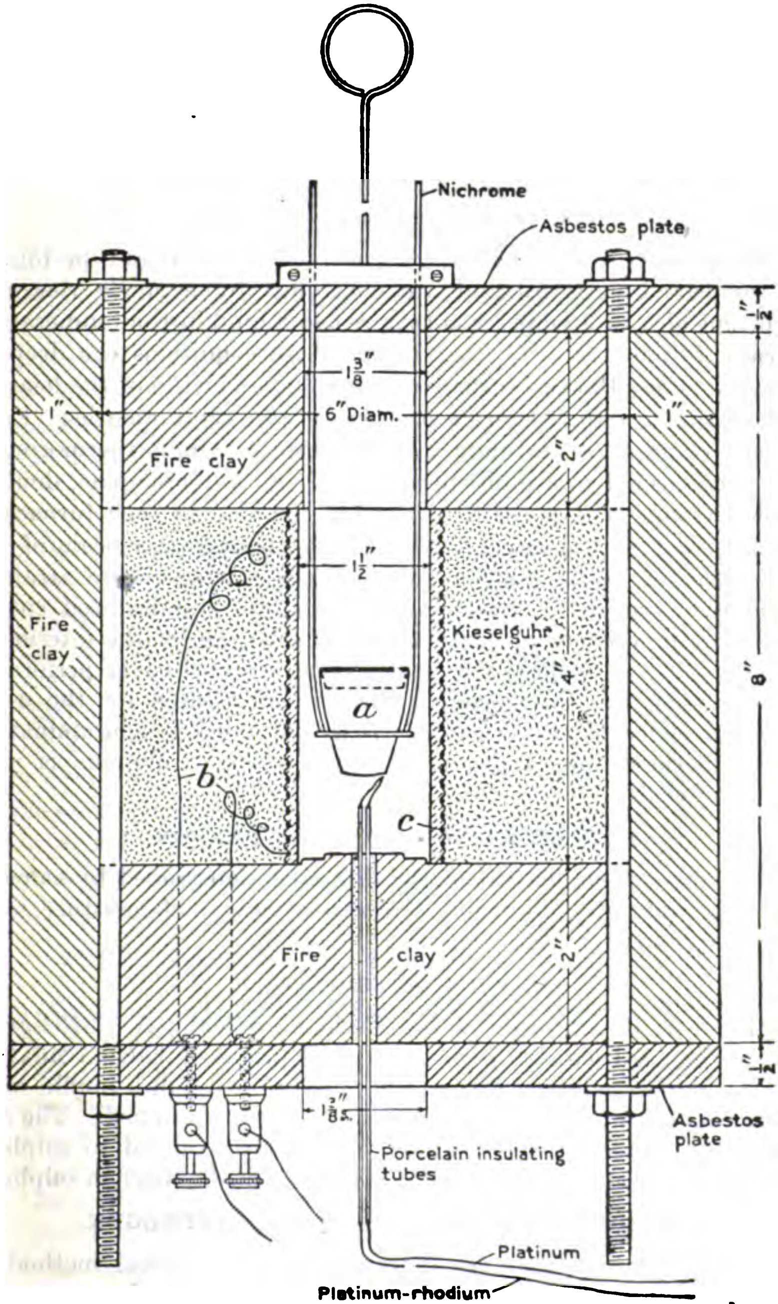

FIGURE 2.—Electric furnace for determination of volatile matter.

the rapid escape of steam and volatile matter.[10] After this preliminary heating for four to six minutes the crucible is placed at once in the furnace at 950° C., and is heated for six minutes.

It should be clearly understood that the volatile matter does not represent any definite compound in the coal. The method of determination is wholly conventional, and any variation in temperature or rate of heating will change the amount of volatile matter determined.

USE OF THE ELECTRIC FURNACE.

Two specially designed electric furnaces of the vertical type (fig. 2) are connected in series and are controlled by a single rheostat. A current of 8 to 9 amperes is required to maintain the temperature of each furnace at 950° C. Under these conditions the drop in potential across the two furnaces is 60 volts. The life of the heating element under daily operation has been six to eight months. Each furnace contains a platinum and platinum-rhodium thermocouple that is connected to a millivoltmeter through a double-pole, double-throw switch. The position of the hot junction in each furnace is so adjusted that the direct reading of the temperature scale of the millivoltmeter is the same as the maximum temperature attained inside the crucible as determined by another standardized couple whose hot junction is in contact with the bottom of the interior of the crucible. In making this comparison a nickel cover perforated for admitting the thermocouple leads is substituted for the usual platinum cover of the crucible. To avoid possible contamination of the thermocouple, 1 gram of ignited silica or alumina is used instead of coal.

DETERMINATION OF FIXED CARBON.

The fixed-carbon content of the sample is determined by calculation—by subtracting the sum of the percentages of moisture, ash, and volatile matter from 100.

SULPHUR DETERMINATION.

Sulphur is determined by the Eschka method. A 1.3734-gram part of the air-dried coal is mixed with 6 grams of Eschka mixture in a No. 1 porcelain crucible and gradually heated in a muffle, with free access of air, until all the carbon has been consumed. The sulphur is extracted with hot water, completely oxidized to sulphate with bromine water, and precipitated and weighed as barium sulphate.

DETERMINATION OF CARBON AND HYDROGEN.

Carbon and hydrogen are determined by the usual method of combustion in a current of oxygen. A 0.2-gram part of the air-dried coal is burned in an electrically heated furnace of the Heraeus type.

[10] Lord, N. W., Experimental work conducted in the chemical laboratory of the United States fuel-testing plant at St. Louis, Mo.: U. S. Geol. Survey Bull. 323 (reprinted as Bull. 28, Bureau of Mines), 1911, pp. 6–7.

Complete oxidation is insured by passing the products of combustion over red-hot copper oxide. A layer of lead chromate, following the copper oxide, removes the sulphur. The water and carbon dioxide are absorbed and weighed in calcium chloride and potassium hydroxide solution, respectively. No correction is made for carbon or hydrogen from inorganic matter in the coal.

NITROGEN DETERMINATION.

Nitrogen is determined by the Kjeldahl-Gunning method. One gram of the air-dried coal is digested with 30 c. c. of concentrated sulphuric acid, 0.5 gram of metallic mercury, and 5 grams of potassium sulphate until the carbon has been completely oxidized and all the nitrogen has been converted to ammonium sulphate. After dilution with water and precipitation of the mercury by the addition of potassium sulphide an excess of sodium hydroxide is added and the ammonia determined by distillation.

DETERMINATION OF CALORIFIC VALUE.

The heat of combustion is determined with the bomb calorimeter. One gram of the air-dried coal is completely burned in compressed oxygen gas, and the total heat evolved is absorbed in a weighed quantity of water in which the bomb is immersed. The rise in temperature of the water is measured with a thermometer that is graduated in hundredths of 1° C., and can be read, by means of a cathetometer, to 0.002° C.

Corrections are made for "radiation losses," oxidation of nitrogen to aqueous nitric acid, and oxidation of sulphur dioxide to aqueous sulphuric acid. The calorific value obtained in this manner is the total heat of combustion with water vapor condensed to liquid water at the temperature of the calorimeter; that is, 20° to 25° C.

INTERPRETATION OF ANALYTICAL RESULTS.[11]

The coal analyses reported in this bulletin are grouped in the usual manner, as follows:

1. The proximate analysis, including results of determinations of moisture, volatile matter, fixed carbon, and ash.
2. The ultimate analysis, including results of determinations of carbon, hydrogen, nitrogen, oxygen, sulphur, and ash.
3. The calorific value, heating value, or heat of combustion.

For many of the samples the analysis is given for three conditions, as follows: (1) As received at the laboratory, (2) computed to a moisture-free condition, and (3) computed to a moisture-free and ash-free condition.

[11] See also Fieldner, A. C., Notes on the sampling and analysis of coal: Tech. Paper 76, Bureau of Mines, 1914, pp. 23-57.

At mines where two or more samples were taken and a composite sample obtained by mixing equal portions of the separate samples, the analysis of the composite sample is given for the three conditions, because presumably the composite sample represents the coal in the mine better than any one of the separate samples.

The analysis of the sample "as received" (condition 1) represents the actual sample as received at the laboratory and, as for a mine sample, represents the coal at the point of sampling in the mine. The "moisture-free" analysis (condition 2) represents the relative composition and heating value of the dry coal; this form of analysis is convenient for comparing similar coals of variable moisture content. The "moisture-free and ash-free" analysis represents approximately the relative composition and calorific value of the dry organic or combustible matter. This form of analysis is only an approximation, because the ash does not have the same weight as the inorganic or incombustible matter in the coal. However, the error does not exceed 1.5 per cent in comparing coals that do not vary much in the character and amount of ash and sulphur.

PROXIMATE ANALYSIS.

The proximate analysis of coal originated in response to the industrial demand for laboratory tests of the relative amounts of certain compounds, either present in the coal or derived from it, that effect its use as a fuel. These compounds are grouped by the proximate analysis as follows:

(1) Water or moisture; (2) mineral impurities that remain in a somewhat altered condition, as ash when the coal is burned; (3) organic or combustible matter, which is approximately represented by the volatile matter and fixed carbon.

MOISTURE CONTENT.

The moisture in coal consists of (1) extraneous moisture, which comes from external sources, such as underground waters trickling over the face of the coal bed, through the coal bed, and, in places going down the dip, from the coal shot down lying in water, condensation from saturated mine air, or, as regards car samples, from atmospheric precipitation or from water used for washing the coal, and (2) inherent mositure, which is one of the products of the original vegetable matter from which coal is derived.

Analysis does not differentiate between extraneous and inherent moisture, because in air-drying coal not only is the extraneous or superficial moisture removed but also more or less of the inherent moisture, the amount depending on the fineness of the coal and the humidity of the air. The percentage loss of weight on air drying should be regarded merely as an indication of the relative tendency of different coals to lose moisture, after removal from the mine, on exposure to comparatively dry atmospheres.

The loss of weight on air drying at 30° to 35° C., combined with the loss of weight occurring when the air-dried sample is heated in a current of dry air at a temperature of 105° C., is considered equal to the total moisture in the coal as received at the laboratory.

ASH.

Ash is the incombustible residue left from complete combustion of the coal. It is derived from the inorganic matter in the coal, and is composed largely of compounds of silica, alumina, lime, and iron, together with smaller quantities of magnesia, titanium, and alkali compounds. The silica, alumina, and titanic oxide are derived from sand, clay, shale, and "slate"; the iron oxide mainly from iron pyrite; and the lime and magnesia from their corresponding carbonates and sulphates.

The ash-forming constituents consist of (1) "inherent" or "intrinsic" impurities that are present in an intimate mixture with the coal substance, and are derived either from the original vegetable material or from external sources during the accumulation of coal-forming plant remains; (2) impurities formed either during the laying down of the coal bed or subsequently, which occur in the form of partings, "veins," and nodules of clay, shale, pyrite, and calcite; and (3) impurities that become mechanically mixed with the coal in the process of mining, such as fragments of roof and floor.

INHERENT IMPURITIES.

The percentage of ash derived from the intimately mixed impurities may be determined by selecting a sample of clean lumps of homogeneous coal, or, better, by placing the coarsely crushed coal in a solution of calcium or zinc chloride with a specific gravity of 1.35. The coal will float and the heavier extraneous impurities will sink. In this way a sample of clean coal may be prepared for analysis. In some samples the percentage of "intrinsic" ash is so low that the ash must have come exclusively from the original coal-forming vegetation. Certain coals have deposited in their minute joints or cleavage planes thin flakes of calcite, gypsum, silica, or clay, and some have veinlets of pyrite. These impurities are not intimately mixed with the coal substance, but can not be separated from the coal by any commercial methods of preparation. In some coals, also, microscopic crystals of pyrite are so distributed that washing does not appreciably lower the sulphur content.

55270°—22——2

EXTRANEOUS IMPURITIES.

The percentage of ash derived from extraneous impurities varies considerably, depending on the number and size of the partings in the bed, the possibility of separating them from the coal, and the care with which the coal is mined. Such impurities of this character, when in the form of "slate" or bone, may be removed to some degree by suitable methods of washing, picking, or screening. The possibility of improving the quality of coal by washing may be determined by the laboratory float-and-sink test already described.

Coal ash, as determined, usually weighs less than the organic matter from which it is produced because of the loss of volatile constituents during ignition. Shale and clay lose their water of hydration; the carbonates are more or less decomposed, giving off carbon dioxide, and the iron pyrite is changed to ferric oxide, giving off sulphur dioxide, either to the atmosphere or to the free calcium oxide that has been formed from the carbonate. In coals containing calcium carbonate a large proportion of the sulphur may be retained in the ash as calcium sulphate.

VOLATILE MATTER AND FIXED CARBON.

The volatile matter and fixed carbon represent approximately the relative proportions of gaseous and solid combustible matter that are obtained from coal by heating it in a closed vessel. The volatile matter consists chiefly of the combustible gases hydrogen, carbon monoxide, and methane and other hydrocarbons, and some noncombustible gases, as carbon dioxide and water vapor. The volatile matter does not include the water that can be removed from the coal by heating it at 105° C.

From the standpoint of the analyst, 950° to 1,000° C. appears to be the best temperature for the determination of volatile matter, as most duplicate determinations made within those limits agree within 0.5 per cent.

The residue of coke left in the crucible after the ash has been deducted is reported as "fixed carbon." The fixed carbon does not represent the total carbon in the coal, for a considerable part of the carbon is expelled as volatile matter, being in combination with hydrogen as hydrocarbon or with oxygen as carbon monoxide and carbon dioxide. Furthermore, fixed carbon is not pure carbon. The carbonized residue contains, in addition to the ash-forming constituents, several tenths per cent of hydrogen and oxygen, from 0.4 to 1.0 per cent nitrogen, and approximately half the sulphur that was in the coal. The terms "volatile matter" or "volatile combustible matter" and "fixed carbon" do not represent definite compounds that existed in the coal before heating. The method of determination is arbitrary, and results are comparable only when the temperature and rate of heating are the same. In general the sum of the fixed carbon and ash may be taken as representing the relative amount of coke yield from coking coals. However, the conditions under which the laboratory determination is made are so different from the conditions in the commercial manufacture of coke or gas that no close agreement can be expected. The slow rate of heating in the industrial processes yields several per cent more coke than is obtained in the laboratory determination.

SULPHUR.

In the proximate analysis of coal the sulphur is included in the volatile matter, fixed carbon, and ash. If the ash contains no lime or alkali oxides, all the sulphur is distributed between the volatile matter and fixed carbon, approximately half the sulphur being retained by the fixed carbon and the remainder escaping with the volatile matter.

FORMS OF OCCURRENCE IN COAL.

Sulphur occurs in coal (1) as pyrite or marcasite, (2) as sulphate of iron, lime, and alumina, and (3) in combination with the coal substance as organic compounds.

In some coal beds the balls, lenses, and bands of pyrite are easily distinguishable in the face of the bed, and may be largely removed by breaking up the lumps of coal containing them and by suitable washing or picking. In other beds the pyrite is disseminated throughout the lumps of coal in veinlets or in such small particles that it is not practicable to separate them from the lump coal or even to remove them from the screenings by washing.

Sulphur combined as sulphates of iron, lime, and alumina may be found in weathered coal. On exposure to air, pyrite and marcasite tend to absorb oxygen and form iron sulphate. Sulphur combined as sulphate has no heating value.

Next to pyritic sulphur the most prominent form of sulphur in coal is that which occurs in some organic combination with the coal substance; indeed many coals contain one-half or more of their sulphur in this form. Powell and Parr [12] have recently developed a method for directly determining the relative amounts of pyritic sulphur in coal. This method has been tested in the Bureau of Mines laboratory and found to give accurate results with a number of coals selected from the Appalachian and interior-province coal fields.[13]

[12] Powell, A. R., and Parr, S. W., A study of the forms in which sulphur occurs in coal: University of Illinois, Engineering Experiment Station Bull. 111, 1919, pp. 44–45.

[13] Powell, A. R., The analysis of sulphur forms in coal, Tech. Paper 254, Bureau of Mines, 1921, 21 pp.

Subbituminous coal is found in most of the western fields, being well known in the field about Boulder and Denver and in North Park, Colo.; Gallup, N. Mex.; Hanna, Douglas, Sheridan, and the Bighorn Basin, Wyo.; Red Lodge and Musselshell, Mont., and in many of the districts of Washington and Oregon.

Lignite.—As used by the Geological Survey the term "lignite" is restricted to the coals that are distinctly brown and generally woody. They are intermediate in quality between peat and subbituminous coal. Lignite is abundant in the North in eastern Montana and North Dakota and in the northwest corner of South Dakota. In the South it is present in all of the Gulf States, but it has been developed commercially only in Texas.

TABULATED ANALYSES.

On the following pages are given the analyses of the samples of coal collected during the period covered by this report.

In the first column of the table, locations of samples are, for brevity, not worded as in the detailed descriptions (pp. 108 to 352).

Table of chemical analyses.

Locality, bed, etc.	Mine notes [a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ALABAMA.																
BIBB COUNTY.																
Belle Ellen; Belle Ellen mine, Youngblood bed (face of 19 south heading)	108	26276	A	1	2.72	34.74	57.87	4.67	1.33	......	......	......	......	1.6	7,899	14,218
Same (face of 22 north heading)	108	26277	A	1	2.70	35.60	55.99	5.71	1.41	......	......	......	......	1.5	7,824	14,083
Same (face of 2 crosscut, 23 north heading)	108	26278	A	1	2.58	35.66	56.16	5.60	1.27	......	......	......	......	1.4	7,791	14,024
Same (face of 70 room, 18 north heading)	108	26279	A	1	2.54	34.91	57.72	4.83	1.17	......	......	......	......	1.5	7,927	14,269
Same (face of 19 north heading)	108	26280	A	1	3.39	33.08	58.59	4.94	1.48	......	......	......	......	2.3	7,857	14,143
Same (composite of samples 26276 to 26280)	108	26281	A	1	2.71	34.67	57.43	5.19	1.26	5.29	79.71	1.42	7.13	1.7	7,865	14,157
				2	......	35.64	59.03	5.33	1.30	5.13	81.93	1.46	4.85	......	8,084	14,551
				3	......	37.65	62.35	......	1.37	5.42	86.54	1.54	5.13	......	8,539	15,370
JEFFERSON COUNTY.																
Bessemer, 7 miles southwest of; Virginia mine, Nickel Plate bed (face of 1 north heading, about 6,300 feet northwest of mine mouth).	109	26217	A	1	1.91	24.88	68.53	4.68	.91	......	......	......	......	1.5	8,172	14,710
Same (face of 19 right heading, about 7,400 feet northwest of mine mouth).	109	26218	A	1	2.72	24.46	68.03	4.79	.70	......	......	......	......	2.2	8,065	14,517
Same (face of 20 right heading, about 6,000 feet northwest of mine mouth).	109	26219	A	1	2.41	23.93	69.05	4.61	.72	......	......	......	......	1.9	8,135	14,643
Same (face of 17 right heading, about 6,600 feet northwest of mine mouth).	109	26220	A	1	2.52	25.52	67.11	4.85	.60	......	......	......	......	2.0	8,089	14,560
Same (composite of samples 26217 to 26220)	109	26221	A	1	2.39	24.41	68.41	4.79	.74	4.74	81.74	1.48	6.51	1.9	8,124	14,623
				2	......	25.01	70.08	4.91	.76	4.59	83.74	1.52	4.48	......	8,323	14,981
				3	......	26.30	73.70	......	.80	4.83	88.06	1.60	4.71	......	8,752	15,754
Same (face of main right heading, about 6,600 feet northwest of mine mouth).	109	26222	A	1	86	24.91	70.02	4.21	.71	......	......	......	......	.4	8,312	14,962
				2	......	25.13	70.62	4.25	.72	......	......	......	......	......	8,384	15,091
				3	......	26.24	73.76	......	.75	......	......	......	......	......	8,756	15,761

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ALABAMA—Continued.																
JEFFERSON COUNTY—continued.																
Majestic; Majestic mine, Black Creek bed (face of 4 room, 1 cross entry left, 4 right north entry, 1,850 feet N. 47° E. of hoisting shaft).	109	32070	A	1	1.89	30.20	62.76	5.15	0.58	......	......	......	......	1.0	8,011	14,420
Same (face of main north entry, 5 left entry, 2,100 feet N. 30° E. of hoisting shaft).	109	32071	A	1	2.64	30.47	62.81	4.08	.64	......	......	......	......	1.7	8,032	14,458
Same (face of 4 right south air course, 1,400 feet S. 70° W. from hoisting shaft).	109	32072	A	1	2.91	31.17	61.85	4.07	.55	......	......	......	......	2.0	7,988	14,378
Same (at room neck, 30 feet outby face of 4 left south entry, 1,500 feet S. 25° W. from hoisting shaft).	109	32073	A	1	1.88	31.25	64.69	2.18	.59	......	......	......	......	.9	8,247	14,845
Same (composite of 32070 to 32073)	109	32074	A	1	2.38	30.34	63.48	3.80	.59	5.21	82.16	1.169	6.55	1.4	8,059	14,506
				2	......	31.08	65.03	3.89	.60	5.07	84.16	1.73	4.55	......	8,256	14,861
				3	......	32.34	67.66	......	.62	5.28	87.57	1.80	4.73	......	8,590	15,462
Palos, 2 miles east of; Bessie mine, Mary Lee bed (face of 25–26 room, 15 right entry, 5,700 feet southwest of mine mouth).	110	26900	A	1	2.06	27.55	59.59	10.80	.77	......	......	......	......	1.4	7,479	13,462
Same (face of 27–28 room, 14 right entry, 5,000 feet southwest of mine mouth).	110	26901	A	1	1.90	26.57	59.03	12.50	.84	......	......	......	......	1.4	7,324	13,183
Same (face of 11–12 room, 18 left entry, 5,800 feet northeast of mine mouth).	110	26902	A	1	2.45	27.75	59.98	9.82	.74	......	......	......	......	1.8	7,560	13,608
Same (composite of samples 26900 to 26902)	110	26903	A	1	2.05	27.48	59.44	11.03	.72	5.04	75.36	1.63	6.22	1.5	7,455	13,419
				2	......	28.05	60.69	11.26	.74	4.91	76.94	1.66	4.49	......	7,611	13,700
				3	......	31.61	68.39	......	.83	5.53	86.70	1.87	5.07	......	8,577	15,439
Same (face of 2 room, 10 left entry)	110	26914	A	1	1.15	30.10	59.40	9.35	.79	......	......	......	......	.5	7,717	13,891
Same (face of 28 room, 9 left entry)	110	26915	A	1	2.11	29.43	58.85	9.61	.70	......	......	......	......	1.4	7,599	13,678
Same (face of 10 right entry)	110	26916	A	1	1.99	29.73	58.96	9.32	.73	......	......	......	......	1.4	7,655	13,779
Same (composite of samples 26914 to 26916)	110	26917	A	1	1.80	29.77	59.04	9.39	.77	5.06	76.78	1.60	6.40	1.1	7,652	13,774
				2	......	30.31	60.13	9.56	.78	4.95	78.19	1.63	4.89	......	7,792	14,026
				3	......	33.51	66.49	......	.86	5.47	86.45	1.80	5.42	......	8,610	15,509

SHELBY COUNTY.																
Aldrich, Aldrich mine, Montevallo bed (face of 9 panel)	111	26730	A	1	2.41	39.99	49.48	8.12	.80					1.0	7,522	13,540
Same (face of 6 panel)	111	26731	A	1	2.34	39.82	51.75	6.09	.71					1.0	7,659	13,786
Same (face of 1 panel)	111	26732	A	1	2.17	38.48	52.80	6.55	.78					.8	7,665	13,797
Same (face of 2 panel)	111	26733	A	1	2.14	38.02	52.30	7.54	.67					.9	7,532	13,558
Same (composite of samples 26730 to 26733)	111	26734	A	1	2.30	38.60	51.87	7.23	.76	5.20	75.75	1.02	10.04	.9	7,582	13,648
				2		39.51	53.09	7.40	.78	5.06	77.53	1.04	8.19		7,760	13,968
				3		42.67	57.33		.84	5.46	83.72	1.12	8.86		8,380	15,084
Helena, 2½ miles southwest of; Eureka No. 2 mine, Helena bed (face of 7 right air course, between 19 and 20 rooms).	112	25543	A	1	2.91	34.83	51.59	10.67	.38					1.4	7,259	13,066
Same (face of 22 room, 6 left entry, 3,300 feet northeast of mine mouth).	112	25544	A	1	2.65	34.46	54.18	8.71	.36					1.0	7,439	13,390
Same (face of 30 room, opposite 8 right crossheading)	112	25545	A	1	2.84	34.66	52.68	9.82	.39					1.3	7,317	13,171
Same (composite of samples 25543 to 25545)	112	25546	A	1	2.90	34.10	53.35	9.65	.41	5.29	73.92	1.18	9.55	1.2	7,326	13,187
				2		35.12	54.94	9.94	.42	5.12	76.13	1.22	7.17		7,545	13,581
				3		39.00	61.00		.47	5.69	84.53	1.35	7.96		8,378	15,080
Maylene, 1½ miles south of; Maylene mine, Maylene bed (face of G heading).	112	26301	A	1	3.46	35.77	51.23	9.54	.45					2.1	7,194	12,949
Same (face of 19 west entry)	112	26302	A	1	2.78	36.68	53.50	7.04	.44					1.4	7,430	13,374
Same (face of 11 room, 15 east heading)	112	26303	A	1	2.92	36.96	53.47	6.65	.48					1.4	7,515	13,527
Same (face of 21 room, 12 west heading)	112	26304	A	1	2.77	37.06	53.70	6.47	.48					1.4	7,573	13,631
Same (composite of samples 26301 to 26304)	112	26305	A	1	2.99	36.55	53.08	7.38	.44	4.94	74.73	1.18	11.33	1.6	7,435	13,383
				2		37.68	54.71	7.61	.45	4.75	77.03	1.22	8.94		7,664	13,795
				3		40.78	59.22		.49	5.14	83.38	1.32	9.67		8,296	14,933
ALASKA.																
ARCTIC COAST.																
Near Wainwright Inlet	113	*26371	B	1	20.65	31.77	44.39	3.19	.34	6.01	57.21	1.13	32.12	10.1	5,421	9,758
				2		40.04	55.94	4.02	.43	4.69	72.10	1.42	17.34		6,832	12,298
INNOKO DISTRICT.				3		41.72	58.28		.45	4.89	75.12	1.48	18.06		7,118	12,812
Tramway between Flat and Iditarod	113	26370	B	1	1.52	7.69	85.60	5.19	.79	3.38	85.87	1.56	3.21	.2	7,943	14,297
				2		7.81	86.92	5.27	.80	3.26	87.19	1.58	1.90		8,065	14,517
MATANUSKA FIELD.				3		8.24	91.76		.84	3.44	92.04	1.67	2.01		8,513	15,323
Chickaloon River, No. 8 bed (sample of washed coal from 120 sacks)	113	30265	A	1	7.16	20.43	62.80	9.61	.52	4.98	73.38	1.27	10.24	6.2	7,169	12,904
				2		22.01	67.64	10.35	.56	4.50	79.04	1.37	4.18		7,722	13,900
				3		24.55	75.45		.62	5.02	88.16	1.53	4.67		8,613	15,503
Emery, sec. 16, T. 19 N., R. 3 E.; Kelly mine, Kelly bed (upper bench in 1 chute, 80 feet west of drift mouth).	113	28731	A	1	4.84	41.64	46.58	6.94	.54	5.92	71.20	1.64	13.76	2.2	7,162	12,892
				2		43.76	48.95	7.29	.57	5.65	74.82	1.72	9.95		7,527	13,549
				3		47.20	52.80		.61	6.09	80.70	1.86	10.74		8,119	14,614
Same (lower bench in 1 chute, 75 feet west of drift mouth)	112	28732	A	1	5.13	42.01	44.08	8.78	.40	5.66	68.96	1.53	14.67	2.5	6,860	12,348
				2		44.28	46.47	9.25	.42	5.37	72.69	1.61	10.66		7,231	13,016
				3		48.79	51.21		.46	5.91	80.10	1.77	11.76		7,622	13,720

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ALASKA—Continued.																
MATANUSKA FIELD—continued.																
Eska, sec. 16, T. 19 N., R. 3 E.; David mine, David bed (2 chute, 75 feet from mine mouth).	114	28733	A	1	4.90	41.55	48.04	5.51	0.52	5.95	71.90	1.63	14.49	2.0	7,241	13,034
				2	......	43.69	50.52	5.79	.55	5.69	75.60	1.71	10.66	......	7,614	13,705
				3	......	46.38	53.62	......	.58	6.04	80.25	1.82	11.31	......	8,082	14,548
Same, Maitland mine, Maitland bed (2 chute or plane, represents 2 feet 10 inches of coal).	115	28736	A	1	5.06	42.01	45.70	7.23	.44	5.63	70.34	1.61	14.75	1.9	7,086	12,755
				2	......	44.25	48.13	7.62	.46	5.34	74.09	1.70	10.79	......	7,464	13,435
				3	......	47.90	52.10	......	.50	5.78	80.20	1.84	11.68	......	8,080	14,544
Same (grab sample from surface of loaded railroad car)	115	28737	C	1	6.99	35.41	37.35	20.25	.39	......	......	......	......	4.0	5,777	10,399
				2	......	38.07	40.16	21.77	.42	......	......	......	......	......	6,211	11,180
				3	......	48.66	51.34	......	.54	......	......	......	......	......	7,940	14,292
Same, Emery mine, Emery bed (1 chute, 60 feet from mine mouth).	114	28735	A	1	5.43	39.13	45.74	9.70	.33	5.65	68.53	1.54	14.25	2.2	6,878	12,371
				2	......	41.38	48.36	10.26	.35	5.34	72.46	1.63	9.96	......	7,268	13,082
				3	......	46.11	53.89	......	.39	5.95	80.74	1.82	11.10	......	8,099	14,578
Same, Eska mine, Eska bed (1 chute)	115	28734	A	1	4.94	38.03	39.55	17.48	.37	5.41	62.01	1.43	13.30	2.1	6,192	11,146
				2	......	40.01	41.60	18.39	.39	5.11	65.23	1.50	9.38	......	6,514	11,725
				3	......	49.02	50.98	......	.48	6.26	79.93	1.84	11.49	......	7,982	14,368
1½ miles northeast of; sec. 10, T. 19 N., R. 3 E.; McCauley prospect, McCauley bed (at face of prospect).	115	28836	A	1	6.81	37.10	46.81	9.28	.53	5.79	66.45	1.21	16.74	3.2	6,607	11,893
				2	......	39.81	50.23	9.96	.57	5.40	71.31	1.30	11.46	......	7,090	12,762
				3	......	44.21	55.79	......	.63	6.00	79.20	1.44	12.73	......	7,874	14,173
Moose Creek, Doherty mine, Doherty bed (grab sample of screenings through ½-inch screen from small cleaning plant).	115	28729	A	1	6.02	29.84	29.99	34.15	.37	......	......	......	......	3.3	4,736	8,525
				2	......	31.75	31.91	36.34	.39	......	......	......	......	......	5,040	9,078
				3	......	49.87	50.13	......	.61	......	......	......	......	......	7,917	14,251
Same (grab sample from surface of coal pile in bunkers at end of tram road).	115	28730	A	1	4.39	33.24	35.10	27.27	.40	......	......	......	......	2.0	5,460	9,822
				2	......	34.77	36.71	28.52	.42	......	......	......	......	......	5,711	10,280
				3	......	48.64	51.36	......	.59	......	......	......	......	......	7,990	14,382
Same, outcrop (3,000 feet up Moose Creek)	116	28837	A	1	4.71	35.51	50.85	8.93	.34	5.33	67.57	1.91	15.92	.5	6,748	12,146
				2	......	37.26	53.37	9.37	.36	5.05	70.91	2.00	12.31	......	7,081	12,746
				3	......	41.11	58.89	......	.40	5.57	78.24	2.21	13.58	......	7,813	14,063
Upper Eska Creek, outcrop (west bank of west fork of middle fork, near north boundary of sec. 9, T. 19 N., R. 3 E.).	116	29362	A	1	5.81	37.92	39.70	16.57	.29	5.38	61.00	1.48	15.28	2.6	6,160	11,088
				2	......	40.26	42.15	17.50	.31	5.02	64.76	1.57	10.75	......	6,540	11,772
				3		48.85	51.15		.38	6.09	78.58	1.91	13.04		7,936	14,285

NENANA FIELD

California Creek; outcrop near SW. ¼ SW. ¼ sec. 15, T. 9 S., R. 6 W. (face of bluff on east bank of California Creek; partly weathered.	116	*26359	B	1	38.22	23.84	22.15	15.79	.36	6.45	31.14	.49	45.77	32.1	2,924	5,663
				2	......	38.59	35.85	25.56	.58	3.56	50.40	.79	19.11	......	4,733	8,519
				3	......	51.84	48.16	......	.78	4.78	67.71	1.06	25.67	......	6,358	11,444
Same, outcrop near SW. ¼ NE. ¼ sec. 27, T. 10 S., R. 6 W. (face of cliff on east bank of California Creek; partly weathered).	116	*26360	B	1	25.66	32.28	22.80	19.26	.21	5.93	37.86	.53	36.21	18.1	3,599	6,478
				2	......	43.42	30.67	25.91	.28	4.14	50.93	.71	18.03	......	4,841	8,714
				3	......	58.60	41.40	......	.38	5.59	68.74	.96	24.33	......	6,534	11,761
Same (duplicate of 26360)	116	*26361	B	1	26.50	25.12	16.40	31.98	.19	5.35	27.40	.48	34.60	19.8	2,615	4,707
				2	......	34.18	22.31	43.51	.26	3.28	37.28	.65	15.02	......	3,558	6,404
				3	......	60.51	39.49	......	.46	5.81	65.99	1.15	26.59	......	6,298	11,336
Healy Creek, 1 mile above mouth of; (outcrop on cliff on north bank of Healy Creek).	117	*26368	B	1	21.50	41.82	30.77	5.91	.25	6.05	49.17	.67	37.95	10.4	4,767	8,581
				2	......	53.27	39.20	7.53	.32	4.66	62.64	.85	24.00	......	6,073	10,931
				3	......	57.61	42.39	......	.35	5.04	67.74	.92	25.95	......	6,567	11,821
Lignite Creek; SW. ¼ SE. ¼ sec. 30, T. 11 S., R. 6 W., B bed (outcrop from cliff on north bank of Lignite Creek; slightly weathered).	117	*26362	B	1	20.62	38.80	30.02	10.56	.19	5.87	47.45	.66	35.27	10.4	4,480	8,064
				2	......	48.88	37.82	13.30	.24	4.51	59.78	.83	21.34	......	5,644	10,159
				3	......	56.38	43.62	......	.28	5.20	68.95	.96	24.61	......	6,510	11,718
NW. ¼ SE. ¼ sec. 26, T. 11 S., R. 6 W. (outcrop on west side of Fault Gulch, Lignite Creek, upper thick bed).	117	*26363	B	1	28.71	35.91	30.26	5.12	.16	6.67	45.81	.59	41.65	19.8	4,311	7,760
				2	......	50.37	42.45	7.18	.22	4.88	64.26	.83	22.63	......	6,047	10,885
				3	......	54.27	45.73	......	.24	5.26	69.23	.89	24.38	......	6,515	11,727
Same, gulch tributary to Lignite Creek from the north, ¾ mile northeast of southwest corner of sec. 26 (face of outcrop).	117	*26364	B	1	22.15	35.39	29.68	12.78	.20	5.91	45.12	.59	35.40	12.2	4,272	7,690
				2	......	45.46	38.12	16.42	.26	4.43	57.96	.76	20.17	......	5,487	9,877
				3	......	54.39	45.61	......	.31	5.30	69.35	.91	24.13	......	6,565	11,817
Same, ¼ mile north of the southeast corner of sec. 26 (face of outcrop).	117	*26365	B	1	23.24	37.59	34.93	4.24	.14	6.25	51.53	.57	37.27	10.7	4,935	8,883
				2	......	48.97	45.51	5.52	.18	4.78	67.13	.74	21.65	......	6,429	11,572
				3	......	51.83	48.17	......	.19	5.06	71.05	.78	22.92	......	6,804	12,247
NE. ¼ NW. ¼ sec. 27, T. 11 S., R. 6 W., 500 feet up west fork of Lignite Creek on tributary draining sec. 27; natural exposure.	118	*26366	B	1	24.32	37.95	29.35	8.38	.19	6.33	46.84	.61	37.65	15.6	4,456	8,021
				2	......	50.15	38.78	11.07	.25	4.80	61.89	.81	21.18	......	5,888	10,598
				3	......	56.39	43.61	......	.28	5.40	69.60	.91	23.81	......	6,621	11,918
NE. ¼ NW. ¼ sec. 5, T. 12 S., R. 7 W., north bank of Lignite Creek, about 1 mile above mouth; natural exposure.	118	*26367	B	1	25.30	36.08	32.64	5.98	.26	6.39	47.55	.59	39.23	16.1	4,520	8,136
				2	......	48.30	43.69	8.01	.35	4.79	63.66	.79	22.40	......	6,051	10,892
				3	......	52.51	47.49	......	.38	5.21	69.20	.86	24.35	......	6,578	11,840
NW. ¼ NW. ¼ sec. 35, T. 11 S., R. 7 W., first large gulch from northwest, to large stream entering Lignite Creek from northwest; natural exposure.	118	*26369	B	1	23.83	35.55	28.87	11.75	.41	5.58	42.67	.66	38.93	14.6	3,893	7,007
				2	......	46.67	37.90	15.43	.54	3.85	56.02	.87	23.29	......	5,111	9,200
				3	......	55.19	44.81	......	.64	4.55	66.24	1.03	27.54	......	6,044	10,879
6 miles from mouth of Lignite Creek, No. 5 bed (weathered outcrop on north side of Lignite Creek).		*26588	A	1	32.51	33.62	27.17	6.70	.14	6.31	39.86	60	46.39	23.5	3,687	6,637
	118			2	......	49.81	40.26	9.93	.21	4.00	59.06	.89	25.91	......	5,463	9,833
				3	......	55.30	44.70	......	.23	4.44	65.57	.99	28.77	......	6,065	10,917
6 miles from mouth of Lignite Creek, No. 1 bed (weathered outcrop on north side of Lignite Creek).	118	*26589	A	1	27.92	35.82	29.23	7.03	.11	6.51	44.99	.50	40.86	18.7	4,437	7,987
				2	......	49.69	40.56	9.75	.15	4.73	62.41	.69	22.27	......	6,155	11,079
				3	......	55.06	44.94	......	.17	5.24	69.15	.76	24.68	......	6,820	12,276

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105°C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample: Laboratory No.[b]	Sample: Kind.[c]	Sample: Condition.[d]	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ARKANSAS.																
FRANKLIN COUNTY.																
Alix 1 mile east of; Dodson No. 2 mine, Denning bed (face of 9 room, 3 west plane).	119	W69641	A	1	3.4	14.10	72.55	9.95	1.69						7,411	13,340
				2		14.6	75.1	10.3	1.75						7,667	13,800
				3		16.28	83.72		1.95						8,550	15,390
Same (face of 3 room, 1 east plane)	119	W69643	A	1	3.0	13.68	75.37	7.95	1.70						7,639	13,750
				2		14.1	77.7	8.2	1.75						7,872	14,170
				3		15.36	84.64		1.91						8,578	15,440
Same (face of 1 east slope)	119	W69644	A	1	3.1	13.76	72.48	10.66	2.96						7,361	13,250
				2		14.2	74.8	11.0	3.05						7,595	13,670
				3		15.96	84.04		3.43						8,533	15,360
Alix, 1 mile east of; Dodson No. 2 mine, Denning bed (tipple samples of lump coal over 1¼-inch screen).	119	W69640, W69646	C	1	2.25	13.69	75.36	8.70	2.35						7,360	13,734
				2		14.00	77.10	8.90	2.40						7,806	14,050
				3		15.37	84.63		2.63						8,568	15,423
Same (tipple of samples of slack coal through 1¼-inch screen)	119	W69642, W69645	C	1	3.10	12.65	55.18	29.07	2.65						5,593	10,068
				2		13.05	56.95	30.00	2.73						5,772	10,390
				3		18.64	81.36		3.90						8,246	14,843
SEBASTIAN COUNTY.																
Bonanza, 3 miles east of; Woodson Barr or No. 135 mine, Upper Hartshorne bed (face of 51 room, 7 west main entry, 4,000 feet from mine mouth.	120	W69378	A	1	2.0	16.07	71.44	10.49	1.57						7,467	13,440
				2		16.4	72.9	10.7	1.60						7,622	13,720
				3		18.36	81.64		1.79						8,533	15,360
Same (1 room, at face of 19 east entry)	120	W69379	A	1	1.7	16.91	73.03	8.36	1.23						7,689	13,840
				2		17.2	74.3	8.5	1.25						7,822	14,080
				3		18.80	81.20		1.37						8,550	15,390
Same (room neck of last room, at face of 9 west entry)	120	W69397	A	1	1.6	17.02	73.41	7.97	1.18						7,756	13,960
				2		17.3	74.6	8.1	1.20						7,879	14,182
				3		18.82	81.18		1.31						8,572	15,430
Same (tipple samples of run-of-mine coal)	119	W69374, W69377	C	1	2.00	16.31	68.77	12.32	1.22						7,236	13,025
				2		16.75	70.60	12.65	1.25						7,430	13,373
				3		19.18	80.82		1.43						8,506	15,310

Hartford, Central No. 10 mine, Hartshorne bed (face of 4 south entry)	120	29835	A	1	2.44	18.91	68.83	9.82	.80	......	......	......	......	2.0	7,463	13,433
Same (face of 2 south entry)	120	29836	A	1	3.35	19.43	66.33	10.89	1.11	......	......	......	......	2.8	7,299	13,138
Same (face of 3 north entry)	120	29837	A	1	2.92	19.64	66.97	10.47	1.39	......	......	......	......	2.4	7,362	13,252
Same (composite of samples 29835 to 29837)	120	29838	A	1	2.89	19.29	67.34	10.48	1.10	4.10	77.39	1.62	5.31	2.4	7,373	13,271
				2	......	19.86	69.35	10.79	1.13	3.89	79.70	1.67	2.82	......	7,593	13,667
				3	......	22.26	77.74	......	1.27	4.36	89.34	1.87	3.16	......	8,512	15,322
Same (tipple samples of run-of-mine coal)	120	W69619, W69624, W69628, W69631	C	1	1.60	18.11	66.86	13.43	.83	......	......	......	......	......	7,216	12,989
				2	......	18.40	67.95	13.65	.84	......	......	......	......	......	7,333	13,200
				3	......	21.31	78.69	......	.97	......	......	......	......	......	8,493	15,287
2½ miles northeast of; Central No. 11 mine, Lower Hartshorne bed (face of 1 east entry, west plane).	121	W69615	A	1	3.8	18.09	70.61	7.50	1.15	......	......	......	......	......	7,589	13,660
				2	......	18.8	73.4	7.8	1.20	......	......	......	......	......	7,889	14,200
				3	......	20.39	79.61	......	1.30	......	......	......	......	......	8,561	15,410
Same (face of 3 east entry, west slope)	121	W69620	A	1	2.7	17.42	70.05	9.83	1.70	......	......	......	......	......	7,495	13,490
				2	......	17.9	72.0	10.1	1.75	......	......	......	......	......	7,706	13,870
				3	......	19.91	80.09	......	1.95	......	......	......	......	......	8,572	15,430
Same (face of 4 east entry, east plane)	121	W69632	A	1	3.5	17.18	69.77	9.55	1.98	......	......	......	......	......	7,450	13,410
				2	......	17.8	72.3	9.9	2.05	......	......	......	......	......	7,722	13,900
				3	......	19.76	80.24	......	2.28	......	......	......	......	......	8,572	15,430
Same (face of 20 room ,2 east entry, east plane)	121	W69633	A	1	3.1	17.15	72.48	7.27	1.79	......	......	......	......	......	7,717	13,890
				2	......	17.7	74.80	7.5	1.85	......	......	......	......	......	7,967	14,340
				3	......	19.14	80.86	......	2.00	......	......	......	......	......	8,611	15,500
Same (tipple samples, run-of-mine coal)	121	W69617, W69621, W69623, W69635	C	1	1.68	17.53	65.82	14.97	2.14	......	......	......	......	......	7,101	12,782
				2	......	17.83	66.94	15.23	2.18	......	......	......	......	......	7,222	13,000
				3	......	21.03	78.97	......	2.57	......	......	......	......	......	8,520	15,336
Huntington, 3 miles west of; Central No. 6 mine, Upper and Lower Hartshorne beds (neck of 8 room, 5 north entry, 2 east entry).	122	27612	A	1	2.69	19.06	70.38	7.87	1.58	......	......	......	......	2.3	7,799	14,038
Same (at junction of 6 east and back entry, southeast entry)	122	27613	A	1	3.65	18.19	67.93	10.23	1.78	......	......	......	......	3.1	7,481	13,466
Same (neck of 21 room, 1 west south entry)	122	27614	A	1	3.77	17.26	69.54	9.43	1.69	......	......	......	......	3.3	7,535	13,563
Same (face of 19 room, 2 east entry, main south entry)	122	27615	A	1	3.32	18.17	69.72	8.79	1.81	......	......	......	......	2.8	7,644	13,759
Same (face of 1 room, 4 back east entry, main north entry)	122	27616	A	1	2.88	18.83	69.65	8.64	2.49	......	......	......	......	2.4	7,698	13,856
Same (composite of samples 27612 to 27616)	122	27617	A	1	3.21	18.06	69.74	8.99	1.87	4.43	78.72	1.55	4.44	2.8	7,613	13,703
				2	......	18.66	72.05	9.29	1.93	4.21	81.33	1.60	1.64	......	7,866	14,159
				3	......	20.57	79.43	......	2.13	4.64	89.66	1.76	1.81	......	8,671	15,608
Same (face 5 east entry, main south east entry)	123	W69329	A	1	4.2	17.53	71.37	6.90	1.10	......	......	......	......	......	7,661	13,790
				2	......	18.3	74.5	7.2	1.15	......	......	......	......	......	7,995	14,390
				3	......	19.72	80.28	......	1.24	......	......	......	......	......	8,611	15,500
Same (duplicate of 69329)	123	W69330	A	1	3.8	18.86	67.82	9.52	1.44	......	......	......	......	......	7,372	13,270
				2	......	19.6	70.5	9.9	1.50	......	......	......	......	......	7,667	13,800
				3	......	21.75	78.25	......	1.66	......	......	......	......	......	8,511	15,320
Same (face of 28 room, 1 west entry, main south entry)	123	W69331	A	1	2.3	17.20	69.26	11.24	2.44	......	......	......	......	......	7,383	13,290
				2	......	17.6	70.9	11.5	2.50	......	......	......	......	......	7,556	13,600
				3	......	19.89	80.11	......	2.82	......	......	......	......	......	8,539	15,370

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ARKANSAS—Continued.																
SEBASTIAN COUNTY—continued.																
Huntington, 3 miles west of; Central No. 6 mine, Upper and Lower Hartshorne beds (duplicate of W69331)	123	W69332	A	1	2.3	17.10	69.76	10.84	2.15						7,428	13,370
				2		17.5	71.4	11.1	2.20						7,606	13,690
				3		19.69	80.31		2.47						8,556	15,400
Same (face of heading, main southeast back entry)	123	W69334	A	1	4.8	18.75	66.07	10.38	1.95						7,250	13,050
				2		19.7	69.4	10.9	2.05						7,617	13,710
				3		22.11	77.89		2.30						8,545	15,380
Same (tipple samples of run-of-mine coal)	123	W69360, W69363	C	1	1.68	17.53	64.86	15.93	1.95						6,996	12,593
				2		17.83	65.97	16.20	1.98						7,116	12,808
				3		21.28	78.72		2.36						8,491	15,284
Same (tipple samples of slack coal through 1½ and over ¾ inch screen).	123	W69357, W69358	C	1	2.10	16.84	61.09	19.97	2.01						6,622	11,919
				2		17.20	62.40	20.40	2.05						6,764	12,175
				3		21.61	78.39		2.58						8,497	15,295
Same (tipple samples of slack coal through ¾-inch screen)	123	W69339, W69359	C	1	4.8	16.47	59.79	18.94	2.08						6,458	11,624
				2		17.3	62.8	19.9	2.18						6,783	12,210
				3		21.60	78.40		2.72						8,468	15,243
WASHINGTON COUNTY.																
Fayetteville, 5½ miles east of; Stanbery wagon mine, Morrow bed (2 left entry, 600 feet from mine mouth).	124	26260	B	1	2.58	30.26	56.79	10.37	2.96					2.0	7,523	13,541
				2		31.06	58.30	10.64	3.04						7,722	13,900
				3		34.76	65.24		3.40						8,642	15,556
5½ miles east of; Wagnon & Reed wagon mine; Morrow bed (main entry, 400 feet from mine mouth).	124	26259	B	1	1.84	29.69	57.85	10.62	3.71	4.95	75.45	1.31	3.96	1.2	7,534	13,561
				2		30.25	58.93	10.82	3.78	4.84	76.86	1.33	2.37		7,675	13,815
				3		33.92	66.08		4.24	5.43	86.18	1.49	2.66		8,606	15,491
CALIFORNIA.																
AMADOR COUNTY.																
Lignite, 4 miles northwest of Ione; Ione mine (1,300 feet S. 50° E. of shaft).	124	*31141	B	1	45.78	30.86	15.78	7.58	1.01	8.20	32.91	.32	49.98	41.1	3,364	6,055
				2		56.92	29.10	13.98	1.86	5.74	60.70	.59	17.13		6,204	11,167
				3		66.17	33.83		2.16	6.67	70.56	.69	19.92		7,212	12,982

Same (1,350 feet S. 50° E. of shaft)	124	*31168	B	1	40.30	31.26	13.21	15.23	1.26					35.7	3,134	5,641
				2		52.36	22.13	25.51	2.11						5,249	9,448
				3		70.29	29.71		2.83						7,047	12,685
MENDOCINO COUNTY.																
Dos Rios, 4 miles east of; NE. ¼ sec. 11, T. 21 N., R. 13 W.; natural outcrop.	125	31139	B	1	11.44	46.75	35.69	6.12	2.64					4.1	6,210	11,178
				2		52.79	40.30	6.91	2.98						7,012	12,622
				3		56.71	43.29		3.20						7,532	13,558
MONTEREY COUNTY.																
Stone Canon, NW. ¼ sec. 14, T. 22 S., R. 13 E., 24 miles from McKay; Stone Canon mine (face of 1 east entry, below the 300-foot level, 300 feet from inside slope and 4,800 feet east of main slope)	125	31100	B	1	6.20	49.96	30.38	13.46	4.49					2.0	6,488	11,678
				2		53.26	32.39	14.35	4.79						6,917	12,451
				3		62.18	37.82		5.59						8,076	14,537
Same (face of 1 west entry, below the 300-foot level, 200 feet west of inside slope and 4,300 feet east of main slope).	125	31101	B	1	8.02	48.46	36.01	7.51	4.09	5.90	65.21	1.24	16.05	3.1	6,739	12,130
				2		52.69	39.15	8.16	4.45	5.45	70.90	1.35	9.69		7,327	13,189
				3		57.37	42.63		4.85	5.93	77.20	1.47	10.55		7,978	14,360
COLORADO.																
BOULDER COUNTY.																
Broomfield, 3 miles northwest of; sec. 28, T. 1 S., R. 69 W.; Monarch No. 2 mine (face of 7 southwest entry).	126	*31314	A	1	19.32	32.53	42.50	5.65	.24					11.8	5,545	9,981
Same (face of main south entry)	126	*31315	A	1	18.98	33.60	42.50	4.92	.29					10.6	5,615	10,107
Same (composite of samples 31314 and 31315)	126	*31316	A	1	19.14	33.44	42.07	5.35	.27	5.97	57.68	1.21	29.52	11.2	5,565	10,017
				2		41.34	52.04	6.62	.33	4.75	71.33	1.50	15.47		6,882	12,388
				3		44.27	55.73		.35	5.09	76.39	1.61	16.56		7,370	13,266
Lafayette; sec. 2, T. 1 S., R. 69 W.; Simpson mine, Lower Simpson bed (face of 13 southwest entry, main south entry).	126	*39391	A	1	20.85	34.47	41.13	3.55	.30	6.11	57.60	1.20	31.24	15.8	5,488	9,878
				2		43.55	51.96	4.49	.38	4.79	72.77	1.52	16.05		6,934	12,481
				3		45.60	54.40		.40	5.02	76.19	1.59	16.80		7,260	13,068
Louisville; sec. 8, T. 1 S., R. 69 W.; Acme mine, Lower Acme bed (face of 5 room, 6 northeast entry).	127	*31384	A	1	20.47	32.83	42.36	4.34	.32	5.95	56.89	1.24	31.26	15.3	5,420	9,756
				2		41.28	53.26	5.46	.40	4.63	71.53	1.56	16.42		6,815	12,267
				3		43.67	56.33		.42	4.90	75.66	1.65	17.37		7,209	12,976
DELTA COUNTY.																
Bowie, ¾ mile northeast of; sec. 10, T. 13 N., R. 91 W.; King mine, King bed (last crosscut between the 6th left entries).	127	28920	A	1	4.16	39.86	50.98	5.00	.55					7	7,320	13,176
				2		41.59	53.19	5.22	.57						7,638	13,748
				3		43.88	56.12		.60						8,059	14,506
EL PASO COUNTY.																
Colorado Springs, 3½ miles northeast of; sec. 33, T. 13 S., R. 66 W.; El Paso mine, A bed (10 feet outby face of 5 east entry, on left rib).	128	*28907	A	1	22.99	34.09	36.55	6.37	.31					6.0	4,856	8,741
Same (face of 18 room, 6 west entry)	128	*28908	A	1	24.86	34.08	35.17	5.89	.33					11.5	4,723	8,501
Same (face of 20 room, 5 east entry)	128	*28909	A	1	23.41	33.02	37.54	6.03	.34					6.1	4,810	8,658
Same (composite of samples 28907 to 28909)	128	*28910	A	1	23.71	33.68	36.49	6.12	.35	6.15	51.13	.78	35.47	7.9	4,804	8,647
				2		44.15	47.83	8.02	.46	4.61	67.02	1.02	18.87		6,297	11,335
				3		48.00	52.00		.50	5.01	72.86	1.11	20.52		6,846	12,323

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6.)

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample: Laboratory No.b	Sample: Kind.c	Sample: Condition.d	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COLORADO—Continued.																
EL PASO COUNTY—continued.																
Pike View Station, 1 mile north of; sec. 18, T. 13 S., R. 66 W.; Pike View mine, A bed (right rib of 8 room, main dip entry, 10 feet outby face, 1 mile northwest of shaft).	129	*28911	A	1	25.82	34.18	35.64	4.36	0.30	......	......	......	......	12.8	4,635	8,343
Same (right rib, 10 entry, opposite 31 room, 1 mile northwest of shaft).	129	*28912	A	1	26.58	33.23	35.53	4.66	.30	......	......	......	......	13.2	4,593	8,267
Same (right rib of 6 room, outby 106 face, 45 entry, 1 mile northwest of shaft).	129	*28913	A	1	25.59	33.22	33.42	7.77	.32	......	......	......	......	12.7	4,443	7,997
Same (face of 25 room, 106 entry 1 mile northwest of shaft)	129	*28914	A	1	25.89	33.76	35.47	4.88	.32	......	......	......	......	12.3	4,605	8,289
Same (right rib of 1 room, 106 entry, 45 entry, 15 feet outby face, 1 mile northwest of shaft).	129	*28915	A	1	26.27	33.11	36.02	4.60	.27	......	......	......	......	12.5	4,588	8,258
Same (composite of samples 28911 to 28915)	129	*28916	A	1	26.00	33.49	35.36	5.15	.30	6.27	49.02	.57	38.69	12.7	4,573	8,231
				2	......	45.26	47.78	6.96	.41	4.57	66.25	.77	21.04	......	6,180	11,124
GUNNISON COUNTY.				3	......	48.65	51.35	......	.44	4.91	71.21	.83	22.61	......	6,642	11,956
Somerset; sec. 9, T. 13 S., R. 90 W.; Somerset mine (left rib of 15 room, 10 east entry).	130	31817	A	1	4.33	39.69	46.68	9.30	.41	5.49	70.62	1.51	12.67	1.6	7,015	12,627
				2	......	41.49	48.79	9.72	.43	5.24	73.82	1.58	9.21	......	7,333	13,199
				3	......	45.96	54.04	......	.48	5.80	81.77	1.75	10.20	......	8,123	14,621
Same (left rib of 17 room, 10 east entry, between 2 and 3 cross-cuts).	130	31798	A	1	2.51	35.30	39.75	22.44	8.76	4.56	56.32	1.13	6.79	.8	5,912	10,642
				2	......	36.21	40.77	23.02	8.99	4.39	57.77	1.16	4.67	......	6,064	10,915
				3	......	47.04	52.96	......	11.68	5.70	75.04	1.51	6.07	......	7,877	14,179
Same (left rib of 17 room, 10 east entry, between 2 and 3 cross-cuts; bony coal).	130	31799	A	1	3.26	35.56	31.80	29.38	1.64	4.60	53.41	1.10	9.87	1.3	5,423	9,761
				2	......	36.76	32.87	30.37	1.70	4.38	55.21	1.14	7.20	......	5,606	10,091
				3	......	52.79	47.21	......	2.44	6.29	79.29	1.64	10.34	......	8,051	14,492
Same (at mouth of 13 room, 10 east entry, top coal)	130	31800	A	1	4.60	40.42	51.60	3.38	.43	5.72	75.09	1.56	13.82	1.9	7,474	13,453
				2	......	42.37	54.09	3.54	.45	5.46	78.71	1.64	10.20	......	7,834	14,101
HUERFANO COUNTY.				3	......	43.92	56.08	......	.47	5.66	81.60	1.70	10.57	......	8,122	14,620
Ravenwood; Ravenwood mine, Cameron bed (face of 11 north main entry).	131	31406	A	1	5.14	37.32	49.65	7.89	.80	......	......	......	......	2.8	6,980	12,564
Same (face of 1 dip entry, 5 south entry)	131	31407	A	1	4.43	38.29	49.21	8.07	.67	......	......	......	......	2.0	7,033	12,659
Same (composite of samples 31406 and 31407)	131	31403	A	1	4.80	38.18	48.95	8.07	.74	5.35	70.97	1.42	13.45	[illegible]	[illegible]	[illegible]

				2	......	40.10	51.42	8.48	.78	5.06	74.55	1.49	9.64	......	7,352	13,239
				3	......	43.82	56.18	......	.85	5.53	81.46	1.63	10.53	......	8,034	14,461
LAS ANIMAS COUNTY.																
Cokedale, 7 miles northwest of; secs. 31 and 32, T. 32 and 33 E., R. 65 W.; Bon Carbo mine, Primero bed (face of 1 south air course).	131	31451	A	1	2.58	34.17	49.45	13.80	.49	5.08	71.00	1.53	8.10	1.7	7,028	12,650
				2	......	35.08	50.75	14.17	.50	4.92	72.88	1.57	5.96	......	7,214	12,985
				3	......	40.87	59.13	......	.58	5.73	84.91	1.83	6.95	......	8,405	15,129
Delagua; sec. 15, T. 31 S., R. 65 W.; Cass mine, Delagua bed (face of 3 east entry).	132	31432	A	1	3.98	38.74	48.97	8.31	.72	......	......	......	......	2.6	7,293	13,127
				2	......	40.35	51.00	8.65	.75	......	......	......	......	......	7,596	13,673
				3	......	44.17	55.83	......	.82	......	......	......	......	......	8,315	14,967
Delagua mine, Delagua bed (face of 7 room, 11 west entry)	133	29351	A	1	3.28	36.92	46.58	13.22	.63	......	......	......	......	1.8	6,821	12,278
				2	......	38.17	48.16	13.67	.65	......	......	......	......	......	7,052	12,694
				3	......	44.21	55.79	......	.75	......	......	......	......	......	8,168	14,702
Delagua 1st north district, Delagua bed (face of 10 room, 8 east entry, 14 east entry).	133	31423	A	1	4.17	36.11	52.49	7.23	.68	......	......	......	......	2.3	7,275	13,095
Same (face of 9 room, 7 east entry, 6 north entry)	133	31424	A	1	4.50	36.06	51.69	7.75	.52					2.6	7,190	12,942
Same (face of 18 east parting)	133	31425	A	1	4.24	36.25	52.93	6.58	.52	......	......	......	......	2.4	7,356	13,241
Same (composite of samples 31423 to 31425)	133	31426	A	1	4.29	36.51	52.03	7.17	.58	5.38	73.93	1.39	11.55	2.4	7,270	13,086
				2	......	38.15	54.36	7.49	.61	5.12	77.24	1.45	8.09	......	7,596	13,673
				3	......	41.24	58.76	......	.66	5.53	83.50	1.57	8.74	......	8,211	14,780
Delagua 3d north district, Delagua bed (face of 17 west entry, 5 north entry).	134	31427	A	1	3.21	38.52	49.92	8.35	.51	......	......	......	......	1.8	7,306	13,151
				2	......	39.80	51.57	8.63	.53	......	......	......	......	......	7,549	13,588
				3	......	43.56	56.44	......	.58	......	......	......	......	......	8,262	14,872
Hastings, sec. 25, T. 32 S., R. 64 W.; Hastings mine, A bed (face of last room, 7½ north entry, 1 mile from mine mouth).	134	29278	A	1	2.48	33.44	48.74	15.34	.70	......	......	......	......	.9	6,906	12,431
				2	......	34.29	49.98	15.73	.72	......	......	......	......	......	7,081	12,746
				3	......	40.69	59.31	......	.85	......	......	......	......	......	8,403	15,125
Same, B bed (right rib in crosscut, main entry, opposite 3 north entry, about 1 mile from mine mouth).	134	29277	A	1	2.42	34.21	52.23	11.14	.61	......	......	......	......	.9	7,256	13,061
				2	......	35.06	53.52	11.42	.63	......	......	......	......	......	7,436	13,385
				3	......	39.58	60.42	......	.71	......	......	......	......	......	8,395	15,111
Same (face of crosscut, 60 feet north of air shaft, between A and B beds).	134	29465	A	1	2.67	37.17	50.00	10.16	.66	......	......	......	......	1.8	7,361	13,250
				2	......	38.19	51.37	10.44	.68	......	......	......	......	......	7,563	13,613
				3	......	42.64	57.36	......	.76	......	......	......	......	......	8,445	15,201
Morley, Morley mine, Morley bed (face of main slope)	135	32046	A	1	1.91	32.37	53.64	12.08	.80	......	......	......	......	1.0	7,254	13,057
Same (face of 7 left entry, main slope)	135	32047	A	1	2.03	33.53	50.83	13.61	.61	......	......	......	......	1.2	7,146	12,863
Same (composite of samples 32046 and 32047)	135	32048	A	1	2.08	32.59	52.55	12.78	.70	4.96	71.73	1.23	8.60	1.1	7,197	12,955
				2	......	33.28	53.67	13.05	.71	4.83	73.25	1.26	6.90	......	7,350	13,230
				3	......	38.28	61.72	......	.82	5.55	84.24	1.45	7.94	......	8,453	15,215
Sopris, NW. ¼ SE. ¼ sec. 33, T. 33 S., R. 64 W.; Sopris No. 2 mine, Cameron bed (face of 3 east entry).	136	31949	A	1	2.10	28.30	51.87	17.73	.73	4.75	69.33	1.25	6.21	1.4	6,864	12,355
				2	......	28.91	52.98	18.11	.75	4.62	70.82	1.28	4.42	......	7,012	12,622
				3	......	35.30	64.70	......	.92	5.64	86.49	1.56	5.39	......	8,563	15,413
Starkville, ½ mile from, Starkville mine, Starkville bed (face of 8 south entry, J-6 entry).	137	32030	A	1	1.50	30.83	53.03	14.64	.60	4.91	71.95	1.16	6.74	.7	7,098	12,776
				2	......	31.30	53.84	14.86	.61	4.81	73.04	1.18	5.50	......	7,206	12,971
				3	......	36.76	63.24	......	.72	5.65	85.79	1.39	6.45	......	8,463	15,233

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COLORADO—Continued.																
MESA COUNTY.																
Cameo, NW. ¼ NW. ¼ sec. 34, T. 10 S., R. 98 W.; Cameo mine, Cameo bed (face of 7 north entry, 6 west entry).	138	28917	A	1	7.34	36.15	46.97	9.54	0.58					1.9	6,543	11,777
Same (face of 22 room, 8 west entry)	138	28918	A	1	7.20	36.89	47.70	8.21	.58					1.9	6,676	12,017
Same (composite of samples 28917 and 28918)	138	28919	A	1	7.15	36.76	47.20	8.89	.57	5.42	67.64	1.40	16.08	1.9	6,606	11,891
				2		39.59	50.84	9.57	.61	4.99	72.85	1.51	10.47		7,115	12,807
				3		43.78	56.22		.67	5.52	80.56	1.67	11.58		7,868	14,162
OURAY COUNTY.																
Ridgway, 12 miles northeast of; NW. ¼ sec. 23, T. 46 N., R. 7 W.; Lou Creek mine (in main entry, 300 feet from mine mouth).	138	31044	B	1	15.46	35.99	40.15	8.40	.81	5.71	57.99	1.08	26.01	6.5	5,576	10,037
				2		42.57	47.49	9.94	.96	4.72	68.60	1.28	14.50		6,596	11,873
				3		47.27	52.73		1.07	5.24	76.17	1.42	16.10		7,324	13,183
PITKIN COUNTY.																
Placita, sec. 6, T. 11 S., R. 88 W.; Placita mine (1,200 feet southwest of mine mouth).	139	25826	B	1	2.23	33.84	57.33	6.60	.49	5.29	78.28	1.71	7.63	1.4	7,842	14,116
				2		34.61	58.64	6.75	.50	5.15	80.06	1.75	5.79		8,021	14,438
				3		37.12	62.88		.54	5.52	85.86	1.88	6.20		8,602	15,484
ROUTT COUNTY.																
Milner, 7 miles south of; NW. ¼ sec. 13, T. 5 N., R. 86 W.; Chergo mine, Wadge bed (face of main slope, 300 feet from mine mouth).	139	31038	B	1	12.82	37.15	44.44	5.59	.43	5.77	63.26	1.49	23.46	4.0	6,130	11,034
				2		42.61	50.98	6.41	.49	4.99	72.57	1.71	13.83		7,032	12,658
				3		45.53	54.47		.52	5.33	77.54	1.83	14.78		7,514	13,525
Mount Harris, secs. 5 and 8, T. 6 N., Mount Harris mine, Wadge bed (left rib, 20 feet from face of 10 south entry).	139	31199	A	1	10.41	38.15	46.51	4.93	.42					5.5	6,475	11,655
Same (face of 3 east entry, main south slope)	139	31200	A	1	12.40	37.62	44.21	5.77	.42					7.1	6,212	11,182
Same (left rib, main south entry, 20 feet from face of G slope)	139	31201	A	1	10.64	37.54	46.18	5.64	.40					5.8	6,415	11,547
Same (face of 7 east back entry, 2 south entry)	139	31202	A	1	11.44	37.15	45.44	5.97	.40					6.4	6,275	11,295
Same (face of 10 east entry, main south entry)	139	31203	A	1	10.84	37.15	45.34	6.67	.40					5.4	6,253	11,255
Same (left rib in last crosscut in A slope, 40 feet from face of entry).	139	31204	A	1	9.90	37.99	46.31	5.80	.40					5.0	6,444	11,599
Same (left rib, main south entry, 30 feet from face)	139	31205	A	1	11.30	38.31	46.42	3.97	.39					6.0	6,464	11,635
Same (rib of main dip entry, 5 feet from face)	139	31206	A	1	10.76	37.81	45.33	6.10	.42					5.8	6,357	11,443

Same (composite of samples 31199 to 31206)	139	31207	A	1	10.97	37.67	45.73	5.63	.41	5.76	65.31	1.63	21.26	5.9	6,364	11,455
				2	......	42.31	51.37	6.32	.46	5.10	73.36	1.83	12.93	......	7,148	12,866
				3	......	45.17	54.83	......	.49	5.44	78.31	1.95	13.81	......	7,630	13,734
Sec. 15, T. 6 N., R. 87 W; Wadge mine, Wadge bed (face of 3 north entry, main entry).	140	31233	A	1	11.49	37.75	45.95	4.81	.41	......	......	......	......	6.9	6,388	11,498
Same (face of 1 north entry, main entry)	140	31234	A	1	10.97	37.89	45.39	5.75	.46	......	......	......	......	6.3	6,352	11,434
Same (composite of samples 31233 and 31234)	140	31235	A	1	11.26	37.61	45.81	5.32	.45	5.75	64.99	1.54	21.95	6.6	6,368	11,462
				2	......	42.38	51.62	6.00	.51	5.07	73.24	1.74	13.44	......	7,176	12,917
				3	......	45.08	54.92	......	.54	5.39	77.91	1.85	14.31	......	7,634	13,741
10 miles south of, at Dunkley Canyon; NW. ¼ sec. 2, T. 4 N., R. 87 W.; Webber mine, Wadge bed (grab sample, face of entry, 125 feet from mine mouth).	141	30862	B	1	13.20	35.81	44.88	6.11	.53	5.68	62.75	1.44	23.49	3.3	6,095	10,971
				2	......	41.26	51.70	7.04	.61	4.85	72.29	1.66	13.55	......	7,022	12,640
				3	......	44.38	55.62	......	.66	5.22	77.76	1.79	14.57	......	7,554	13,597
Oak Creek, sec. 36, T. 4 N., R. 86 W.; Argo mine, Pinnacle bed (face of south entry, 5,000 feet southwest of mine mouth).	141	31130	A	1	8.48	39.05	49.24	3.23	.47	......	......	......	......	3.5	6,895	12,411
Same (15 feet from face of 9 slope, left rib, 120 feet below south entry).	141	31131	A	1	9.29	39.27	48.21	3.23	.48	......	......	......	......	3.8	6,803	12,245
Same (face of south slope, 375 feet below 4 level)	141	31132	A	1	7.98	39.03	46.57	6.42	.44	......	......	......	......	3.4	6,677	12,019
Same (face of 3 level, 2,100 feet from south slope)	141	31133	A	1	8.91	38.78	48.30	4.01	.45	......	......	......	......	3.4	6,786	12,215
Same (composite of samples 31130 to 31133)	141	31134	A	1	8.62	39.13	48.00	4.25	.41	5.75	69.41	1.50	18.68	3.5	6,787	12,217
				2	......	42.82	52.53	4.65	.45	5.24	75.96	1.64	12.06	......	7,427	13,369
				3	......	44.91	55.09	......	.47	5.50	79.67	1.72	12.64	......	7,789	14,020
WELD COUNTY.																
Erie, 6 miles northeast of; sec. 34, T. 2 N., R. 68 W.; Puritan mine (face of 13 room, 4 northwest entry).	142	*31323	A	1	24.63	29.83	41.96	3.58	.34	6.30	54.77	1.20	33.81	16.4	5,287	9,517
				2	......	39.58	55.67	4.75	.45	4.72	72.67	1.59	15.82	......	7,015	12,627
				3	......	41.56	58.44	......	.47	4.96	76.30	1.67	16.60	......	7,365	13,257
Frederick, ½ mile west of; sec. 36, T. 2 N., R. 68 W.; Baum mine (face of 13 room 16 northeast entry).	142	*31344	A	1	25.18	29.81	41.05	3.96	.37	6.29	53.63	1.20	34.55	19.8	5,114	9,205
				2	......	39.84	54.87	5.29	.49	4.66	71.68	1.60	16.28	......	6,835	12,303
				3	......	42.07	57.93	......	.52	4.92	75.69	1.69	17.18	......	7,217	12,991
IDAHO.																
FREMONT COUNTY.																
Monida, 15 miles east of; sec 11, T. 14 N., R. 38 E.; Scott & Buey mine (face of main entry, 110 feet from mine mouth).	143	*29281	B	1	18.37	31.09	40.09	10.45	.71	......	......	......	......	7.9	5,149	9,268
				2	......	38.09	49.11	12.80	.87	......	......	......	......	......	6,308	11,354
				3	......	43.68	56.32	......	1.00	......	......	......	......	......	7,234	13,021
TETON COUNTY.																
Driggs, 10 miles west of; sec. 36, T. 5 N., R. 43 E.; Bellent mine (face of main entry, 315 feet N. 35° W. of mine mouth).	143	29182	B	1	7.67	39.61	48.19	4.53	.54	5.94	70.82	1.37	16.80	4.8	6,986	12,575
				2	......	42.90	52.19	4.91	.58	5.51	76.71	1.48	10.81	......	7,567	13,621
				3	......	45.11	54.89	......	.61	5.79	80.67	1.56	11.87	......	7,957	14,323
Victor, 8 miles west of; sec 25 (?), T. 3 N., R. 44 E.; Pine Creek Pass mine (north wall of slope, 12 feet from mine mouth).	143	29280	B	1	20.34	20.10	28.97	30.59	1.12	......	......	......	......	14.3	3,513	6,323
				2	......	25.23	36.37	38.40	1.41	......	......	......	......	......	4,410	7,938
				3	......	40.96	59.04	......	2.29	......	......	......	......	......	7,159	12,886

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.
[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).
[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.
[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes *a* (page).	Sample. Laboratory No. *b*	Kind. *c*	Condition. *d*	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ILLINOIS.																
CHRISTIAN COUNTY.																
Pana, 1 mile northeast of; Springside mine, No. 6 bed (face of 20 main entry, main north entry, 5,400 feet from shaft).	143	25748	A	1	13.62	37.60	39.62	9.16	3.78	......	......	......	......	4.6	6,122	11,020
Same (face of 13 room, 17 west entry, main north entry, 5,400 feet from shaft).	143	25749	A	1	13.72	37.42	39.05	9.81	4.11	......	......	......	......	5.2	6,026	10,847
Same (face of 10 room, 5 south entry, 5 east entry, main north entry, 2,700 feet from shaft.)	143	25750	A	1	12.52	34.74	39.06	13.68	3.40	......	......	......	......	4.7	5,770	10,386
Same (face of 7 east entry, main north entry, 4,500 feet from shaft)	143	25751	A	1	12.31	38.59	39.15	9.95	3.54	......	......	......	......	3.9	6,159	11,086
Same (composite of samples 25748 to 25751)......................	143	25752	A	1	13.04	36.98	39.25	10.73	3.66	5.58	59.83	1.14	19.06	4.6	6,031	10,856
				2	......	42.53	45.13	12.34	4.21	4.75	68.80	1.31	8.59	......	6,936	12,485
				3	......	48.52	51.48	......	4.80	5.42	78.49	1.49	9.80	......	7,913	14,243
Same (face of 9 room, 14 north entry, main east south entry, 4,800 feet southeast from shaft).	143	26336	A	1	11.89	37.14	40.58	10.39	3.88	......	......	......	......	9.3	6,142	11,056
Same (face of main east south entry, 5,400 feet southeast from shaft).	143	26337	A	1	11.98	38.52	39.18	10.32	4.21	......	......	......	......	5.4	6,178	11,120
Same (composite of samples 26336 and 26337)....................	143	26338	A	1	11.93	38.21	39.50	10.36	4.00	5.73	61.37	1.02	17.52	7.3	6,159	11,086
				2	......	43.39	44.85	11.76	4.54	5.00	69.69	1.16	7.85	......	6,994	12,589
				3	......	49.17	50.83	......	5.15	5.67	78.98	1.31	8.89	......	7,926	14,267
FRANKLIN COUNTY.																
Buckner, ½ mile east of; United No. 14 mine, No. 6 bed (face of 8 panel, 6 north entry, main east entry, inby 9 room neck).	144	26129	A	1	10.61	33.39	48.37	7.63	1.02	5.74	67.41	1.53	16.67	6.9	6,586	11,855
				2	......	37.35	54.11	8.54	1.14	5.10	75.41	1.71	8.10	......	7,368	13,262
				3	......	40.84	59.16	......	1.25	5.58	82.45	1.87	8.85	......	8,056	14,501
Bush, 1¼ miles northwest of; sec. 31, T. 7 S., R. 1 E.; Bush No. 2 mine, No. 6 bed (face of main northeast entry).	145	30877	B	1	8.72	34.31	46.15	10.82	3.81	......	......	......	......	4.7	6,413	11,543
Same (end of northwest entry)..................................	145	30878	B	1	10.04	33.77	47.53	8.66	2.43	......	......	......	......	5.6	6,514	11,725
Same (face of 5 south entry, 2 west entry, south entry).........	145	30879	B	1	9.67	33.32	46.67	10.34	3.07	......	......	......	......	4.7	6,415	11,547
Same (end of main south entry)................................	145	30880	B	1	9.27	34.27	45.48	10.98	3.79	......	......	......	......	4.6	6,367	11,461

Same (composite of samples 30877 to 30880)	145	30881	B	1	9.41	34.06	46.30	10.23	3.29	5.30	64.41	1.27	15.50	4.9	6,417	11,551
				2	......	37.60	51.11	11.29	3.63	4.69	71.10	1.40	7.89	......	7,084	12,751
				3	......	42.39	57.61	......	4.09	5.29	80.15	1.58	8.89	......	7,986	14,375
Christopher, 1 mile north of; Old Ben No. 10 mine, No. 6 bed (last crosscut, 12 northeast entry, at mouth of 1 east entry).	146	29741	A	1	9.73	34.19	48.99	7.09	1.08	......	......	......	......	6.8	6,665	11,997
Same (12 room neck, 5 west entry, 6 southwest entry)	146	29742	A	1	10.34	33.70	46.90	9.06	.54	......	......	......	......	7.4	6,405	11,529
Same (face of 19 room, 100 feet from 10 northwest entry)	146	29743	A	1	9.28	34.17	48.77	7.78	.74	......	......	......	......	6.5	6,603	11,885
Same (last crosscut, 3 northeast entry, at mouth of 4 west entry)	146	29744	A	1	9.17	34.29	49.15	7.39	1.17	......	......	......	......	5.5	6,757	12,163
Same (face of 14 southwest entry, at 22 room)	146	29745	A	1	10.56	34.81	44.73	9.90	.45	......	......	......	......	7.8	6,308	11,354
Same (last crosscut, 11 west entry, 3 southeast entry, at 8 room)	146	29746	A	1	10.36	32.12	47.21	10.31	.56	......	......	......	......	7.4	6,292	11,326
Same (composite of samples 29741 to 29746)	146	29747	A	1	9.77	34.15	47.45	8.63	.75	5.34	66.23	1.51	17.54	6.9	6,514	11,725
				2	......	37.85	52.59	9.56	.83	4.71	73.40	1.67	9.83	......	7,219	12,994
				3	......	41.85	58.15	......	.92	5.21	81.16	1.85	10.86	......	7,982	14,368
Same (at 18 room, 10 northwest entry, 60 feet from entry; top coal)	146	29754	A	1	9.50	36.82	49.82	3.86	.79	......	......	......	......	5.3	6,953	12,515
				2	......	40.69	55.04	4.27	.87	......	......	......	......	......	7,683	13,829
				3	......	42.50	57.50	......	.91	......	......	......	......	......	8,026	14,447
1¾ miles north of; sec. 14, T. 6 S., R. 1 E.; Old Ben No. 11 mine, No. 6 bed (face of 2 north entry, 12 west entry, 1 northwest entry).	146	30892	B	1	10.04	35.48	47.29	7.19	.77	......	......	......	......	3.8	6,636	11,945
Same (face of main west entry)	146	30893	B	1	11.33	32.38	47.18	9.11	.59	......	......	......	......	4.3	6,350	11,430
Same (face of 1 northeast entry)	146	30894	B	1	9.04	36.20	47.86	6.90	1.28	......	......	......	......	3.9	6,758	12,164
Same (face of 1 southeast entry, 4 east panel, 29 room)	146	30895	B	1	10.43	33.10	48.50	7.97	.52	......	......	......	......	3.6	6,507	11,713
Same (composite of samples 30892 to 30895)	146	30896	B	1	10.18	34.31	47.79	7.72	.77	5.53	66.64	1.54	17.80	3.9	6,571	11,828
				2	......	38.20	53.21	8.59	.86	4.90	74.19	1.71	9.75	......	7,315	13,167
				3	......	41.79	58.21	......	.94	5.36	81.16	1.87	10.67	......	8,003	14,405
Herrin, 4 miles north and 1 mile east of; sec. 33, T. 7 S., R. 2 E.; No. 5 (Franklin Emery) mine, No. 6 bed (face of 14 room, 7 northwest entry).	147	30867	B	1	10.74	32.20	50.91	6.15	.83	......	......	......	......	4.9	6,667	12,001
Same (crosscut between 1 and 2 northeast entries)	147	30868	B	1	10.36	32.52	47.17	9.95	.63	......	......	......	......	5.1	6,309	11,356
Same (face of 3 room, 7 southeast entry)	147	30869	B	1	9.86	32.38	49.68	8.08	.93	......	......	......	......	4.2	6,625	11,925
Same (stub of 7 west entry, 4 south entry, west entry)	147	30870	B	1	10.91	32.32	50.89	5.88	.56	......	......	......	......	5.1	6,694	12,049
Same (composite of samples 30867 to 30870)	147	30871	B	1	10.54	32.42	49.33	7.71	.72	5.40	66.92	1.48	17.77	4.8	6,566	11,819
				2	......	36.24	55.14	8.62	.80	4.73	74.80	1.65	9.40	......	7,339	13,210
				3	......	39.66	60.34	......	.88	5.18	81.85	1.81	10.28	......	8,031	14,456
Orient, Orient mine, No. 6 bed (car sample from 15 loaded cars)		30266	C	1	7.86	34.10	49.62	8.42	1.18	5.32	68.19	1.54	15.35	2.9	6,745	12,141
	148			2	......	37.01	53.85	9.14	1.28	4.83	74.01	1.67	9.07	......	7,320	13,176
				3	......	40.73	59.27	......	1.41	5.32	81.46	1.84	9.97	......	8,056	14,501
Same (car sample from 17 loaded cars)	148	30267	C	1	7.83	34.70	47.96	9.51	1.20	5.33	67.25	1.58	15.18	2.8	6,646	11,963
				2	......	37.65	52.03	10.32	1.30	4.84	72.97	1.66	8.91	......	7,211	12,980
				3	......	41.98	58.02	......	1.45	5.40	81.37	1.85	9.93	......	8,041	14,474
Same (car sample from 32 loaded cars)	148	30644	C	1	8.02	35.66	48.46	7.86	1.07	5.38	68.57	1.55	15.57	1.7	6,738	12,128
				2	......	38.77	52.68	8.55	1.16	4.88	74.55	1.69	9.17	......	7,326	13,187
				3	......	42.39	57.60	......	1.26	5.34	81.52	1.85	10.02	......	8,011	14,420
Same (car sample from 159 loaded cars)	148	31050	C	1	7.35	36.70	47.88	8.07	1.02	5.35	69.00	1.57	14.99	3.1	6,758	12,164
				2	......	39.61	51.68	8.71	1.10	4.89	74.47	1.69	9.14	......	7,294	13,129
				3	......	43.39	56.61	......	1.20	5.36	81.57	1.85	10.02	......	7,990	14,382

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ILLINOIS—Continued.																
FRANKLIN COUNTY—continued.																
Royalton, North or No. 1 mine, No. 6 bed (car sample from 13 loaded cars)	148	30205	C	1	7.64	31.37	50.03	10.96	1.06	5.06	66.21	1.45	15.26	4.4	6,493	11,687
				2	......	33.96	54.17	11.87	1.15	4.56	71.69	1.57	9.16	......	7,030	12,654
				3	......	38.53	61.47	......	1.30	5.17	81.35	1.78	10.40	......	7,977	14,359
Same (car sample from 22 loaded cars)	148	30207	C	1	8.86	31.23	49.28	10.63	1.10	5.23	65.97	1.48	15.59	5.9	6,446	11,603
				2	......	34.27	54.07	11.66	1.21	4.66	72.38	1.62	8.47	......	7,073	12,731
				3	......	38.79	61.21	......	1.37	5.28	81.93	1.83	9.59	......	8,007	14,413
Sesser, 1½ miles southeast of; Sesser No. 1 mine, No. 6 bed (face of main east entry).	148	26492	A	1	9.54	32.91	48.41	9.14	.98	......	......	......	......	7.2	6,540	11,772
Same (face of 1 new south entry, main east entry)	148	26493	A	1	9.58	33.25	50.16	7.01	1.08	......	......	......	......	6.6	6,695	12,051
Same (face of 2 room, 3,200 feet E. 10° S.)	148	26494	A	1	10.97	33.70	46.86	8.47	.99	......	......	......	......	7.9	6,484	11,671
Same (face of main north entry)	148	26495	A	1	10.26	33.17	48.39	8.18	1.31	......	......	......	......	6.2	6,588	11,858
Same (face of 8 east entry, main north entry)	148	26496	A	1	9.68	32.90	48.35	9.07	1.09	......	......	......	......	6.9	6,496	11,693
Same (composite of samples 26492 to 26496)	148	26497	A	1	10.06	33.40	48.19	8.35	1.11	5.47	66.77	1.27	17.03	7.0	6,565	11,817
				2	......	37.14	53.58	9.28	1.23	4.84	74.24	1.41	9.00	......	7,300	13,140
				3	......	40.94	59.06	......	1.36	5.34	81.83	1.55	9.92	......	8,047	14,485
Same (car sample from 9 loaded cars)	148	30206	C	1	8.49	34.11	48.71	8.69	1.11	5.29	67.86	1.46	15.59	4.8	6,702	12,064
				2	......	37.28	53.22	9.50	1.21	4.75	74.16	1.60	8.78	......	7,324	13,183
				3	......	41.19	58.81	......	1.34	5.25	81.95	1.77	9.69	......	8,093	14,567
Same (car sample from 5 loaded cars)	148	30208	C	1	8.05	34.51	47.67	9.77	1.06	5.40	67.21	1.49	15.07	4.8	6,626	11,927
				2	......	37.53	51.85	10.62	1.15	4.90	73.09	1.62	8.62	......	7,206	12,971
				3	......	41.99	58.01	......	1.29	5.48	81.78	1.81	9.64	......	8,063	14,513
Same (car sample from 10 loaded cars)	148	30485	C	1	9.66	34.06	47.27	9.01	1.17	5.47	66.65	1.43	16.27	3.1	6,592	11,866
				2	......	37.70	52.33	9.97	1.30	4.87	73.77	1.58	8.51	......	7,297	13,135
				3	......	41.87	58.13	......	1.44	5.41	81.94	1.75	9.46	......	8,105	14,589
Same (car sample from 8 loaded cars)	148	30486	C	1	10.04	33.61	48.01	8.34	1.10	5.47	67.19	1.51	16.39	3.3	6,610	11,898
				2	......	37.36	53.37	9.27	1.22	4.84	74.69	1.68	8.30	......	7,348	13,226
				3	......	41.18	58.82	......	1.34	5.33	82.32	1.85	9.16	......	8,099	14,578

West Frankfort, ½ mile south of; sec. 25, T. 7 S., R. 2 E., Old Ben No. 8 mine, No. 6 bed (face of 4 east north entry).	149	30887	B	1	11.15	33.95	47.50	7.40	1.36	......	......	......	......	6.9	6,519	11,734
Same (face of 6 west entry, main south entry)	149	30888	B	1	9.08	34.99	48.21	7.72	1.43	......	......	......	......	5.5	6,677	12,019
Same (face of main south entry)	149	30889	B	1	10.31	33.54	49.91	6.24	1.11	......	......	......	......	6.3	6,697	12,055
Same (composite of samples 30887 to 30889)	149	30890	B	1	10.38	33.42	49.00	7.20	1.26	5.43	67.76	1.52	16.83	6.3	6,616	11,909
				2	......	37.29	54.68	8.03	1.41	4.78	75.61	1.70	8.47	......	7,382	13,288
				3	......	40.55	59.45	......	1.53	5.20	82.21	1.85	9.21	......	8,026	14,447
1 mile east of; sec. 20, T. 7 S., R. 3 E.; Old Ben No. 9 mine, No. 6 bed (face of 4 west entry, main south entry).	150	30882	B	1	9.94	33.39	48.99	7.68	1.14	......	......	......	......	6.0	6,600	11,880
Same (face of 1 east entry, northeast entry)	150	30883	B	1	10.04	33.08	49.42	7.46	1.24	......	......	......	......	6.1	6,610	11,898
Same (face of main south entry)	150	30884	B	1	10.73	33.02	47.65	8.60	1.61	......	......	......	......	7.0	6,465	11,637
Same (face of back north entry)	150	30885	B	1	10.05	33.93	48.58	7.44	1.40	......	......	......	......	5.5	6,602	11,884
Same (composite of samples 30882 to 30885)	150	30886	B	1	10.23	33.76	48.26	7.75	1.33	5.36	66.85	1.45	17.26	6.1	6,597	11,875
				2	......	37.61	53.76	8.63	1.48	4.70	74.47	1.62	9.10	......	7,349	13,228
				3	......	41.16	58.84	......	1.62	5.14	81.51	1.77	9.96	......	8,043	14,477
PERRY COUNTY.																
Duquoin, 3 miles east of; Paradise mine, No. 6 bed (face of 26 room, 2 south entry, main east entry).	150	26462	A	1	10.45	33.92	47.88	7.75	.83	......	......	......	......	6.0	6,516	11,729
Same (face of 12 south entry, 2 plug east entry)	150	26463	A	1	10.66	33.04	47.60	8.70	.82	......	......	......	......	4.9	6,439	11,590
Same (face of main east entry)	150	26464	A	1	10.61	33.04	46.72	9.63	1.02	......	......	......	......	5.6	6,340	11,412
Same (face of main north entry)	150	26465	A	1	11.26	33.84	46.18	8.72	.80	......	......	......	......	2.4	6,380	11,484
Same (face of 7 west entry, main north entry)	150	26466	A	1	11.75	33.49	45.94	8.82	.78	......	......	......	......	6.7	6,329	11,392
Same (face of 9 south entry, 5 west entry, main north entry)	150	26467	A	1	11.47	32.81	47.22	8.50	1.08	......	......	......	......	5.6	6,380	11,484
Same (composite of samples 26462 to 26467)	150	26468	A	1	10.76	33.10	47.37	8.77	.84	5.38	64.49	1.36	19.16	5.2	6,402	11,524
				2	......	37.09	53.08	9.83	.94	4.68	72.27	1.52	10.76	......	7,174	12,913
				3	......	41.13	58.87	......	1.04	5.19	80.15	1.69	11.93	......	7,956	14,321
Same (face of 6 room, 10 south entry, main east entry, top coal)	151	26469	A	1	13.73	33.99	49.58	2.70	.77	......	......	......	......	7.8	6,702	12,064
				2	......	39.40	57.47	3.13	.89	......	......	......	......	......	7,769	13,984
				3	......	40.67	59.33	......	.92	......	......	......	......	......	8,020	14,436
3 miles south of; sec. 29, T. 6 S., R. 1 W.; Security No. 1 mine, No. 6 bed (face of 2 room, 17 north entry, 4 west north entry).	151	31033	B	1	12.34	33.48	45.02	9.16	1.82	......	......	......	......	7.2	6,206	11,171
Same (face of 3 south entry, 8 west south entry)	151	31034	B	1	12.19	34.16	44.50	9.15	1.32	......	......	......	......	6.9	6,247	11,245
Same (face of 8 room, south of 6 east south entry)	151	31035	B	1	11.93	33.50	45.35	9.22	1.36	......	......	......	......	7.2	6,254	11,257
Same (face of 18 room, south entry, 4 west south entry)	151	31036	B	1	11.86	34.13	44.63	9.38	1.46	......	......	......	......	7.0	6,242	11,236
Same (composite of samples 31033 to 31036)	151	31037	B	1	12.04	33.89	44.85	9.22	1.52	5.51	63.13	1.32	19.30	7.1	6,237	11,227
				2	......	38.53	50.99	10.48	1.73	4.74	71.77	1.50	9.78	......	7,091	12,764
				3	......	43.04	56.96	......	1.93	5.30	80.17	1.68	10.92	......	7,921	14,258
SALINE COUNTY.																
Grayson, 2½ miles east of Eldorado; No. 6 mine, No. 5 bed (face of 7 room, 8 east entry, 3 southwest entry).	152	28448	A	1	4.73	37.88	47.70	9.69	4.13	......	......	......	......	2.7	6,924	12,463
Same (face of 5 west entry, 4 southwest entry)	152	28449	A	1	4.94	39.50	45.79	9.77	3.94	......	......	......	......	2.3	6,900	12,420
Same (composite of samples 28448 and 28449)	152	28450	A	1	4.71	38.50	46.90	9.89	4.08	5.53	68.87	1.45	10.18	2.5	6,928	12,470
				2	......	40.40	49.22	10.38	4.28	5.26	72.27	1.52	6.30	......	7,270	13,086
				3	......	45.08	54.92	......	4.78	5.87	80.64	1.70	7.01	......	8,112	14,602

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C., 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ILLINOIS—Continued.																
WILLIAMSON COUNTY.																
Herrin, 4 miles northeast of; sec. 5, T. 8 S., R. 2 E.; Pond Creek (Bobby Dix) mine, No. 6 bed (face at end of main south entry).	152	30872	B	1	9.13	32.21	47.97	10.69	0.80	......	......	......	......	3.0	3,689	11,500
Same (face at end of main north entry)........	152	30873	B	1	8.84	32.52	49.81	8.83	1.09	......	......	......	......	2.6	6,596	11,873
Same (face of 6 east entry, main south entry)........	152	30874	B	1	9.75	33.36	51.37	5.52	.88	......	......	......	......	3.6	6,822	12,280
Same (face of 5 south west entry)........	152	30875	B	1	10.82	31.11	49.02	9.05	.88	......	......	......	......	4.5	6,470	11,646
Same (composite of samples 30872 to 30875)........	152	30876	B	1	9.44	32.99	48.95	8.62	.93	5.17	67.06	1.51	16.71	3.4	6,588	11,858
				2	......	36.43	54.05	9.52	1.03	4.55	74.05	1.67	9.18	......	7,274	13,093
				3	......	40.26	59.74	......	1.14	5.03	81.84	1.85	10.14	......	8,039	14,470
3½ miles northwest of; sec. 1, T. 8 S., R. 1 E.; No. 2 (Weaver) mine, No. 6 bed (face of back south entry, main south entry).	153	30863	B	1	9.72	32.84	50.65	6.79	.96	......	......	......	......	3.5	6,681	12,026
Same (face of 3 west entry, main north entry)........	153	30864	B	1	9.40	34.38	47.35	8.87	1.28	......	......	......	......	3.9	6,556	11,801
Same (face of 7 west south entry)........	153	30865	B	1	10.58	32.47	46.30	10.65	1.57	......	......	......	......	5.7	6,290	11,322
Same (composite of samples 30863 to 30865)........	153	30866	B	1	9.94	32.92	48.30	8.84	1.28	5.34	66.18	1.46	16.90	4.4	6,508	11,714
				2	......	36.55	53.63	9.82	1.42	4.71	73.49	1.62	8.94	......	7,226	13,007
				3	......	40.53	59.47	......	1.57	5.22	81.49	1.80	9.92	......	8,013	14,423
4½ miles northwest of; Rend No. 2 mine, No. 6 bed (face of 7 room, 1 south stub entry, 8 west entry, main south entry).	154	28811	A	1	9.13	31.48	51.00	8.39	.97	......	......	......	......	3.6	6,568	11,822
Same (face of 10 east entry, main south entry)........	154	28810	A	1	8.31	32.40	50.75	8.54	1.33	......	......	......	......	3.2	6,647	11,965
Same (face of 12 room, 3 west entry, main north entry)........	154	28812	A	1	8.82	35.15	47.90	8.13	1.07	......	......	......	......	3.2	6,647	11,965
Same (face of 2 room, 2 north panel, 2 east entry, main north entry).	154	28813	A	1	9.31	32.93	49.63	8.13	.82	......	......	......	......	3.8	6,612	11,902
Same (face of 26 room, 1 east entry, main south entry)........	154	28814	A	1	9.78	33.08	49.93	7.21	.75	......	......	......	......	3.6	6,647	11,965
Same (composite of samples 28810 to 28814)........	154	28815	A	1	9.33	32.76	49.94	7.97	.97	5.48	67.05	1.43	17.10	3.8	6,618	11,912
				2	......	36.13	55.08	8.79	1.07	4.90	73.95	1.58	9.71	......	7,299	13,138
				3	......	39.61	60.39	......	1.17	5.37	81.08	1.73	10.65	......	8,003	14,405
INDIANA.																
GREENE COUNTY.																
Jasonville, 3 miles southwest of; Gilmour No. 7 mine, No. 4 bed (10 feet from face of 15 east entry, south).	154	31295	A	1	13.38	36.69	43.10	6.83	1.39	......	......	......	......	10.3	6,481	11,666
Same (face of 6 room, 6 south entry, 15 east entry, south)........	154	31296	A	1	13.09	36.93	43.23	6.75	1.13	......	......	......	......	10.0	6,482	11,668
Same (face of 17 east entry, south entry, opposite 4 south entry).	154	31297	A	1	14.66	35.39	43.57	6.38	1.05	......	......	......	......	11.6	6,388	11,498

Same (face of 5 room, 2 south entry, 18 west entry, south)	155	31298	A	1	12.78	35.91	42.09	9.22	1.02					9.7	6,332	11,398
Same (composite of samples 31295 to 31298)	155	31299	A	1	13.51	36.26	42.93	7.30	1.08	5.82	64.51	1.45	19.84	10.4	6,413	11,543
				2		41.92	49.64	8.44	1.25	4.99	74.59	1.68	9.05		7,415	13,347
				3		45.79	54.21		1.37	5.45	81.47	1.83	9.88		8,099	14,578
Linton, 2 miles northwest of; Vandalia No. 24 mine, No. 4 bed (face of 4 room, 5 east entry, 5 north entry).	155	31278	A	1	13.72	36.84	42.94	6.50	.97					10.1	6,515	11,727
Same (face of 4 north entry, 600 feet from main west entry)	155	31279	A	1	13.61	36.98	41.47	7.94	1.40					10.6	6,403	11,525
Same (face of 9 northwest entry, opposite 15 room)	155	31280	A	1	11.88	38.84	42.08	7.20	1.52					8.7	6,582	11,848
Same (composite of samples 31278 to 31280)	155	31281	A	1	12.99	37.21	42.63	7.17	1.32	5.89	64.91	1.47	19.24	9.8	6,480	11,664
				2		42.77	48.99	8.24	1.52	5.11	74.60	1.69	8.84		7,447	13,405
				3		46.61	53.39		1.66	5.57	81.30	1.84	9.63		8,116	14,609
KNOX COUNTY.																
South Bruceville, 1½ miles south of Bruceville, in Washington Township; T. 4 N., R 9 W.; No. 1 mine, No. 5 bed (face of 4 room, 4 southeast entry).	156	27632	A	1	9.70	38.57	42.02	9.71	3.04					7.5	6,477	11,659
Same (face of 14 room, 1 north entry, main east entry)	156	27633	A	1	9.73	37.13	40.84	12.30	3.19					7.5	6,266	11,279
Same (face of 2 west entry, straight south entry)	156	27634	A	1	8.97	38.46	41.70	10.87	3.45					6.7	6,449	11,608
Same (composite of samples 27632 to 27634)	156	27635	A	1	9.47	38.27	41.36	10.90	3.21	5.53	62.28	.98	17.10	7.2	6,412	11,542
				2		42.27	45.69	12.04	3.55	4.95	68.79	1.08	9.59		7,083	12,749
				3		48.06	51.94		4.04	5.63	78.21	1.23	10.89		8,053	14,495
Same (3 breakthrough from face of 2 west entry, straight south entry, lower half of bed).	156	27636	A	1	10.18	38.36	40.79	10.67	3.37					8.0	6,365	11,457
				2		42.71	45.41	11.88	3.75						7,086	12,755
				3		48.47	51.53		4.26						8,041	14,474
Same (face of 10 room, 1 southeast entry)	156	27660	A	1	10.14	37.11	43.71	9.04	3.00	5.65	64.88	1.18	16.25	7.1	6,512	11,722
				2		41.30	48.64	10.06	3.34	5.03	72.20	1.31	8.06		7,247	13,045
				3		45.92	54.08		3.71	5.59	80.28	1.46	8.96		8,058	14,504
Same (face of 8 room, 2 east entry, back north entry)	156	27661	A	1	10.47	37.22	40.53	11.78	3.12	5.39	62.09	1.22	16.40	7.6	6,271	11,288
				2		41.57	45.27	13.16	3.48	4.72	69.35	1.36	7.93		7,004	12,607
				3		47.87	52.13		4.01	5.44	79.86	1.57	9.12		8,065	14,517
PIKE COUNTY.																
Winslow, Ayrshire No. 7 mine, No. 5 bed (car sample from 10 loaded cars).	157	30228	C	1	12.31	35.05	46.54	6.10	.97	5.92	66.53	1.51	18.97	9.6	6,609	11,896
				2		39.97	53.07	6.96	1.11	5.19	75.87	1.72	9.15		7,537	13,567
				3		42.96	57.04		1.19	5.58	81.55	1.85	9.83		8,101	14,582
Same (car sample from 10 loaded cars)	157	30229	C	1	13.23	34.59	46.72	5.46	.89	5.96	66.35	1.48	19.86	10.6	6,567	11,821
				2		39.86	53.85	6.29	1.03	5.17	76.47	1.71	9.33		7,568	13,622
				3		42.53	57.47		1.10	5.52	81.60	1.82	9.96		8,076	14,537
Same (car sample from 10 loaded cars)	157	30230	C	1	12.98	35.74	45.56	5.72	.88	5.96	66.43	1.54	19.47	9.9	6,578	11,840
				2		41.07	52.36	6.57	1.01	5.19	76.34	1.77	9.12		7,559	13,606
				3		43.96	56.04		1.08	5.55	81.71	1.89	9.77		8,090	14,562
Same (car sample from 5 loaded cars)	157	30231	C	1	13.02	35.53	46.41	5.04	.96	6.02	66.87	1.54	19.57	10.3	6,631	11,936
				2		40.85	53.36	5.79	1.10	5.25	76.88	1.77	9.21		7,624	13,723
				3		43.36	56.64		1.17	5.57	81.61	1.88	9.77		8,093	14,567
Same (car sample from loading boom while car was being loaded)	157	30843	C	1	12.73	36.04	45.72	5.51	.93	5.85	66.80	1.50	19.41	3.6	6,589	11,860
				2		41.30	52.39	6.31	1.07	5.09	76.55	1.72	9.26		7,550	13,590
				3		44.08	55.92		1.14	5.43	81.71	1.84	9.88		8,059	14,506

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample: Laboratory No.[b]	Sample: Kind.[c]	Sample: Condition.[d]	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
INDIANA—Continued.																
SULLIVAN COUNTY.																
Dugger, 1½ miles southwest of; Vandalia No. 10 mine, No. 4 bed (face of main north entry, opposite 15 east entry).	157	31262	A	1	14.32	34.01	44.94	6.73	1.32	......	......	......	......	11.4	6,467	11,641
Same (face of 3 west entry, 2 south entry, 500 feet from 1 south entry).	157	31263	A	1	12.37	36.35	44.94	6.34	1.81	......	......	......	......	8.8	6,613	11,903
Same (face of 20 room, 14 north entry, 14 east north)	157	31264	A	1	11.39	37.37	43.35	7.89	1.50	......	......	......	......	8.4	6,611	11,900
Same (opposite 14 room, 2 south entry, 3 east entry, 3 south entry).	157	31265	A	1	12.30	35.87	44.91	6.92	1.43	......	......	......	......	9.3	6,582	11,848
Same (face of main north entry, opposite 15 east entry; "mother coal."	157	31266	A	1	25.98	13.84	57.83	2.35	.25	5.32	64.66	0.58	26.84	24.9	5,931	10,676
				2	......	18.70	78.13	3.17	.34	3.28	87.36	.78	5.07	......	8,013	14,423
				3	......	19.31	80.69	......	.35	3.39	90.22	.81	5.23	......	8,275	14,895
Same (composite of samples 31262 to 31265)	157	31267	A	1	12.61	36.02	44.49	6.88	1.51	5.87	65.65	1.48	18.61	9.5	6,552	11,794
				2	......	41.22	50.91	7.87	1.73	5.12	75.12	1.69	8.47	......	7,497	13,495
				3	......	44.74	55.26	......	1.88	5.56	81.54	1.83	9.19	......	8,137	14,647
2¼ miles southwest of; Vandalia No. 22 mine, No. 4 bed (face of main south entry).	158	31274	A	1	10.70	37.89	42.23	9.18	2.69	......	......	......	......	8.2	6,523	11,741
Same (face of main air course)	158	31275	A	1	11.03	38.51	43.69	6.77	1.90	......	......	......	......	7.4	6,708	12,074
Same (face of 1 west entry, main north entry)	158	31276	A	1	10.92	38.26	42.95	7.87	3.24	......	......	......	......	8.4	6,625	11,925
Same (composite of samples 31274 to 31276)	158	31277	A	1	10.84	38.42	42.78	7.96	2.63	5.76	65.36	1.44	16.85	8.0	6,601	11,882
				2	......	43.09	47.98	8.93	2.95	5.11	73.31	1.62	8.08	......	7,404	13,327
				3	......	47.32	52.68	......	3.24	5.61	80.50	1.78	8.87	......	8,130	14,634
3 miles north of; Ayrdale No. 27 mine, No. 4 bed (50 feet from 2 east entry, 5 northeast entry).	159	31290	A	1	12.78	36.51	43.97	6.74	1.23	......	......	......	......	9.8	6,515	11,727
Same (50 feet from 3 south entry, 3 southeast entry)	159	31291	A	1	12.35	36.39	43.54	7.72	1.46	......	......	......	......	9.3	6,492	11,686
Same (face of 23 room, 5 north entry, east entry)	159	31292	A	1	12.49	37.13	42.89	7.49	1.12	......	......	......	......	9.6	6,509	11,716
Same (face of 5 room, 1 west entry, 1 north entry, 3 east entry, north entry.)	159	31293	A	1	12.88	35.12	45.28	6.72	1.15	......	......	......	......	9.9	6,533	11,759
Same (composite of samples 31290 to 31292)	159	31294	A	1	12.67	35.86	44.31	7.16	1.21	5.86	65.33	1.46	18.98	9.6	6,516	11,729
				2	......	41.06	50.74	8.20	1.39	5.10	74.81	1.67	8.83	......	7,461	13,430
				3	......	44.73	55.27	......	1.51	5.56	81.49	1.82	9.62	......	8,127	14,629

Sullivan, 5 miles east of; Vandalia No. 17 mine, No. 6 bed (face of 1 room, 5 north entry, east entry).	160	31268	A	1	12.49	36.32	43.33	7.86	2.34	.....	.....	.....	.....	8.8	6,425	11,565
Same (face of 9 room, 2 south entry, west entry)	160	31269	A	1	12.71	36.90	42.12	8.27	2.26	.....	.....	.....	.....	9.4	6,363	11,453
Same (face of 13 room, 4 southeast entry)	160	31270	A	1	14.30	36.19	41.93	7.58	2.02	.....	.....	.....	.....	10.6	6,318	11,372
Same (face of 3 north entry, east entry, opposite 13 room)	160	31271	A	1	11.76	37.03	42.49	8.72	2.57	.....	.....	.....	.....	8.0	6,413	11,543
Same (face of 2 west entry, 2 north entry, west entry)	160	31272	A	1	10.89	36.15	41.92	11.04	2.42	.....	.....	.....	.....	7.5	6,291	11,324
Same (composite of samples 31268 to 31272)	160	31273	A	1	12.38	36.63	42.28	8.71	2.26	5.70	63.41	1.28	18.64	8.9	6,342	11,416
				2	.....	41.81	48.25	9.94	2.58	4.93	72.37	1.46	8.72	.....	7,238	13,028
				3	.....	46.43	53.57	.....	2.86	5.47	80.36	1.62	9.69	.....	8,037	14,467
7 miles east of; Vandalia No. 28 mine, No. 4 bed (100 feet south of air shaft).	160	31282	A	1	14.94	35.52	43.70	5.84	.96	.....	.....	.....	.....	12.3	6,436	11,585
Same (100 feet north of air shaft)	160	31283	A	1	14.11	35.12	43.54	7.23	1.44	.....	.....	.....	.....	11.0	6,345	11,421
Same (face of 1 east entry, south entry, 60 feet from shaft)	160	31284	A	1	15.58	34.24	43.30	6.88	1.24	.....	.....	.....	.....	12.7	6,256	11,261
Same (composite of samples 31282 to 31284)	160	31285	A	1	14.93	34.32	44.10	6.65	1.27	5.93	63.79	1.43	20.93	12.0	6,342	11,416
				2	.....	40.34	51.84	7.82	1.49	5.02	74.99	1.68	9.00	.....	7,455	13,419
			A	3	.....	43.76	56.24	.....	1.62	5.45	81.35	1.82	9.76	.....	8,087	14,557
VERMILION COUNTY.																
Clinton, 3½ miles southwest of; Clinton No. 4 mine, No 4 bed (face of 8 south entry).	161	31257	A	1	14.32	34.68	44.14	6.86	1.10	.....	.....	.....	.....	10.4	6,359	11,446
Same (face of 1 room, 15 south entry, 16 west entry)	161	31258	A	1	15.58	35.06	42.27	7.09	.82	.....	.....	.....	.....	11.3	6,207	11,173
Same (face of 3 east entry, 8 south entry)	161	31259	A	1	15.30	33.40	43.50	7.80	1.05	.....	.....	.....	.....	12.0	6,160	11,088
Same (face of 7 room, 1 north entry, main west entry)	161	31260	A	1	13.57	35.38	43.81	7.24	1.33	.....	.....	.....	.....	9.8	6,382	11,488
Same (composite of samples 31257 to 31260)	161	31261	A	1	14.68	34.21	43.86	7.25	1.10	5.89	63.48	1.38	20.90	10.9	6,293	11,327
				2	.....	40.10	51.40	8.50	1.29	4.99	74.40	1.62	9.20	.....	7,376	13,277
				3	.....	43.83	56.17	.....	1.41	5.45	81.31	1.77	10.06	.....	8,061	14,510
VIGO COUNTY.																
Coal Bluff, 1 mile northwest of; Vigo No. 74 mine, Minshall bed (face of 12 east south entry, near mouth of 14 room; bony coal).	162	26118	A	1	11.77	37.17	39.24	11.82	2.28	.....	.....	.....	.....	8.8	.....	.....
				2	.....	42.13	44.47	13.40	2.58	.....	.....	.....	.....	.....	.....	.....
				3	.....	48.65	51.35	.....	2.98	.....	.....	.....	.....	.....	.....	.....
Same (face of 6 room, 106 feet inby 14 west south entry)	162	26119	A	1	12.57	37.98	41.13	8.32	2.85	.....	.....	.....	.....	9.5	6,428	11,570
Same (face of main south entry, 50 feet inby 16 east entry)	162	26120	A	1	12.54	36.05	41.54	9.87	3.82	.....	.....	.....	.....	9.3	6,232	11,218
Same (face of 34 room, 7 west entry, 200 feet from entry)	162	26121	A	1	13.60	37.47	40.46	8.47	2.45	.....	.....	.....	.....	10.4	6,301	11,342
Same (at 2 breakthrough, 6 room, 3 north entry, 7 west entry)	162	26122	A	1	12.73	37.72	42.56	6.99	1.60	.....	.....	.....	.....	7.7	6,499	11,698
Same (face of 12 east south entry, near mouth of 14 room)	162	26123	A	1	13.86	36.68	41.72	7.74	2.45	.....	.....	.....	.....	9.0	6,370	11,466
Same (composite of samples 26119 to 26123)	162	26124	A	1	13.10	36.83	41.73	8.34	2.60	6.01	63.37	1.29	18.39	9.2	6,380	11,484
				2	.....	42.38	48.02	9.60	2.99	5.24	72.92	1.48	7.77	.....	7,341	13,214
				3	.....	46.88	53.12	.....	3.31	5.80	80.66	1.64	8.59	.....	8,121	14,618
Terre Haute, 5 miles west of; Vandalia No. 82 mine, No. 3 bed (face of 4 south entry).	163	31286	A	1	9.78	39.79	41.09	9.34	4.00	.....	.....	.....	.....	6.7	6,529	11,752
Same (face of main east entry)	163	31287	A	1	9.78	38.38	39.81	12.03	5.38	.....	.....	.....	.....	6.9	6,309	11,356
Same (face of 2 west entry)	163	31288	A	1	9.38	38.91	40.34	11.37	5.56	.....	.....	.....	.....	6.2	6,393	11,507
Same (composite of samples 31286 to 31288)	163	31289	A	1	9.73	38.52	40.91	10.84	5.00	5.54	62.14	1.25	15.23	6.6	6,396	11,513
				2	.....	42.67	45.32	12.01	5.54	4.94	68.84	1.38	7.29	.....	7,085	12,753
				3	.....	48.49	51.51	.....	6.30	5.61	78.24	1.57	8.28	.....	8,052	14,494

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KANSAS.																
CHEROKEE COUNTY.																
Stone City, ½ mile northeast of; Mayer No. 9 mine, Cherokee bed (face of 1 east entry, north entry).	164	27222	A	1	5.16	34.78	51.62	8.44	3.27	......	......	......	......	3.6	7,237	13,027
				2	......	36.67	54.43	8.90	3.45	......	......	......	......	......	7,631	13,736
				3	......	40.25	59.75	......	3.79	......	......	......	......	......	8,377	15,079
Same (in last crosscut between straight and back north entries).	164	27223	A	1	6.22	33.38	52.04	8.36	3.01	......	......	......	......	4.5	7,161	12,890
				2	......	35.59	55.50	8.91	3.21	......	......	......	......	......	7,636	13,745
				3	......	39.07	60.93	......	3.52	......	......	......	......	......	8,383	15,089
Same (in last crosscut between straight and back north entries).	164	27224	A	1	6.19	33.32	52.63	7.86	2.82	......	......	......	......	4.5	7,216	12,989
				2	......	35.52	56.10	8.38	3.01	......	......	......	......	......	7,692	13,846
				3	......	38.77	61.23	......	3.29	......	......	......	......	......	8,396	15,113
Same (face of 1 east entry, north entry)	164	27225	A	1	5.09	34.47	52.17	8.27	3.34	5.23	71.81	1.20	10.15	3.6	7,268	13,082
				2	......	36.32	54.97	8.71	3.52	4.91	75.66	1.26	5.94	......	7,658	13,784
				3	......	39.78	60.22	......	3.86	5.38	82.88	1.38	6.50	......	8,389	15,100
CRAWFORD COUNTY.																
Edison, ½ mile north of, SW. ¼ sec. 13, T. 29 S., R. 24 E.; Wear No. 21 mine, Cherokee bed (face of 1 room, 1 stub north entry, 5 west entry, main east entry).	164	30293	A	1	3.31	34.34	50.12	12.23	4.87	......	......	......	......	1.8	6,973	12,551
Same (face of 1 room, 1 stub north entry, 5 west entry, 1 north entry, main east entry).	164	30294	A	1	4.17	34.16	50.16	11.51	4.68	......	......	......	......	2.7	6,909	12,436
Same (composite of samples 30293 and 30294)	164	30295	A	1	3.89	34.25	50.06	11.80	4.65	4.86	68.84	1.15	8.70	2.3	6,942	12,496
				2	......	35.64	52.08	12.28	4.84	4.61	71.63	1.20	5.44	......	7,223	13,001
				3	......	40.63	59.37	......	5.51	5.26	81.66	1.37	6.20	......	8,234	14,821
KENTUCKY.																
CHRISTIAN COUNTY.																
Mannington; Williams mine, Empire bed (face of 1 room, 2 north entry, 80 feet from entry).	165	W70506	A	1	9.14	34.92	46.86	9.09	2.92	......	......	......	......	......	6,644	11,959
				2	......	38.43	51.57	10.00	3.21	......	......	......	......	......	7,312	13,162
				3	......	42.70	57.30	......	3.57	......	......	......	......	......	8,125	14,624
Same (face of 4 room, 2 west entry, 110 feet from entry)	165	W70507	A	1	9.00	33.61	47.67	9.72	[illegible]	......					[illegible]	[illegible]

				2	......	36.93	52.39	10.68	4.04	......	......	......	......	......	[illegible]	[illegible]
				3	......	41.35	58.65	......	4.52	......	......	......	......	......	8,096	14,572
Same (face of 1 south entry)	165	W70508	A	1	9.69	34.35	49.48	6.48	2.34	......	......	......	......	......	6,836	12,305
				2	......	38.04	54.79	7.17	2.59	......	......	......	......	......	7,570	13,625
				3	......	40.98	59.02	......	2.79	......	......	......	......	......	8,154	14,677
Same (tipple sample of coal being loaded into cars)	165	W70509	C	1	9.23	33.67	46.38	10.72	3.14	......	......	......	......	......	6,490	11,682
				2	......	37.09	51.10	11.81	3.46	......	......	......	......	......	7,150	12,870
				3	......	42.06	57.94	......	3.92	......	......	......	......	......	8,108	14,594
Same (tipple sample of coal being loaded into cars	165	W70510	C	1	9.09	35.56	45.70	9.65	3.09	......	......	......	......	......	6,558	11,804
				2	......	39.12	50.26	10.62	3.40	......	......	......	......	......	7,213	12,984
				3	......	43.77	56.23	......	3.80	......	......	......	......	......	8,070	14,526
Same (tipple sample of coal being loaded into cars)	165	W70511	C	1	8.88	35.93	45.87	9.32	3.06	......	......	......	......	......	6,619	11,914
				2	......	39.43	50.34	10.23	3.36	......	......	......	......	......	7,264	13,075
				3	......	43.93	56.07	......	3.74	......	......	......	......	......	8,091	14,564
LETCHER COUNTY.																
Fleming, 1 mile west of; Acme mine, Elkhorn bed (at 16 room neck, 20 feet from face of 3 entry).	166	29845	A	1	2.91	36.92	57.23	2.94	.67	......	......	......	......	1.2	7,904	14,227
Same (20 feet from face of 2 entry, 10 feet outby 15 room)	166	29846	A	1	3.10	36.46	57.22	3.22	.64	......	......	......	......	1.5	7,851	14,132
Same (composite of samples 29845 and 29846)	166	29847	A	1	3.00	36.62	57.25	3.13	.65	5.39	79.81	1.53	9.49	1.3	7,889	14,200
				2	......	37.75	59.02	3.23	.67	5.22	82.28	1.58	7.02	......	8,133	14,639
				3	......	39.01	60.99	......	.69	5.39	85.03	1.63	7.26	......	8,405	15,129
WEBSTER COUNTY.																
Clay, 1 mile west of; West Kentucky No. 7 mine, No. 12 bed (face of 11 room, 14 south entry, 2 left entry, main rise, 150 feet from entry).	167	30747	A	1	6.78	33.43	46.39	13.40	1.21	......	......	......	......	2.8	6,508	11,714
Same (face of 24 room, 3 left entry, east dip entry, 250 feet from entry).	167	30748	A	1	4.61	36.55	51.67	7.17	1.08	......	......	......	......	1.3	7,231	13,016
Same (face of 10 room, 2 south entry, 7 right east dip entry, 100 feet from entry).	167	30749	A	1	4.49	35.32	49.97	10.22	1.04	......	......	......	......	1.3	6,967	12,541
Same (face of 3 south entry, 3 left entry, main rise, 220 feet from 3 left entry).	167	30750	A	1	5.99	35.06	52.35	6.60	1.08	......	......	......	......	1.9	7,167	12,901
Same (composite of samples 30747 to 30750)	167	30751	A	1	5.35	34.92	50.39	9.34	1.05	5.12	70.39	1.55	12.55	1.8	6,945	12,501
				2	......	36.89	53.24	9.87	1.11	4.79	74.37	1.64	8.22	......	7,337	13,207
				3	......	40.93	59.07	......	1.23	5.31	82.52	1.82	9.12	......	8,140	14,652
MARYLAND.																
ALLEGANY COUNTY.																
Allegany, 1½ mile northeast of; Tyson No. 3 mine, Tyson (Upper Sewickley) bed (face of 3 room, 2 right heading).	168	26506	B	1	2.74	19.90	71.37	5.99	.98	4.54	80.55	1.78	6.16	1.8	7,910	14,238
				2	......	20.46	73.38	6.16	1.01	4.36	82.82	1.83	3.82	......	8,133	14,639
				3	......	21.80	78.20	......	1.08	4.65	88.25	1.95	4.07	......	8,667	15,601
Barrellville, ½ mile northeast of; Bond mine, Bluebaugh (Brookville) bed (at rib of straight heading, 180 feet northeast of 1 left heading).	168	26985	B	1	3.06	15.59	71.06	10.29	2.50	4.20	77.01	1.16	4.84	2.4	7,440	13,392
				2	......	16.08	73.30	10.62	2.58	3.98	79.44	1.20	2.18	......	7,675	13,815
				3	......	17.99	82.01	......	2.89	4.45	88.88	1.34	2.44	......	8,587	15,457

a Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

b Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

c The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

d The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.[e]	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MARYLAND—Continued.																
ALLEGANY COUNTY—continued.																
Barrellville, ½ mile southwest of; Emrick No. 1 mine, Bluebaugh bed (face of main heading).	168	26504	B	1	2.34	15.20	69.42	13.04	0.82	4.16	73.47	1.28	7.23	1.6	7,320	13,176
				2	......	15.56	71.09	13.35	.84	3.99	75.23	1.31	5.28	......	7,496	13,493
				3	......	17.96	82.04	......	.97	4.60	86.82	1.51	6.10	......	8,651	15,572
½ mile northeast of; Parker mine, Parker bed (face of 2 room, on right, at top of dip heading).	169	26539	B	1	3.75	16.66	74.68	4.91	1.13	4.55	81.87	1.40	6.14	2.8	7,920	14,256
				2	......	17.31	77.59	5.10	1.17	4.29	85.06	1.45	2.93	......	8,229	14,812
				3	......	18.24	81.76	......	1.23	4.52	89.63	1.53	3.09	......	8,671	15,608
1 mile southwest of; Pratt's mine, Brush Creek bed (face of main heading, 80 feet in entry).	169	26542	B	1	3.77	15.92	71.06	9.25	1.21	4.59	78.04	1.58	5.33	3.1	7,548	13,586
				2	......	16.54	73.85	9.61	1.26	4.33	81.10	1.64	2.06	......	7,844	14,119
				3	......	18.30	81.70	......	1.39	4.79	89.72	1.81	2.29	......	8,678	15,620
Barton, ¾ mile north of; Moscow No. 3 mine, Bakerstown bed (face of 4 room, 2 left heading).	169	26533	B	1	2.30	17.43	70.33	9.94	2.22	4.33	77.87	1.70	3.94	1.6	7,578	13,640
				2	......	17.84	71.99	10.17	2.27	4.17	79.70	1.74	1.95	......	7,756	13,961
				3	......	19.86	80.14	......	2.53	4.64	88.72	1.94	2.17	......	8,634	15,541
Swanton mine, Bakerstown bed (at right rib, face of 6 heading)..	170	26978	B	1	2.90	16.27	69.94	10.89	1.93	4.29	76.56	1.54	4.79	2.3	7,415	13,347
				2	......	16.76	72.02	11.22	1.99	4.09	78.85	1.59	2.26	......	7,637	13,747
				3	......	18.88	81.12	......	2.24	4.61	88.82	1.79	2.54	......	8,602	15,484
Same (face of 2 right butt, main entry)........................	170	26966	B	1	2.34	20.34	69.56	7.76	1.15	4.60	78.20	1.58	6.71	1.8	7,780	14,004
				2	......	20.83	71.22	7.95	1.18	4.44	80.08	1.62	4.73	......	7,967	14,341
				3	......	22.63	77.37	......	1.28	4.82	87.00	1.76	5.14	......	8,655	15,579
Borden Shaft; Consolidation No. 12 mine, Pittsburgh bed ("Klondike heading," off left empty, slant entry).	170	26528	B	1	2.17	18.89	71.60	7.34	1.02	4.66	81.01	1.95	4.02	1.3	7,875	14,175
				2	......	19.31	73.19	7.50	1.04	4.52	82.81	1.99	2.14	......	8,050	14,490
				3	......	20.88	79.12	......	1.12	4.89	89.53	2.15	2.31	......	8,703	15,665
Eckhart; Washington No. 2 mine, Tyson bed (face of 6 room, 4 left heading).	171	26507	B	1	2.22	19.46	72.67	5.65	.89	4.71	82.23	1.73	4.79	1.5	8,013	14,423
				2	......	19.90	74.32	5.78	.91	4.56	84.10	1.77	2.88	......	8,195	14,751
				3	......	21.12	78.88	......	.97	4.84	89.26	1.88	3.05	......	8,697	15,655
Ellerslie, 2 miles west of; Ellerslie clay mine, Mercer bed (face of 1 right butt, 1 right heading).	171	26987	B	1	2.91	20.86	58.63	17.60	3.78	4.31	66.48	1.06	6.77	2.4	6,766	12,179
				2	......	21.49	60.38	18.13	3.89	4.11	68.47	1.09	4.31	......	6,969	12,544
				3	......	26.25	73.75	......	4.75	5.02	83.63	1.33	5.27	......	8,512	15,322
Same; Quakertown bed (at right rib, 2 right heading, 20 feet from main heading).	171	26988	B	1	3.05	21.13	59.31	15.51	2.83	4.45	66.94	1.13	8.14	2.6	6,788	12,218
				2	......	21.80	61.17	17.03	2.92	4.24	69.05	1.17	5.59	......	7,002	12,604
				3	......	26.28	73.72	......	3.52	5.11	83.23	1.41	6.73	......	8,440	15,192

Franklin Station; Miller & Greene No. 1 mine, Clarion bed (face of butt entry, main heading).	172	26544	B	1	1.87	19.81	64.46	13.86	3.60	4.16	73.72	1.18	3.48	1.2	7,246	13,043
				2	......	20.19	65.69	14.12	3.67	4.03	75.13	1.20	1.85	......	7,384	13,291
				3	......	23.51	76.49	....	4.27	4.69	87.48	1.40	2.16	......	8,598	15,476
Frostburg, 1½ miles northeast of; Consolidation No. 9 mine, Tyson bed (in manway of 1 room, 2 right entry).	172	26510	B	1	3.15	18.17	70.52	8.16	1.00	4.54	78.98	1.63	5.69	2.1	7,704	13,867
				2	......	18.76	72.81	8.43	1.03	4.33	81.55	1.68	2.98	......	7,954	14,317
				3	......	20.49	79.51	....	1.12	4.73	89.06	1.83	3.26	......	8,687	15,637
1½ miles north of; Consolidation No. 14 mine, Pittsburgh bed (in air course, 125 feet from mouth of Clifton opening).	172	W68177	A	1	2.00	17.80	69.30	10.90	.88	......	......	......	......	......	7,536	13,565
Same (in Oil House heading, opposite 25 room)	172	W68215	A	1	2.30	16.30	70.60	10.80	.83	......	......	......	......	......	7,498	13,496
Same (composite of samples W68177 and W68215)	172	30164	A	1	2.15	17.78	69.13	10.94	1.10	4.30	76.87	1.86	4.93	......	7,462	13,432
				2	......	18.17	70.65	11.18	1.12	4.15	78.56	1.90	3.09	......	7,626	13,727
				3	......	20.46	79.54	....	1.26	4.67	88.45	2.14	3.48	......	8,586	15,455
Same (tipple sample of run-of-mine coal being loaded)	172	W68176	C	1	2.40	17.20	62.80	17.60	1.07	......	......	......	......	......	6,839	12,310
Same (tipple sample of run-of-mine coal being loaded)	172	W68198	C	1	2.40	17.50	64.00	16.10	1.22	......	......	......	......	......	6,986	12,575
Same (tipple sample of run-of-mine coal being loaded)	172	W68199	C	1	2.30	17.00	63.80	16.90	1.17	......	......	......	......	......	6,900	12,420
Same (composite of samples W68176, W68198, and W68199)	172	30165	C	1	2.38	17.39	63.12	17.11	1.37	4.10	70.91	1.71	4.80	......	6,862	12,350
				2	......	17.81	64.66	17.53	1.40	3.93	72.64	1.75	2.75	......	7,029	12,652
				3	......	21.60	78.40	....	1.70	4.77	88.08	2.12	3.33	......	8,523	15,341
Same (tipple sample, run-of-mine coal being loaded)	172	30092	C	1	2.40	16.83	63.70	17.07	1.40	4.12	70.99	1.62	4.80	......	6,848	12,326
				2	......	17.24	65.27	17.49	1.43	3.94	72.74	1.66	2.74	......	7,016	12,629
				3	......	20.89	79.11	....	1.73	4.78	88.16	2.01	3.32	......	8,503	15,305
Gannon's Station; Washington No. 1 mine, Lower Kittanning bed (face of right air course, 2,200 feet west of entry).	173	26979	B	1	2.90	15.35	69.69	12.06	2.48	4.13	75.45	1.21	4.67	2.3	7,331	13,196
				2	......	15.81	71.77	12.42	2.55	3.92	77.71	1.25	2.15	......	7,550	13,590
				3	......	18.05	81.95	....	2.91	4.48	88.73	1.43	2.45	......	8,621	15,518
Hoffman; Consolidation No. 3 mine, Pittsburgh bed (north side of main heading.)	174	26526	B	1	2.43	19.02	71.19	7.36	1.04	4.41	79.80	1.91	5.48	1.6	7,826	14,087
				2	......	19.49	72.97	7.54	1.07	4.24	81.79	1.96	3.40	......	8,021	14,438
				3	......	21.08	78.92	....	1.16	4.59	88.46	2.12	3.67	......	8,675	15,615
Little Allegany, ½ mile north of; Union No. 1 mine, Pittsburgh bed (face of 5 room, 4 left heading).	174	26529	B	1	2.34	21.96	67.87	7.83	1.38	4.69	79.33	1.81	4.96	1.5	7,795	14,031
				2	......	22.49	69.49	8.02	1.41	4.54	81.23	1.85	2.95	......	7,982	14,368
				3	......	24.45	75.55	....	1.53	4.94	88.31	2.01	3.21	......	8,678	15,620
Lord, ½ mile west of; Consolidation No. 7 mine, Pittsburgh bed (upper section of the Midway).	174	26530	B	1	2.21	20.52	70.19	7.08	.96	4.71	81.15	1.93	4.17	1.4	7,906	14,231
				2	......	20.98	71.78	7.24	.98	4.56	82.98	1.97	2.27	......	8,085	14,553
				3	......	22.62	77.38	....	1.06	4.92	89.46	2.12	2.44	......	8,716	15,689
Lonaconing; Georges Creek No. 3 mine, Tyson bed (face of Broadback's room, 3 right heading).	174	26509	B	1	2.56	19.95	72.37	5.12	1.04	4.69	82.62	1.70	4.83	1.6	8,043	14,477
				2	......	20.47	74.28	5.25	1.07	4.53	84.79	1.74	2.62	......	8,255	14,859
				3	......	21.60	78.40	....	1.13	4.78	89.49	1.84	2.76	......	8,712	15,682
Kingsley mine, Waynesburg bed (face of main heading, at right rib, 600 feet from entry).	175	26984	B	1	3.13	19.62	63.93	13.32	2.50	4.46	73.24	1.56	4.92	2.6	7,210	12,978
				2	......	20.25	66.00	13.75	2.58	4.24	75.61	1.61	2.21	......	7,443	13,397
				3	......	23.48	76.52	....	2.99	4.92	87.66	1.87	2.56	......	8,629	15,532
⅜ mile northeast of; test opening, Franklin bed (100 feet S. 55° E. from opening).	175	26540	B	1	3.75	18.03	70.06	8.16	1.31	4.74	78.09	1.56	6.14	2.9	7,562	13,612
				2	......	18.73	72.79	8.48	1.36	4.49	81.14	1.62	2.91	......	7,857	14,143
				3	......	20.47	79.53	....	1.49	4.91	88.66	1.77	3.17	......	8,585	15,453
Luke, ½ mile north of; Devon mine, Lower Kittanning bed (face of main heading).	176	26511	B	1	2.36	15.39	71.46	10.79	1.49	4.35	77.09	1.39	4.89	1.5	7,529	13,552
				2	......	15.76	73.19	11.05	1.53	4.19	78.96	1.42	2.85	......	7,711	13,880
				3	......	17.72	82.28	....	1.72	4.71	88.77	1.60	3.20	......	8,669	15,604

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MARYLAND—continued.																
ALLEGANY COUNTY—continued.																
Midland, ½ mile southwest of; Consolidation No. 8 mine, Pittsburgh bed (face of 8 room, 3 right entry).	176	W68192	A	1	1.80	18.20	71.70	8.30	0.83	......	......	......	......	......	7,813	14,063
Same (face of 59 room, Keating heading)	176	W68195	A	1	2.30	18.50	73.20	6.10	.59	......	......	......	......	......	7,973	14,351
Same (composite of samples W68192 and W68195)	176	30162	A	1	2.05	18.13	72.24	7.58	.77	4.61	80.77	1.87	4.40	......	7,851	14,132
				2	......	18.51	73.75	7.74	.79	4.47	82.46	1.91	2.63	......	8,015	14,427
				3	......	20.06	79.94	......	.86	4.85	89.38	2.07	2.84	......	8,687	15,637
Same (tipple sample of run-of-mine coal being loaded)	176	W68203	C	1	1.90	18.10	72.90	7.10	.83	......	......	......	......	......	7,925	14,265
Same (tipple sample of run-of-mine coal being loaded)	176	W68209	C	1	1.70	18.50	72.20	7.60	.98	......	......	......	......	......	7,884	14,191
Same (tipple sample of run-of-mine coal being loaded)	176	W68211	C	1	1.80	17.19	73.84	7.17	.83	......	......	......	......	......	7,950	14,310
Same (tipple sample of run-of-mine coal being loaded)	176	W68213	C	1	1.80	17.00	74.20	7.00	.79	......	......	......	......	......	7,889	14,240
Same (composite of samples W68203, W68209, W68211, and W68213).	176	30163	C	1	1.80	18.47	72.41	7.32	.85	4.58	81.19	1.78	4.28	......	7,881	14,186
				2	......	18.81	73.74	7.45	.87	4.46	82.68	1.81	2.73	......	8,025	14,445
				3	......	20.32	79.68	......	.94	4.82	89.34	1.96	2.94	......	8,671	15,608
Montell; Montell Tunnel (Mertons) mine, Bluebaugh bed (face of 1 left heading in south side).	177	26505	B	1	3.18	16.30	65.02	15.50	1.41	4.20	72.11	1.22	5.56	2.4	6,948	12,506
				2	......	16.83	67.16	16.01	1.46	3.98	74.48	1.26	2.81	......	7,176	12,917
				3	......	20.04	79.96	......	1.74	4.74	88.68	1.50	3.34	......	8,544	15,379
Same, Lower Kittanning bed (face of Frederick heading)	177	26977	B	1	2.88	19.89	68.90	8.33	1.36	4.83	78.87	1.28	5.33	2.4	7,728	13,910
				2	......	20.48	70.94	8.58	1.40	4.64	81.21	1.32	2.85	......	7,958	14,324
				3	......	22.40	77.60	......	1.53	5.08	88.84	1.44	3.11	......	8,705	15,669
Morrison; Gin Sang mine, Bakerstown bed (face of main right heading).	178	26532	B	1	1.27	15.59	72.55	10.59	2.12	4.13	78.48	1.44	3.24	.6	7,583	13,649
				2	......	15.79	73.48	10.73	2.15	4.04	79.49	1.46	2.13	......	7,681	13,826
				3	......	17.69	82.31	......	2.40	4.53	89.04	1.64	2.39	......	8,604	15,487
Mount Savage, 1¼ miles north of; Bald Knob mine, Pittsburgh bed (face of 7 room, main heading).	178	W71053	A	1	3.58	18.00	67.08	11.34	1.14	......	......	......	......	......	7,262	13,071
				2	......	18.67	69.57	11.76	1.18	......	......	......	......	......	7,531	13,556
				3	......	21.16	78.84	......	1.34	......	......	......	......	......	8,535	15,363
Same (face of 2 right heading)	178	W71054	A	1	3.27	16.80	68.08	11.85	1.67	......	......	......	......	......	7,332	13,198
				2	......	17.37	70.38	12.25	1.73	......	......	......	......	......	7,580	13,644
				3	......	19.79	80.21	......	1.97	......	......	......	......	......	8,638	15,549
Same (face of 5 room, 2 left heading)	178	W71055	A	1	2.69	18.15	67.80	11.36	1.52	......	......	......	......	......	7,372	13,270
				2	......	18.65	69.68	11.67	1.56	......	......	......	......	......	7,576	13,637
				3	......	21.11	78.89	......	1.77	......	......	......	......	......	8,577	15,430

Same (face of main heading)	178	W71056	A	1	3.00	17.38	61.92	17.70	1.34							6,793	12,228
				2		17.92	63.83	18.25	1.38							7,003	12,606
				3		21.92	78.08		1.69							8,567	15,420
Same (car samples of loaded run-of-mine coal)	178	W71130, W71133	C	1	3.38	17.71	64.66	14.25	1.27							7,052	12,694
				2		18.33	66.92	14.75	1.31							7,299	13,138
				3		21.50	78.50		1.54							8,561	15,411
Same (car samples of loaded run-of-mine coal)	178	W71134, W71137	C	1	3.20	17.84	64.22	14.74	1.46							7,036	12,664
				2		18.43	66.34	15.23	1.51							7,268	13,083
				3		21.74	78.26		1.78							8,575	15,434
2½ miles northwest of; No. 6 (fire clay) mine, Mount Savage (Mercer) bed (at butt opening, main heading, 600 feet from entry).	179	26580	B	1	2.76	18.80	62.74	15.70	1.28	4.33	72.45	1.03	5.21	2.2	7,014	12,625
				2		19.33	64.52	16.15	1.32	4.13	74.51	1.06	2.83		7,213	12,983
				3		23.05	76.95		1.57	4.93	88.86	1.26	3.38		8,602	15,484
¾ mile east of; Henry Mullaney's mine, Lower Freeport bed (face of main heading, 120 feet from mouth).	180	26543	B	1	3.15	15.55	61.44	19.86	3.98	3.88	66.15	1.17	4.96	2.2	6,493	11,687
				2		16.06	63.43	20.51	4.11	3.64	68.30	1.21	2.23		6,704	12,067
				3		20.20	79.80		5.17	4.58	85.92	1.52	2.81		8,434	15,181
Ocean Station; Consolidation No. 1 mine, Pittsburgh bed (face of Spitzman's heading).	180	26527	B	1	2.92	18.69	69.63	8.76	.99	4.86	77.48	1.87	6.04	2.1	7,683	13,829
				2		19.25	71.73	9.02	1.02	4.68	79.81	1.93	3.54		7,914	14,245
				3		21.16	78.84		1.12	5.14	87.72	2.12	3.90		8,698	15,656
Same (face of rock heading, 2 right entry)	181	W68178	A	1	2.50	18.40	70.40	8.70	.78						7,747	13,945
Same (face of 5 room, Old Lye heading, inside 20 heading)	181	W68181	A	1	1.90	18.10	72.00	8.00	.78						7,840	14,112
Same (face of 7 room, 9 right entry, straight slope entry)	181	W68217	A	1	1.80	17.60	72.40	8.20	1.18						7,845	14,121
Same (face of 4 room, 9 heading, Hawkins heading)	181	W68218	A	1	1.70	18.90	73.20	6.20	.59						8,013	14,423
Same (Spitzman's heading, 210 feet outside of 2 right entry)	181	W68226	A	1	4.10	17.70	71.20	7.00	.77						7,715	13,887
Same (composite of samples W68178, W68181, W68217, W68218, and W68226).	181	30179	A	1	1.24	17.89	73.15	7.72	.95	4.51	80.97	1.87	3.98		7,881	14,186
				2		18.11	74.07	7.82	.96	4.42	81.99	1.89	2.92		7,980	14,364
				3		19.65	80.35		1.04	4.79	88.94	2.05	3.18		8,657	15,583
Same (tipple sample of coal being loaded)	181	W68182	C	1	2.10	18.40	70.80	8.70	.83						7,750	13,950
Same (tipple sample of coal being loaded)	181	W68197	C	1	2.00	17.50	72.00	8.50	.83						7,760	13,968
Same (tipple sample of coal being loaded)	181	W68216	C	1	1.90	17.30	72.10	8.70	.88						7,760	13,968
Same (tipple sample of coal being loaded)	181	W68221	C	1	1.90	18.60	70.70	8.80	.83						7,737	13,927
Same (composite of samples W68182, W68197, W68216, and W68221).	181	30180	C	1	1.98	18.32	71.28	8.42	.90	4.52	79.85	1.84	4.47		7,763	13,973
				2		18.69	72.72	8.59	.92	4.39	81.46	1.88	2.76		7,920	14,256
				3		20.45	79.55		1.01	4.80	89.12	2.06	3.01		8,664	15,595
Short Gap, 1¾ miles east of Clarysville; Stanton-Georges Creek No. 1 mine, Upper Freeport bed (face of 3 room, 4 right entry).	181	26521	B	1	3.30	16.19	70.89	9.62	1.35	4.50	78.12	1.32	5.09	2.6	7,522	13,540
				2		16.74	73.31	9.95	1.40	4.27	80.78	1.37	2.23		7,779	14,002
				3		18.59	81.41		1.55	4.74	89.71	1.52	2.48		8,639	15,550
Westernport, ½ mile north of; Tacoma mine, Lower Kittanning bed (face of 8 room, 1 right heading).	182	26520	B	1	1.94	15.61	72.49	9.96	1.58	4.24	78.68	1.38	4.16	1.2	7,597	13,675
				2		15.92	73.92	10.16	1.61	4.10	80.24	1.41	2.48		7,747	13,945
				3		17.72	82.28		1.79	4.56	89.32	1.57	2.76		8,623	15,521
GARRETT COUNTY.																	
Barnum; Monroe No. 1 mine, Lower Kittanning bed (right rib of 6 left heading, 50 feet from main heading).	182	26983	B	1	1.71	18.49	69.88	9.92	1.61	4.29	78.34	1.07	4.77	1.1	7,664	13,795
				2		18.81	71.10	10.09	1.64	4.17	79.70	1.09	3.31		7,797	14,035
				3		20.92	79.08		1.82	4.64	88.64	1.21	3.69		8,672	15,610
Barton; Monroe No. 2 mine, Bakerstown bed (face of 7 right heading, 1,200 feet northwest from entry).	183	26982	B	1	2.26	15.77	73.06	8.91	.61	4.20	79.79	1.51	4.98	1.6	7,726	13,907
				2		16.13	74.75	9.12	.62	4.04	81.63	1.54	3.05		7,904	14,227
				3		17.75	82.25		.68	4.45	89.82	1.69	3.36		8,698	15,656

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No.b	Sample. Kind.c	Sample. Condition.d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MARYLAND—Continued.																
GARRETT COUNTY—continued.																
Bayard Station, ½ mile east of; Nethkin mine, Upper Freeport bed (face of 2 left heading).	183	26524	B	1	3.18	19.20	67.65	9.97	1.51	4.40	77.10	1.20	5.82	2.3	7,480	13,464
				2	......	19.83	69.87	10.30	1.56	4.18	79.63	1.24	3.09	......	7,725	13,905
				3	......	22.11	77.89	......	1.74	4.66	88.77	1.38	3.45	......	8,612	15,502
Blaine Station, ¾ mile east of; Hamill No. 2 mine, Lower Kittanning bed (face of air course, 2 left heading, at boundary line).	184	26980	B	1	1.83	16.50	71.69	9.98	2.46	4.29	78.70	1.28	3.29	1.2	7,635	13,743
				2	......	16.81	73.02	10.17	2.51	4.17	80.16	1.30	1.69	......	7,777	13,999
				3	......	18.71	81.29	......	2.79	4.64	89.23	1.45	1.89	......	8,657	15,583
Blaine, 1 mile east of; Peerless No. 3 mine, Upper Freeport bed (face of 1 room, 5 left heading).	184	26981	B	1	1.76	18.08	72.42	7.74	1.80	4.33	80.77	1.36	4.00	1.1	7,884	14,191
				2	......	18.40	73.72	7.88	1.83	4.20	82.22	1.38	2.49	......	8,025	14,445
				3	......	19.97	80.03	......	1.99	4.56	89.25	1.50	2.70	......	8,711	15,680
Bloomington, 1 mile west of; Bloomington No. 7 mine, Lower Kittanning bed (face of 6 room, 3 left heading).	184	26512	B	1	3.12	14.67	70.51	11.70	2.05	4.18	76.13	1.27	4.67	2.3	7,348	13,226
				2	......	15.14	72.78	12.08	2.12	3.95	78.58	1.31	1.96	......	7,585	13,653
				3	......	17.22	82.78	......	2.41	4.49	89.38	1.49	2.23	......	8,627	15,529
Chaffee, 2 miles northwest of; Chaffee mine, Lower Kittanning bed (face of main heading).	185	26514	B	1	2.39	16.41	71.82	9.38	2.01	4.37	78.54	1.29	4.41	1.6	7,615	13,707
				2	......	16.81	73.58	9.61	2.06	4.20	80.46	1.32	2.35	......	7,802	14,044
				3	......	18.60	81.40	......	2.28	4.65	89.01	1.46	2.60	......	8,631	15,536
Crellin, 2 miles southwest of; Guthrie mine, Lower Kittanning bed (face of 18 left room, main heading).	185	26989	B	1	2.66	22.99	63.62	10.73	2.06	4.76	75.74	1.41	5.30	2.0	7,450	13,410
				2	......	23.62	65.36	11.02	2.12	4.58	77.81	1.45	3.02	......	7,653	13,775
				3	......	26.54	73.46	......	2.38	5.15	87.44	1.63	3.40	......	8,600	15,480
Friendsville, 1½ miles south of; McCulloh mine, Lower Kittanning bed (face of new heading, 50 feet above old heading).	186	26519	B	1	3.63	22.91	62.05	11.41	3.96	4.75	73.19	1.30	5.39	2.8	7,297	13,135
				2	......	23.77	64.39	11.84	4.11	4.51	75.95	1.35	2.24	......	7,572	13,630
				3	......	26.96	73.04	......	4.66	5.12	86.15	1.53	2.54	......	8,589	15,460
Gannons Station; Washington No. 5 mine, Bakerstown bed (face of 2 south heading).	186	26531	B	1	2.77	16.79	70.64	9.80	1.43	4.32	76.77	1.58	6.10	2.0	7,589	13,660
				2	......	17.27	72.65	10.08	1.47	4.12	78.96	1.63	3.74	......	7,805	14,049
				3	......	19.21	80.79	......	1.63	4.58	87.81	1.81	4.17	......	8,680	15,624
Gorman, 1½ miles east of; Strathmore mine, Upper Freeport bed (face of 7 room, 2 right heading).	187	26523	B	1	2.62	16.66	64.34	16.38	1.38	4.01	71.81	1.19	5.23	1.9	6,955	12,519
				2	......	17.11	66.07	16.82	1.42	3.82	73.74	1.22	2.98	......	7,142	12,856
				3	......	20.57	79.43	......	1.71	4.59	88.65	1.47	3.58	......	8,586	15,455
Grantsville, 1½ miles west of; Beachey's mine, Grantsville bed (face of 6 room, 2 right heading).	187	26541	B	1	3.30	21.88	66.86	7.96	1.18	4.61	78.34	1.43	6.48	2.4	7,657	13,783
				2	......	22.63	69.14	8.23	1.22	4.38	81.01	1.48	3.68	......	7,918	14,252
				3	......	24.66	75.34	......	1.33	4.77	88.28	1.61	4.01	......	8,628	15,530

Harrison, 1 mile east of; Dodson No. 3 mine, Lower Kittanning bed (face of 4 butt entry, 1 left heading).	187	26513	B	1	2.53	15.44	72.74	9.29	1.79	4.44	79.25	1.27	3.96	1.7	7,613	13,703
				2	......	15.84	74.63	9.53	1.84	4.27	81.31	1.30	1.75	......	7,811	14,060
				3	......	17.51	82.49	......	2.03	4.72	89.87	1.44	1.94	......	8,633	15,539
1 mile west of; Dodson No. 5 mine, Upper Kittanning bed (face 2 room, 1 right heading).	188	26537	B	1	3.57	16.29	71.73	8.41	.66	4.38	79.13	1.43	5.99	2.8	7,630	13,734
				2	......	16.89	74.39	8.72	.68	4.13	82.06	1.48	2.93	......	7,912	14,242
				3	......	18.50	81.50	......	.74	4.52	89.90	1.62	3.22	......	8,668	15,602
Hubbard; Ajax Hocking No. 1 mine, Lower Kittanning bed (face of 3 room, 1 right heading).	188	26515	B	1	3.80	17.42	65.56	13.22	2.25	4.43	74.23	1.22	4.65	3.0	7,163	12,893
				2	......	18.11	68.15	13.74	2.34	4.17	77.16	1.27	1.32	......	7,446	13,403
				3	......	20.99	79.01	......	2.71	4.83	89.45	1.47	1.54	......	8,632	15,538
Lonaconing, 2 miles northwest of; Koontz mine, Tyson bed (face of main heading).	189	26508	B	1	3.30	21.16	69.79	5.75	1.14	4.70	80.27	1.62	6.52	2.5	7,906	14,231
				2	......	21.88	72.17	5.95	1.18	4.48	83.01	1.68	3.70	......	8,176	14,717
				3	......	23.27	76.73	......	1.25	4.76	88.26	1.79	3.94	......	8,694	15,649
3 miles northwest of; new opening, Upper Freeport bed (face of main heading, 350 feet inside of opening).	189	26522	B	1	1.40	17.49	58.71	22.40	3.16	3.70	66.04	1.17	3.53	.8	6,447	11,605
				2	......	17.74	59.54	22.72	3.20	3.59	66.98	1.19	2.32	......	6,539	11,770
				3	......	22.96	77.04	......	4.14	4.65	86.67	1.54	3.00	......	8,461	15,230
Oakland, 4½ miles north of; Chisholm mine, Lower Kittanning bed (face of 1 room, 1 left heading).	189	26517	B	1	4.47	20.16	67.72	7.65	1.42	4.79	77.75	1.31	7.08	3.2	7,574	13,633
				2	......	21.10	70.89	8.01	1.49	4.49	81.39	1.37	3.25	......	7,928	14,270
				3	......	22.94	77.06	......	1.62	4.88	88.48	1.49	3.53	......	8,619	15,514
8 miles north of; John Sines mine, Mercer bed (face of main heading, 70 feet from mine mouth).	189	26538	B	1	2.77	24.80	52.86	19.57	4.49	4.16	64.17	1.29	6.32	1.9	6,516	11,729
				2	......	25.51	54.36	20.13	4.62	3.96	66.00	1.33	3.96	......	6,702	12,064
				3	......	31.94	68.06	......	5.78	4.96	82.63	1.67	4.96	......	8,391	15,104
6 miles northwest of; O. R. Leighton mine, "Galitzen" bed (face of heading in new opening, 60 feet from entry).	190	26536	B	1	2.23	25.44	57.53	14.80	4.80	4.65	70.80	1.30	3.65	1.7	7,110	12,798
				2	......	26.02	58.84	15.14	4.91	4.50	72.41	1.33	1.71	......	7,272	13,090
				3	......	30.66	69.34	......	5.79	5.30	85.33	1.57	2.01	......	8,569	15,424
6½ miles northwest of; Taylor Sines mine, Upper Freeport bed (left rib of main heading, west of left heading).	190	26525	B	1	3.48	25.78	62.41	8.33	3.79	4.74	76.23	1.39	5.52	2.4	7,610	13,698
				2	......	26.71	64.66	8.63	3.93	4.51	78.98	1.44	2.51	......	7,885	14,193
				3	......	29.23	70.77	......	4.30	4.94	86.44	1.58	2.74	......	8,630	15,534
3½ miles north of; E. Z. Tower mine, "Galitzen" bed (face of main heading).	190	26534	B	1	4.32	21.33	64.41	9.94	2.46	4.68	75.21	1.42	6.29	3.3	7,371	13,268
				2	......	22.29	67.32	10.39	2.57	4.39	78.61	1.48	2.56	......	7,704	13,867
				3	......	24.87	75.13	......	2.87	4.90	87.72	1.65	2.86	......	8,597	15,475
Swallow Falls, 2 miles southwest of; J. W. Beeghly mine, "Galitzen" bed (face of 2 room, 1 left heading).	191	26535	B	1	3.92	25.72	59.86	10.50	2.41	4.68	73.63	1.46	7.32	2.8	7,294	13,129
				2	......	26.77	62.30	10.93	2.51	4.41	76.63	1.52	4.00	......	7,592	13,666
				3	......	30.05	69.95	......	2.82	4.05	86.03	1.71	4.49	......	8,524	15,343
1 mile east of; L. G. Shaeffer mine, Lower Kittanning bed (face of 2 room, 3 right heading).	191	26518	B	1	3.03	27.78	57.69	11.50	3.73	4.84	73.64	1.23	5.06	2.1	7,288	13,118
				2	......	28.65	59.49	11.86	3.85	4.64	75.94	1.27	2.44	......	7,515	13,527
				3	......	32.51	67.49	......	4.37	5.26	86.16	1.44	2.77	......	8,527	15,349
MISSISSIPPI.																
CHOCTAW COUNTY.																
Reform, ½ mile south of; Mississippi O. & G. C. J. S. mine (face of main entry, 100 feet from mine mouth).	191	*25914	B	1	47.20	24.99	21.28	6.53	.46	......	......	......	......	34.4	3,163	5,693
				2	......	47.33	40.30	12.37	.87	......	......	......	......	......	5,990	10,782
				3	......	54.01	45.99	......	.99	......	......	......	......	......	6,836	12,305
Same	191	*25915	B	1	48.76	24.24	21.24	5.76	.42	......	......	......	......	37.3	3,093	5,567
				2	......	47.31	41.45	11.24	.82	......	......	......	......	......	6,036	10,865
				3	......	53.30	46.70	......	.92	......	......	......	......	......	6,800	12,240

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MONTANA.																
BIG HORN COUNTY.																
Lodgegrass, 13 miles southeast of; sec. 33, T. 7 S., R. 37 E.; prospect, Carney bed (50 feet northwest of prospect opening).	192	*28149	B	1	22.52	32.20	40.23	5.05	0.30	......	......	......	......	14.8	5,050	9,090
				2	......	41.56	51.92	6.52	.39	......	......	......	......	......	6,518	11,732
				3	......	44.46	55.54	......	.42	......	......	......	......	......	6,972	12,550
15 miles southeast of; prospect, Carney bed (face of main entry, 25 feet from prospect opening).	192	*29370	B	1	24.16	31.27	39.49	5.08	.38	6.33	53.11	0.98	34.12	16.3	4,965	8,937
				2	......	41.23	52.07	6.70	.50	4.81	70.03	1.29	16.67	......	6,547	11,785
				3	......	44.19	55.81	......	.54	5.16	75.06	1.38	17.86	......	7,017	12,631
BROADWATER COUNTY.																
Lombard, 1 mile west of; Western mine (face 1 stub room, north entry).	192	*28556	A	1	2.98	24.05	49.17	23.80	8.00	......	......	......	......	2.3	5,872	10,570
				2	......	24.79	50.68	24.53	8.25	......	......	......	......	......	6,052	10,894
				3	......	32.85	67.15	......	10.93	......	......	......	......	......	8,019	14,434
Same	192	*28557	A	1	3.27	23.56	49.72	23.45	7.92	......	......	......	......	2.2	5,899	10,618
				2	......	24.36	51.40	24.24	8.19	......	......	......	......	......	6,098	10,976
				3	......	32.16	67.84	......	10.81	......	......	......	......	......	8,049	14,488
CARBON COUNTY.																
Red Lodge; sec. 27, T. 7 S., R. 20 E.; Red Lodge No. 4 mine, No. 4 bed (face of 46 room, 10 east entry).	192	*29466	A	1	11.28	33.61	44.51	10.60	.72	......	......	......	......	6.3	5,797	10,435
Same (face of 45 room, 12 east entry)	192	*29467	A	1	11.12	33.62	44.81	10.45	.80	......	......	......	......	5.6	5,813	10,463
Same (face of 129 room, 9 east entry)	192	*29468	A	1	11.20	35.07	40.40	13.33	1.23	......	......	......	......	5.5	5,623	10,121
Same (face of 1 room, 8 east entry)	192	*29469	A	1	9.89	35.14	42.26	12.71	1.27	......	......	......	......	4.2	5,739	10,330
Same (composite of samples 29466 to 29469)	192	*29470	A	1	10.77	34.21	43.17	11.85	1.00	5.25	59.25	1.28	21.37	5.4	5,746	10,343
				2	......	38.34	48.38	13.28	1.12	4.54	66.40	1.43	13.23	......	6,440	11,592
				3	......	44.21	55.79	......	1.29	5.21	76.57	1.65	15.25	......	7,426	13,367
Washoe; Washoe mine, Bear Creek No. 3 bed (left neck of 9 room, 50 feet from 3 east entry).	193	*28622	A	1	10.48	34.92	45.56	9.04	.95	......	......	......	......	4.4	6,022	10,840
Same (upper end of parting in main north entry, near 4 east entry).	193	*28623	A	1	10.99	34.47	43.57	10.97	1.21	......	......	......	......	4.5	5,823	10,481
Same (20 feet from face in 1 east back entry)	193	*28624	A	1	10.43	33.16	41.48	14.93	1.35	......	......	......	......	4.1	5,576	10,037

Same (left side neck of 13 room, 15 feet from 2 east entry)	193	*28625	A	1	10.44	35.63	43.90	10.03	.97	......	......	......	......	3.8	5,970	10,746
Same (composite of samples 28622 to 28625)	193	*28626	A	1	10.47	34.67	43.65	11.21	1.13	5.58	59.77	1.29	21.02	4.2	5,847	10,525
				2	......	38.72	48.76	12.52	1.26	4.94	66.76	1.44	13.08	......	6,531	11,756
				3	......	44.26	55.74	......	1.44	5.65	76.31	1.65	14.95	......	7,466	13,439
GALLATIN COUNTY.																
Sec. 3, T. 9 S., R. 3 E.; prospect (face of drift, 30 feet from mouth; sample weathered).	194	*26729	B	1	7.88	35.56	47.40	9.16	1.07	......	......	......	......	3.6	6,272	11,290
				2	......	38.60	51.46	9.94	1.16	......	......	......	......	......	6,808	12,254
				3	......	42.86	57.14	......	1.29	......	......	......	......	......	7,560	13,608
MUSSELSHELL COUNTY.																
Roundup, 1 mile west of; sec. 23, T. 8 N., R. 25 E.; Roundup A mine, Roundup bed (right rib, 20 feet from face of 40 room, 2 back entry, 2 west entry).	194	28999	A	1	14.95	32.34	44.65	8.06	.59	......	......	......	......	3.5	5,831	10,496
Same (face of 3 room, 1 north entry, 2 west entry, 15 feet from entry).	194	29000	A	1	13.68	33.48	46.02	6.82	.45	......	......	......	......	3.2	6,040	10,872
Same (north rib of 7 west parting, main slope)	194	29001	A	1	12.91	32.62	45.95	8.52	.54	......	......	......	......	3.3	6,007	10,813
Same (south rib of main east entry, 200 feet west of pumps)	194	29002	A	1	13.26	31.79	45.70	9.25	1.58	......	......	......	......	3.8	5,904	10,627
Same (face of main entry, 1 west entry, 600 feet from slope)	194	29003	A	1	14.07	31.67	46.83	7.43	.41	......	......	......	......	3.5	5,873	10,571
Same (composite of samples 28999 to 29003)	194	29004	A	1	13.56	32.86	45.53	8.05	.70	5.56	61.98	.98	22.73	3.5	5,937	10,687
				2	......	38.02	52.67	9.31	.81	4.69	71.70	1.13	12.36	......	6,869	12,364
				3	......	41.92	58.08	......	.89	5.17	79.06	1.25	13.63	......	7,574	13,633
PHILLIPS COUNTY.																
Malta, 38 miles southeast of; sec. 18, T. 24 N., R. 33 E.; Spencer mine (face of main entry, 15 feet south of mine mouth).	195	*27221	B	1	24.06	26.76	22.80	26.38	.59	......	......	......	......	17.4	2,889	5,200
				2	......	35.24	30.02	34.74	.78	......	......	......	......	......	3,804	6,847
				3	......	54.00	46.00	......	1.20	......	......	......	......	......	5,829	10,492
NEVADA.																
MINERAL COUNTY.																
35 miles south of Yerington, Lyon County; sec 1, T. 7 N., R. 27 E.; prospect (face of entry, 30 feet from mine mouth; coal weathered).	195	*30792	B	1	27.48	24.70	20.04	27.78	3.05	......	......	......	......	19.0	2,847	5,125
				2	......	34.06	27.63	38.31	4.21	......	......	......	......	......	3,926	7,067
				3	......	55.21	44.79	......	6.82	......	......	......	......	......	6,364	11,455
NEW MEXICO.																
RIO ARRIBA COUNTY.																
Lumberton, 1½ miles southwest of; NE. ¼ sec. 8, T. 31 N., R. 1 W.; prospect (face of drift 50 feet from prospect mouth; slightly weathered).	195	31076	B	1	3.32	36.45	49.82	10.41	2.20	......	......	......	......	1.8	7,201	12,962
				2	......	37.70	51.53	10.77	2.28	......	......	......	......	......	7,448	13,406
				3	......	42.25	57.75	......	2.56	......	......	......	......	......	8,347	15,025
Monero, 1 mile southwest of; SW. ¼ sec. 7, T. 31 N., R. 1 E.; Old Sims mine, Upper bed (face of entry, 135 feet from mine mouth; sample weathered).	196	29279	B	1	7.16	37.11	50.46	5.27	.65	......	......	......	......	2.1	6,758	12,164
				2	......	39.97	54.35	5.68	.70	......	......	......	......	......	7,279	13,102
				3	......	42.38	57.62	......	.74	......	......	......	......	......	7,717	13,891

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No.b	Sample. Kind.c	Sample. Condition.d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MONTANA.																
BIG HORN COUNTY.																
Lodgegrass, 13 miles southeast of; sec. 33, T. 7 S., R. 37 E.; prospect, Carney bed (50 feet northwest of prospect opening).	192	*28149	B	1	22.52	32.20	40.23	5.05	0.30					14.8	5,050	9,090
				2		41.56	51.92	6.52	.39						6,518	11,732
				3		44.46	55.54		.42						6,972	12,550
15 miles southeast of; prospect, Carney bed (face of main entry, 25 feet from prospect opening).	192	*29370	B	1	24.16	31.27	39.49	5.08	.38	6.33	53.11	0.98	34.12	16.3	4,965	8,937
				2		41.23	52.07	6.70	.50	4.81	70.03	1.29	16.67		6,547	11,785
				3		44.19	55.81		.54	5.16	75.06	1.38	17.86		7,017	12,631
BROADWATER COUNTY.																
Lombard, 1 mile west of; Western mine (face 1 stub room, north entry).	192	*28556	A	1	2.98	24.05	49.17	23.80	8.00					2.3	5,872	10,570
				2		24.79	50.68	24.53	8.25						6,052	10,894
				3		32.85	67.15		10.93						8,019	14,434
Same	192	*28557	A	1	3.27	23.56	49.72	23.45	7.92					2.2	5,899	10,618
				2		24.36	51.40	24.24	8.19						6,098	10,976
				3		32.16	67.84		10.81						8,049	14,488
CARBON COUNTY.																
Red Lodge; sec. 27, T. 7 S., R. 20 E.; Red Lodge No. 4 mine, No. 4 bed (face of 46 room, 10 east entry).	192	*29466	A	1	11.28	33.61	44.51	10.60	.72					6.3	5,797	10,435
Same (face of 45 room, 12 east entry)	192	*29467	A	1	11.12	33.62	44.81	10.45	.80					5.6	5,813	10,463
Same (face of 129 room, 9 east entry)	192	*29468	A	1	11.20	35.07	40.40	13.33	1.23					5.5	5,623	10,121
Same (face of 1 room, 8 east entry)	192	*29469	A	1	9.89	35.14	42.26	12.71	1.27					4.2	5,739	10,330
Same (composite of samples 29466 to 29469)	192	*29470	A	1	10.77	34.21	43.17	11.85	1.00	5.25	59.25	1.28	21.37	5.4	5,746	10,343
				2		38.34	48.38	13.28	1.12	4.54	66.40	1.43	13.23		6,440	11,592
				3		44.21	55.79		1.29	5.24	76.57	1.65	15.25		7,426	13,367
Washoe; Washoe mine, Bear Creek No. 3 bed (left neck of 9 room, 50 feet from 3 east entry).	193	*28622	A	1	10.48	34.92	45.56	9.04	.95					4.4	6,022	10,840
Same (upper end of parting in main north entry, near 4 east entry).	193	*28623	A	1	10.99	34.47	43.57	10.97	1.21					4.5	5,823	10,481
Same (20 feet from face in 1 east back entry)	193	*28624	A	1	10.43	33.16	41.48	14.93	1.35					4.1	5,576	10,037

Same (left side neck of 13 room, 15 feet from 2 east entry)	193	*28625	A	1	10.44	35.63	43.90	10.03	.97						3.8	5,970	10,746
Same (composite of samples 28622 to 28625)	193	*28626	A	1	10.47	34.67	43.65	11.21	1.13	5.58	59.77	1.29	21.02	4.2	5,847	10,525
				2		38.72	48.76	12.52	1.26	4.94	66.76	1.44	13.08		6,531	11,756
				3		44.26	55.74		1.44	5.65	76.31	1.65	14.95		7,466	13,439
GALLATIN COUNTY.																
Sec. 3, T. 9 S., R. 3 E.; prospect (face of drift, 30 feet from mouth; sample weathered).	194	*26729	B	1	7.88	35.56	47.40	9.16	1.07					3.6	6,272	11,290
				2		38.60	51.46	9.94	1.16						6,808	12,254
				3		42.86	57.14		1.29						7,560	13,608
MUSSELSHELL COUNTY.																
Roundup, 1 mile west of; sec. 23, T. 8 N., R. 25 E.; Roundup A mine, Roundup bed (right rib, 20 feet from face of 40 room, 2 back entry, 2 west entry).	194	28999	A	1	14.95	32.34	44.65	8.06	.59					3.5	5,831	10,496
Same (face of 3 room, 1 north entry, 2 west entry, 15 feet from entry).	194	29000	A	1	13.68	33.48	46.02	6.82	.45					3.2	6,040	10,872
Same (north rib of 7 west parting, main slope)	194	29001	A	1	12.91	32.62	45.95	8.52	.54					3.3	6,007	10,813
Same (south rib of main east entry, 200 feet west of pumps)	194	29002	A	1	13.26	31.79	45.70	9.25	1.58					3.8	5,904	10,627
Same (face of main entry, 1 west entry, 600 feet from slope)	194	29003	A	1	14.07	31.67	46.83	7.43	.41					3.5	5,873	10,571
Same (composite of samples 28999 to 29003)	194	29004	A	1	13.56	32.86	45.53	8.05	.70	5.56	61.98	.98	22.73	3.5	5,937	10,687
				2		38.02	52.67	9.31	.81	4.69	71.70	1.13	12.36		6,869	12,364
				3		41.92	58.08		.89	5.17	79.06	1.25	13.63		7,574	13,633
PHILLIPS COUNTY.																
Malta, 38 miles southeast of; sec. 18, T. 24 N., R. 33 E.; Spencer mine (face of main entry, 15 feet south of mine mouth).	195	*27221	B	1	24.06	26.76	22.80	26.38	.59					17.4	2,889	5,200
				2		35.24	30.02	34.74	.78						3,804	6,847
				3		54.00	46.00		1.20						5,829	10,492
NEVADA.																
MINERAL COUNTY.																
35 miles south of Yerington, Lyon County; sec 1, T. 7 N., R. 27 E.; prospect (face of entry, 30 feet from mine mouth; coal weathered).	195	*30792	B	1	27.48	24.70	20.04	27.78	3.05					19.0	2,847	5,125
				2		34.06	27.63	38.31	4.21						3,926	7,067
				3		55.21	44.79		6.82						6,364	11,455
NEW MEXICO.																
RIO ARRIBA COUNTY.																
Lumberton, 1½ miles southwest of; NE. ¼ sec. 8, T. 31 N., R. 1 W.; prospect (face of drift 50 feet from prospect mouth; slightly weathered).	195	31076	B	1	3.32	36.45	49.82	10.41	2.20					1.8	7,201	12,962
				2		37.70	51.53	10.77	2.28						7,448	13,406
				3		42.25	57.75		2.56						8,347	15,025
Monero, 1 mile southwest of; SW. ¼ sec. 7, T. 31 N., R. 1 E.; Old Sims mine, Upper bed (face of entry, 135 feet from mine mouth; sample weathered).	196	29279	B	1	7.16	37.11	50.46	5.27	.65					2.1	6,758	12,164
				2		39.97	54.35	5.68	.70						7,279	13,102
				3		42.38	57.62		.74						7,717	13,891

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No.b	Sample. Kind.c	Sample. Condition.d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NEW MEXICO—Continued.																
SAN JUAN COUNTY.																
Farmington, 18 miles northwest of; NW. ¼ sec. 22, T. 32 N., R. 13 W.; Bill Thomas mine, Carbonero bed (500 feet northwest of mine mouth).	196	29249	B	1	5.93	39.06	44.02	10.99	0.63					2.9	6,696	12,053
				2		41.52	46.80	11.68	.67						7,118	12,812
				3		47.01	52.99		.76						8,059	14,506
18 miles northeast of; SE. ¼ sec. 21, T. 32 N., R. 13 W.; Jones mine, Carbonero bed (500 feet S. 60° W. from mine mouth).	196	29250	B	1	6.93	38.12	43.04	11.91	1.32					3.3	6,460	11,628
				2		40.96	46.24	12.80	1.42						6,941	12,494
				3		46.97	53.03		1.63						7,960	14,328
16 miles northwest of; SW. ¼ sec. 28, T 30 N., R. 15 W.; Marcelius mine, Carbonero bed (main slope, 300 feet from mine mouth; slightly weathered)	197	29025	B	1	8.75	41.67	41.25	8.33	.62					1.4	6,475	11,655
				2		45.67	45.20	9.13	.68						7,096	12,773
				3		50.26	49.74		.75						7,809	14,056
16 miles northwest of; NW. ¼ sec. 16, T. 30 N., R. 15 W.; prospect drift, Carbonero bed (face of entry, 50 feet from mouth; sample weathered).	197	29026	B	1	9.63	37.20	40.50	12.67	2.36					1.4	5,852	10,534
				2		41.18	44.82	14.02	2.61						6,476	11,657
				3		47.88	52.12		3.04						7,532	13,558
25 miles west of; SW. ¼ sec. 21, T. 30 N., R. 16 W.; Ship Rock Indian School mine (350 feet down main entry and 150 feet up right entry).	198	29006	B	1	10.12	39.94	45.77	4.17	.85					2.1	6,674	12,014
				2		44.44	50.92	4.64	.95						7,425	13,365
				3		46.60	53.40		1.00						7,787	14,017
SOCORRO COUNTY.																
Carthage; Government mine, Carthage bed (face of 3 room, 2 left entry, rise room).	198	30214	A	1	3.66	39.74	46.75	9.85	.99					2.2	7,142	12,856
Same (face of 2 room, 22 slant entry, main entry)	198	30215	A	1	2.80	36.43	42.80	17.97	.65					1.4	6,498	11,696
Same (composite of samples 30214 and 30215)	198	30216	A	1	3.19	37.96	45.10	13.75	.82	5.25	68.36	1.32	10.50	1.8	6,837	12,307
				2		39.21	46.59	14.20	.85	5.06	70.62	1.36	7.91		7,063	12,713
				3		45.70	54.30		.99	5.90	82.31	1.59	9.21		8,232	14,818
NORTH DAKOTA.																
WARD COUNTY.																
Burlington, ½ mile east of; Conon mine, lignite bed (face of main entry; on rib, 700 feet east of mine mouth).	198	*31702	A	1	37.82	25.90	27.20	9.08	.25					30.8	3,392	6,106

Same (face of 2 room, 2 east main entry, 800 feet from mine mouth).	198	*31703	A	1	37.54	24.20	27.72	10.54	.28					30.8	3,296	5,933
Same (face of 3 room, main back entry, 600 feet east of mine mouth).	198	*31704	A	1	35.60	24.15	28.39	11.86	.23					28.6	3,317	5,971
Same (composite of samples 31702 to 31704)	198	*31705	A	1	36.93	24.92	27.72	10.43	.22	6.39	37.36	.61	44.99	30.1	3,339	6,010
				2		39.51	43.95	16.54	.35	3.63	59.23	.97	19.28		5,294	9,529
				3		47.34	52.66		.42	4.35	70.97	1.16	23.10		6,343	11,417
WILLIAMS COUNTY.																
Ray, 10 miles southwest of; sec. 29, T. 155 N., R. 96 W.; Pittsley mine, lignite bed (face of 1 left entry, 100 feet north of mine mouth).	199	*29251	B	1	42.34	24.95	28.69	3.93	.36	7.30	37.79	.66	49.96	33.1	3,517	6,331
				2		43.34	49.83	6.83	.63	4.50	65.64	1.15	21.25		6,109	10,996
				3		46.52	53.48		.68	4.83	70.44	1.23	22.82		6,557	11,803
Same	199	*29253	B	1	41.91	25.46	27.28	5.35	.35					33.3	3,522	6,340
				2		43.83	46.96	9.21	.60						6,063	10,913
				3		48.27	51.73		.66						6,678	12,020
Wheelock, 7 miles southeast of; sec. 29, T. 155 N., R. 97 W.; Jim Monuen mine, lignite bed (face of 2 left entry, 300 feet west of mine mouth).	200	*29252	B	1	42.09	25.04	24.40	8.47	1.32	7.10	35.17	.46	47.48	33.7	3,330	5,994
				2		43.24	42.13	14.63	2.28	4.18	60.73	.79	17.39		5,750	10,350
				3		50.65	49.35		2.67	4.90	71.14	.93	20.37		6,736	12,125
OHIO.																
COLUMBIANA COUNTY.																
East Liverpool, 3 miles northeast of; sec. 36; Liverpool Township; Delaney mine, Middle Kittanning bed (65 feet north of mine mouth).	200	25592	B	1	4.33	36.75	54.31	4.61	1.46					1.7	7,589	13,660
				2		38.41	56.77	4.82	1.53						7,933	14,279
				3		40.35	59.65		1.61						8,334	15,001
3½ miles northeast of: Duck mine, Middle Kittanning bed (50 feet northeast of mine mouth).	200	25589	B	1	5.08	35.78	53.15	5.99	2.07					2.7	7,412	13,342
				2		37.69	56.00	6.31	2.18						7,809	14,056
				3		40.23	59.77		2.33						8,335	15,003
2¾ miles northeast of; N. ½ sec. 28; Gaston mine, Upper Freeport bed (65 feet from mine mouth).	201	25583	B	1	5.27	36.28	49.51	8.94	4.01					3.0	7,118	12,812
				2		38.30	52.26	9.44	4.23						7,514	13,525
				3		42.29	57.71		4.67						8,297	14,935
1¾ miles north of; sec. 33, center; Johnson mine, Middle Kittanning bed (50 feet north of mine mouth).	201	25588	B	1	4.79	34.83	52.95	7.43	1.79	5.39	73.99	1.38	10.02	2.7	7,329	13,192
				2		36.58	55.62	7.80	1.88	5.10	77.71	1.45	6.06		7,698	13,856
				3		39.67	60.33		2.04	5.53	84.28	1.57	6.58		8,349	15,028
2¼ miles north of; SW. ¼ sec. 28; Kinsey mine, Lower Freeport bed (65 feet north of mine mouth).	201	25585	B	1	3.58	38.47	47.48	10.47	4.49	5.39	70.04	1.56	8.05	1.8	7,138	12,848
				2		39.90	49.24	10.86	4.66	5.18	72.64	1.62	5.04		7,403	13,325
				3		44.76	55.24		5.23	5.81	81.49	1.82	5.65		8,305	14,949
½ mile north of; sec. 24, center; Malone's mine, Lower Kittanning bed (15 feet northeast of mine mouth).	202	25590	B	1	2.66	41.73	43.99	11.62	8.03					1.2	7,085	12,753
				2		42.87	45.19	11.94	8.25						7,278	13,100
				3		48.68	51.32		9.37						8,265	14,877
3¾ miles northeast of; SE. ¼ sec. 23; Moore's mine, Lower Freeport bed (60 feet southwest of mine mouth).	202	25586	B	1	4.27	36.43	47.66	11.64	3.04					2.2	6,977	12,559
				2		38.05	49.79	12.16	3.18						7,288	13,118
				3		43.32	56.68		3.62						8,297	14,935
4 miles northeast of; W. ½ sec. 24; Smith mine, Middle Kittanning bed (125 feet east of mine mouth).	203	25584	B	1	4.03	36.69	53.03	6.25	2.61	5.46	74.65	1.64	9.39	1.7	7,496	13,493
				2		38.23	55.26	6.51	2.72	5.22	77.79	1.71	6.05		7,811	14,060
				3		40.89	59.11		2.91	5.58	83.20	1.83	6.48		8,355	15,039

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau, all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OHIO—Continued.																
COLUMBIANA COUNTY—continued.																
New Salisbury, ½ mile northeast of; sec. 34; McClain Fire Brick Co. mine, Upper Freeport bed (900 feet east of mine mouth).	203	25892	B	1	3.46	36.74	48.87	10.93	4.28	5.24	69.89	1.38	8.28	1.5	7,073	12,731
				2	......	38.06	50.62	11.32	4.48	5.03	72.39	1.43	5.40	......	7,326	13,187
				3	......	42.92	57.08	......	5.00	5.67	81.63	1.61	6.08	......	8,262	14,872
Wellsville, sec. 5; Ainsworth mine, Lower Kittanning bed (30 feet S. 16° E. of mine mouth).	204	25898	B	1	4.46	40.86	49.73	4.95	3.52	......	......	......	......	2.6	7,540	13,572
				2	......	42.77	52.05	5.18	3.68	......	......	......	......	......	7,892	14,206
				3	......	45.11	54.89	......	3.88	......	......	......	......	......	8,323	14,981
Sec. 15; Dangelo mine, Mahoning bed (40 feet south of mine mouth).	204	25896	B	1	3.15	39.32	51.15	6.38	3.55	5.56	75.35	1.35	7.81	1.1	7,548	13,586
				2	......	40.60	52.81	6.59	3.67	5.38	77.80	1.39	5.17	......	7,798	14,027
				3	......	43.46	56.54	......	3.93	5.76	83.28	1.49	5.54	......	8,342	15,016
1½ miles northwest of; sec. 11; Householder's mine, Upper Freeport bed (20 feet S. 35° W. from mine mouth).	204	25894	B	1	5.13	38.01	48.58	8.28	3.78	......	......	......	......	2.9	7,200	12,960
				2	......	40.07	51.20	8.73	3.98	......	......	......	......	......	7,590	13,662
				3	......	43.90	56.10	......	4.36	......	......	......	......	......	8,316	14,969
Sec. 5; Sheckler mine, Lower Freeport bed (55 feet N. 10° W. from mine mouth).	205	25895	B	1	5.94	32.73	49.81	11.52	1.49	5.28	68.30	1.35	12.06	3.6	6,728	12,107
				2	......	34.80	52.95	12.25	1.58	4.91	72.62	1.44	7.20	......	7,151	12,872
				3	......	39.67	60.33	......	1.80	5.60	82.76	1.64	8.20	......	8,149	14,668
3 miles northwest of; sec. 18; Smith's mine, Upper Freeport bed (150 feet W. 12° S. from mine mouth).	205	25893	B	1	3.43	37.81	51.28	7.48	2.86	5.53	74.31	1.48	8.34	1.4	7,425	13,365
				2	......	39.15	53.10	7.75	2.96	5.33	76.95	1.53	5.48	......	7,689	13,840
				3	......	42.44	57.56	......	3.21	5.78	83.41	1.66	5.94	......	8,335	15,003
Sec. 9; Wooster's clay mine, Lower Kittanning bed (100 feet W. 10° S. from mine mouth).	206	25897	B	1	2.67	38.46	50.19	8.68	5.71	......	......	......	......	1.1	7,340	13,212
				2	......	39.51	51.57	8.92	5.87	......	......	......	......	......	7,541	13,574
				3	......	43.38	56.62	......	6.44	......	......	......	......	......	8,279	14,902
Same, Wooster's strip pit, Middle Kittanning bed (340 feet west of mine mouth).	206	25900	B	1	3.41	34.66	51.18	10.75	.70	5.22	71.62	1.45	10.26	1.2	7,128	12,830
				2	......	35.88	52.99	11.13	.72	5.01	74.15	1.50	7.49	......	7,380	13,284
				3	......	40.37	59.63	......	.81	5.64	83.43	1.69	8.43	......	8,304	14,947
West Point, West Point mine, Upper Freeport bed (1,800 feet southwest of mine mouth).	206	25580	B	1	3.37	37.89	51.68	7.06	2.92	......	......	......	......	1.5	7,471	13,448
Same (500 feet northeast of mine mouth)........................	206	25581	B	1	3.77	38.32	49.93	7.98	3.65	......	......	......	......	1.8	7,398	13,316
Same (composite of samples 25580 and 25581)...................	206	25582	B	1	3.60	37.80	51.22	7.38	3.21	5.35	73.68	1.85	8.53	1.6	7,439	13,390
				2	......	39.21	53.13	7.66	3.33	5.13	76.43	1.92	5.53	......	7,716	13,889
				3	......	42.46	57.54	......	3.61	5.56	82.77	2.08	5.98	......	8,356	15,041

JEFFERSON COUNTY.																
Cream City, sec. 25; Cream City mine, Middle Kittanning bed (340 feet N. 20° E. from mine mouth).	207	25899	B	1	2.64	36.75	49.46	11.15	2.07	5.26	71.04	1.49	8.99	.7	7,158	12,884
				2	......	37.15	50.80	11.45	2.13	5.10	72.97	1.53	6.82	......	7,352	13,234
				3	......	42.63	57.37	......	2.41	5.76	82.41	1.73	7.70	......	8,303	14,945
Empire, 2½ miles southwest of; Knox Township; sec. 9; Culp's mine, Pittsburgh bed (275 feet S. 35° W. from mine mouth).	207	25784	B	1	3.18	38.11	49.35	9.36	4.02	......	......	......	......	1.0	7,187	12,937
				2	......	39.36	50.97	9.67	4.15	......	......	......	......	......	7,423	13,361
				3	......	43.58	56.42	......	4.59	......	......	......	......	......	8,218	14,792
Irondale, sec. 26; Banfield mine, Lower Freeport bed (250 feet S. 10° W. from mine mouth).	208	25785	B	1	4.26	35.55	48.10	12.09	2.36	......	......	......	......	2.5	6,941	12,494
				2	......	37.13	50.24	12.63	2.46	......	......	......	......	......	7,250	13,050
				3	......	42.50	57.50	......	2.82	......	......	......	......	......	8,298	14,936
Same, Banfield No. 3 mine, Lower Kittanning bed (400 feet S. 57° E. from mine mouth).	208	25787	B	1	3.44	37.17	46.71	12.68	7.30	......	......	......	......	2.1	6,907	12,438
				2	......	38.49	48.38	13.13	7.56	......	......	......	......	......	7,154	12,877
				3	......	44.31	55.69	......	8.70	......	......	......	......	......	8,235	14,823
Same, East Ohio No. 2 mine, Lower Kittanning bed (3,000 feet east of mine mouth).	209	25901	B	1	2.21	39.63	47.50	10.66	4.96	5.28	71.04	1.34	6.72	.7	7,236	13,025
				2	......	40.53	48.57	10.90	5.07	5.14	72.65	1.37	4.87	......	7,400	13,320
				3	......	45.49	54.51	......	5.69	5.77	81.54	1.54	5.46	......	8,305	14,949
Same, Nicholson mine, Upper Freeport bed (600 feet W. 10° S. from mine mouth).	209	25788	B	1	3.73	36.54	51.24	8.49	2.87	......	......	......	......	1.8	7,290	13,122
				2	......	37.95	53.23	8.82	2.98	......	......	......	......	......	7,572	13,630
				3	......	41.62	58.38	......	3.27	......	......	......	......	......	8,304	14,947
Yellow Creek, 5 miles south of; Knox Township; sec. 16; local mine, near New Somerset, Pittsburgh bed (150 feet S. 5° W. from mine mouth).	209	25786	B	1	3.37	37.86	48.78	9.99	3.94	......	......	......	......	1.4	7,178	12,920
				2	......	39.17	50.49	10.34	4.08	......	......	......	......	......	7,429	13,372
				3	......	43.70	56.30	......	4.55	......	......	......	......	......	8,286	14,915
Sec. 14; Yellow Creek mine, Upper Freeport bed (30 feet west of mine mouth).	210	25890	B	1	4.75	38.28	51.91	5.06	1.76	......	......	......	......	2.7	7,480	13,464
				2	......	40.19	54.50	5.31	1.85	......	......	......	......	......	7,853	14,135
				3	......	42.44	57.56	......	1.95	......	......	......	......	......	8,294	14,929
Same (50 feet southwest from opening)	......	25891	B	1	3.43	36.26	49.57	10.74	5.05	5.15	69.66	1.37	8.03	1.5	7,068	12,722
				2	......	37.55	51.33	11.12	5.23	4.94	72.13	1.42	5.16	......	7,319	13,174
				3	......	42.25	57.75	......	5.88	5.56	81.15	1.60	5.81	......	8,235	14,823
OKLAHOMA.																
COAL COUNTY.																
Lehigh, 3,000 feet northeast of; sec. 14; T. 1 S., R. 10 E.; Folsom Morris No. 5 mine, McAlester bed (face of 1 south entry, 8½ slope, top entry).	211	30707	A	1	6.61	38.21	42.54	12.64	4.15	......	......	......	......	1.9	6,206	11,171
Same (face of 11 south entry, 5½ slope, bottom entry)	211	30708	A	1	6.98	38.31	42.35	12.36	3.71	......	......	......	......	2.1	6,229	11,212
Same (face of 4 south entry, 5½ slope, bottom entry)	211	30709	A	1	7.74	38.53	42.20	11.53	5.16	......	......	......	......	2.5	6,184	11,131
Same (face of 14 north entry, 5 slope, top entry)	211	30710	A	1	6.57	39.75	42.03	11.65	3.68	......	......	......	......	2.0	6,269	11,284
Same (face of 13 north entry, 5 slope, top entry)	211	30711	A	1	6.17	39.26	42.67	11.90	4.54	......	......	......	......	1.6	6,296	11,333
Same (composite of samples 30707 to 30711)	211	30712	A	1	6.59	38.62	42.87	11.92	4.27	5.01	62.75	1.52	14.53	2.0	6,258	11,264
				2	......	41.34	45.90	12.76	4.57	4.58	67.17	1.63	9.29	......	6,699	12,058
				3	......	47.39	52.61	......	5.24	5.25	77.00	1.87	10.64	......	7,679	13,822

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105 °C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page.)	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OKLAHOMA—Continued.																
COAL COUNTY—continued.																
Lehigh, 1½ miles east of; sec. 24, T. 1 S., R. 10 E.; Folsom Morris No. 8 mine, McAlester bed (face of 6 south entry, main slope, bottom entry).	212	30713	A	1	6.31	38.29	43.14	12.26	4.27	......	......	......	......	1.7	6,286	11,315
Same (face of 6 south entry, plane entry, top entry)	212	30714	A	1	7.12	40.38	42.28	10.22	3.46	......	......	......	......	2.1	6,342	11,416
Same (face of 7 south entry, plane entry, top entry)	212	30715	A	1	7.06	39.72	42.41	10.81	3.66	......	......	......	......	2.3	6,317	11,371
Same (face of 5 north entry, main slope entry, bottom entry)	212	30716	A	1	6.09	40.28	40.63	13.00	4.75	......	......	......	......	1.9	6,237	11,227
Same (face of 6 north entry, plane entry, top entry)	212	30717	A	1	7.07	40.64	41.68	10.61	3.42	......	......	......	......	2.4	6,321	11,378
Same (composite of samples 30713 to 30717)	212	30718	A	1	6.89	39.36	42.30	11.45	3.93	4.95	63.15	1.48	15.04	2.1	6,300	11,340
				2	......	42.27	45.43	12.30	4.22	4.50	67.82	1.59	9.57	......	6,766	12,179
				3	......	48.20	51.80	......	4.81	5.13	77.34	1.81	10.91	......	7,715	13,887
Phillips, ½ mile east of; sec. 2, T. 1 S., R. 10 E.; Folsom Morris No. 6 mine, McAlester bed (face of 10 north entry, 6½ slope, top entry).	213	30719	A	1	6.13	39.95	45.15	8.77	3.32	......	......	......	......	2.2	6,653	11,975
Same (face of 10 north entry, main slope entry, bottom entry)	213	30720	A	1	5.81	40.05	45.70	8.44	3.76	......	......	......	......	1.9	6,708	12,074
Same (face of 11 south entry, main slope entry, top entry)	213	30721	A	1	5.58	39.87	45.45	9.10	3.42	......	......	......	......	1.4	6,664	11,995
Same (face of 10 south entry, 6½ slope, top entry)	213	30722	A	1	5.69	40.30	46.46	7.55	3.25	......	......	......	......	1.8	6,786	12,215
Same (face of 10 south entry, main slope entry, top entry)	213	30723	A	1	5.88	39.06	45.23	9.83	3.97	......	......	......	......	1.8	6,538	11,768
Same (composite of samples 30719 to 30723)	213	30724	A	1	5.94	39.46	45.79	8.81	3.58	5.06	66.96	1.60	13.99	1.8	6,677	12,019
				2	......	41.95	48.68	9.37	3.81	4.68	71.19	1.70	9.25	......	7,099	12,778
				3	......	46.29	53.71	......	4.20	5.16	78.55	1.88	10.21	......	7,833	14,099
HASKELL COUNTY.																
McCurtain, 1 mile northwest of; Blue Ridge No. 3 mine, Panama bed (face of 7 west entry, main slope entry).	214	W69353	A	1	3.00	22.70	67.02	7.28	.78	......	......	......	......	......	7,661	13,790
				2	......	23.40	69.10	7.50	.80	......	......	......	......	......	7,900	14,220
				3	......	25.30	74.70	......	.86	......	......	......	......	......	8,545	15,380
Same (face of 6 west entry, main slope entry)	214	W69354	A	1	3.20	22.36	67.76	6.68	.68	......	......	......	......	......	7,756	13,960
				2	......	23.10	70.00	6.90	.70	......	......	......	......	......	8,011	14,420
				3	......	24.81	75.19	......	.75	......	......	......	......	......	8,606	15,4[illegible]

Same (face of 7 east entry, main slope entry)	214	W69355	A	1	2.40	22.55	67.53	7.52	.78						7,761	13,970
				2		23.10	69.20	7.70	.80						7,956	14,320
				3		25.03	74.97		.87						8,617	15,510
Same (face of 6 east entry, main slope entry)	214	W69356	A	1	2.90	22.62	67.10	7.38	.83						7,750	13,950
				2		23.30	69.10	7.60	.85						7,978	14,360
				3		25.22	74.78		.92						8,639	15,550
1¼ miles west of; sec 21, T. 8 N., R. 22 E.; Blue Ridge No. 4 mine, Panama bed (left north rib, 40 feet from face of main slope).	214	29840	A	1	2.28	22.82	68.00	6.90	.91					1.7	7,801	14,042
Same (face of 4 west entry, main slope entry)	214	29841	A	1	3.71	22.57	68.72	5.00	1.04					3.2	7,904	14,227
Same (composite of samples 29840 and 29841)	214	29843	A	1	3.02	22.75	68.22	6.00	.99	4.76	80.85	1.80	5.60	2.5	7,860	14,148
				2		23.46	70.35	6.19	1.02	4.56	83.36	1.86	3.01		8,104	14,587
				3		25.01	74.99		1.09	4.86	88.86	1.98	3.21		8,639	15,550
Same (face of 5 east entry, main slope entry)	214	W69349	A	1	2.50	23.50	66.49	7.51	.73						7,728	13,910
				2		24.10	68.20	7.70	.75						7,928	14,270
				3		26.11	73.89		.81						8,589	15,460
Same (face of 4 west entry, main slope entry)	214	W69350	A	1	3.20	22.65	66.21	7.94	.92						7,672	13,810
				2		23.40	68.40	8.20	.95						7,928	14,270
				3		25.49	74.51		1.03						8,639	15,550
Same (face of 5 room, 4 east entry, main slope entry)	214	W69351	A	1	2.60	23.57	67.40	6.43	.78						7,822	14,080
				2		24.20	69.20	6.60	.80						8,028	14,450
				3		25.91	74.09		.86						8,595	15,470
Same (face of 5 west entry, main slope entry)	214	W69352	A	1	2.90	22.92	67.77	6.41	.83						7,778	14,000
				2		23.60	69.80	6.60	.85						8,011	14,420
				3		25.27	74.73		.91						8,578	15,440
Same (tipple samples of lump coal over 1-inch bar screen)	214	W69412, W69416, W69417, W69418	C	1	1.63	21.94	60.74	15.69	.73						7,050	12,690
				2		22.30	61.75	15.95	.74						7,167	12,900
				3		26.53	73.47		.88						8,527	15,348
Same (tipple sample of slack coal through 1-inch bar screen)	214	W69415, W69419	C	1	4.00	20.74	58.03	17.23	.77						6,709	12,077
				2		21.60	60.45	17.95	.80						6,989	12,580
				3		26.33	73.67		.98						8,518	15,332
1 mile west of; Blue Ridge No. 5 mine, Panama bed (face of 2 west entry, main slope entry).	216	29839	A	1	3.57	22.53	66.04	7.86	.73					3.1	7,652	13,774
Same (face of 3 room, 2 east entry, main slope entry)	216	29842	A	1	3.44	21.38	68.58	6.60	1.01					3.0	7,801	14,042
Same (composite of samples 29839 and 29842)	216	29844	A	1	3.61	21.78	67.29	7.32	.86	4.77	79.51	1.67	5.87	3.0	7,706	13,871
				2		22.60	69.81	7.59	.89	4.53	82.49	1.73	2.77		7,997	14,391
				3		24.46	75.54		.96	4.90	89.26	1.87	3.01		8,651	15,572
Stigler, 2 miles from; Turner strip pit, Stigler (McAlester) bed (near north end of pit).	217	26323	B	1	3.75	27.14	66.59	2.52	.63	5.24	83.14	1.88	6.59	3.1	8,134	14,641
				2		28.20	69.18	2.62	.65	5.01	86.38	1.95	3.39		8,451	15,212
				3		28.96	71.04		.67	5.14	88.70	2.00	3.49		8,678	15,620
3 miles northwest of; sec. 5, T. 9 N., R. 21 E.; strip pit, Stigler bed (face of workings).	217	30344	A	1	3.07	26.11	66.27	4.55	.69					2.1	7,972	14,350
				2		26.94	68.37	4.69	.71						8,225	14,805
				3		28.27	71.73		.74						8,630	15,534

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau: all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OKLAHOMA—Continued.																
HASKELL COUNTY—continued.																
Tamaha, 3½ miles from; Nunnally strip pit, Stigler (McAlester) bed (at face of pit).	217	26324	B	1	3.04	21.32	69.58	6.06	3.83	......	......	......	......	2.7	7,934	14,281
				2	......	21.99	71.76	6.25	3.95	......	......	......	......	......	8,183	14,729
				3	......	23.46	76.54	......	4.21	......	......	......	......	......	8,729	15,712
Near sec. 19, T. 11 N., R. 22 E.; Old Slope mine, Stigler bed (near mouth of slope; mine not in operation).	217	30706	A	1	5.52	22.67	64.17	7.64	3.40	......	......	......	......	3.6	7,408	13,325
				2	......	23.99	67.92	8.09	3.60	......	......	......	......	......	7,835	14,103
				3	......	26.10	73.90	......	3.92	......	......	......	......	......	8,524	15,343
Whitefield, 1 mile south and 1 mile west of; sec. 24; Ligon strip pit, Stigler (?) bed (face of workings).	217	26325	B	1	3.88	29.70	63.90	2.52	1.38	......	......	......	......	2.9	8,073	14,531
				2	......	30.90	66.48	2.62	1.44	......	......	......	......	......	8,399	15,118
				3	......	31.73	68.27	......	1.48	......	......	......	......	......	8,625	15,525
LATIMER COUNTY.																
Degnan, ¼ mile west of; M. K. & T. No. 19 mine, Lower Hartshorne bed (face of 3 east entry, main slope entry).	218	W69530	A	1	11.20	33.48	46.62	8.70	1.78	......	......	......	......	......	6,650	11,970
				2	......	37.70	52.50	9.80	2.00	......	......	......	......	......	7,483	13,470
				3	......	41.79	58.21	......	2.22	......	......	......	......	......	7,995	14,390
Same (face of 2 east entry, inside plane entry)	218	W69542	A	1	2.90	36.12	55.64	5.34	.83	......	......	......	......	......	7,689	13,840
				2	......	37.20	57.30	5.50	.85	......	......	......	......	......	7,917	14,250
				3	......	39.37	60.63	......	.90	......	......	......	......	......	8,378	15,080
Same (face of 4 east entry, main slope entry)	218	W69547	A	1	3.70	36.88	53.83	5.59	.87	......	......	......	......	......	7,572	13,630
				2	......	38.30	55.90	5.80	.90	......	......	......	......	......	7,861	14,150
				3	......	40.66	59.34	......	.96	......	......	......	......	......	8,345	15,020
Same (face of 5 east entry, main slope entry)	218	W69552	A	1	2.90	34.76	53.41	8.93	1.21	......	......	......	......	......	7,389	13,300
				2	......	35.80	55.00	9.20	1.25	......	......	......	......	......	7,611	13,700
				3	......	39.43	60.57	......	1.38	......	......	......	......	......	8,383	15,090
Same (face of 1 east entry, inside plane entry)	215	W69560	A	1	4.20	36.88	53.46	5.46	.81	......	......	......	......	......	7,480	13,480
				2	......	38.50	55.80	5.70	.85	......	......	......	......	......	7,817	14,070
				3	......	40.83	59.17	......	.90	......	......	......	......	......	8,289	14,920
Same (tipple sample of lump coal over 2½-inch screen)	218	W69532 W69533	C	1	2.55	37.32	53.60	6.53	.97	......	......	......	......	......	7,569	13,624
				2	......	38.30	55.00	6.70	1.00	......	......	......	......	......	7,767	13,980
				3	......	41.05	58.95	......	1.07	......	......	......	......	......	8,325	14,984

Same (tipple sample of nut coal through 2½-inch and over 1½-inch screen).	218	W69541	C	1	2.40	35.82	51.68	10.10	1.05						7,315	13,166
		W69544		2		36.70	52.95	10.35	1.08						7,495	13,490
				3		40.94	59.06		1.20						8,360	15,047
Same (tipple sample of slack coal through 1½-inch screen)	218	W69543	C	1	4.75	34.77	51.43	9.05	.98						7,205	12,968
		W69548		2		36.50	54.00	9.50	1.03						7,564	13,615
				3		40.33	59.67		1.14						8,358	15,044
Gowen, 1 mile west of; secs. 22, 23, 26, 27, T. 5 N., R. 17 E.; Rock Island No. 40 mine, Lower Hartshorne bed (face of 5 room, 9 west entry, 41 slope entry).	218	30270	A	1	3.84	37.26	52.36	6.54	1.39					2.3	7,453	13,415
Same (face of 15 room, 7 west entry, 41 slope entry)	218	30271	A	1	3.46	39.24	50.41	6.89	.86					2.0	7,391	13,304
Same (face of 8 east entry, 41 slope entry)	218	30272	A	1	4.40	36.80	51.36	7.44	1.28					2.8	7,318	13,172
Same (face of 50 room, 6 west entry, 40 slope entry)	218	30273	A	1	4.08	38.81	51.32	5.79	1.91					2.6	7,491	13,484
Same (face of 5 east air course, 41 slope entry)	218	30274	A	1	3.92	38.36	52.44	5.28	1.14					2.3	7,529	13,552
Same (face of 6 east entry, 41 slope entry)	218	30275	A	1	4.09	38.64	50.76	6.51	2.20					2.4	7,449	13,408
Same (face of 5 west entry, 41 slope entry)	218	30276	A	1	3.97	37.71	50.65	7.67	1.02					2.5	7,311	13,160
Same (composite of samples 30270 to 30276)	218	30277	A	1	3.89	38.14	51.41	6.56	1.44	5.38	74.27	1.89	10.46	2.4	7,420	13,356
				2		39.68	53.49	6.83	1.50	5.15	77.28	1.97	7.27		7,721	13,898
				3		42.59	57.41		1.61	5.53	82.94	2.11	7.81		8,287	14,917
Red Oak, 3½ miles southeast of; Hilling No. 2 mine, Lower Hartshorne bed (face of 2 east air course, main slope entry).	219	W69613	A	1	6.00	31.02	58.66	4.32	1.13						7,600	13,680
				2		33.00	62.40	4.60	1.20						8,083	14,550
				3		34.59	65.41		1.26						8,472	15,250
Same (face of east plane entry, main slope entry)	219	W69630	A	1	3.90	32.10	59.77	4.23	1.25						7,745	13,940
				2		33.40	62.20	4.40	1.30						8,061	14,510
				3		34.94	65.06		1.36						8,433	15,180
Same (face of 1 east entry, main slope entry)	219	W69634	A	1	4.20	31.81	59.97	4.02	1.01						7,839	14,110
				2		33.20	62.60	4.20	1.05						8,183	14,730
				3		34.65	65.35		1.10						8,545	15,380
Same (tipple samples of coal being loaded)	219	W69611 W69622	C	1	2.38	32.46	58.13	7.03	1.16						7,668	13,803
		W69627		2		33.25	59.55	7.20	1.19						7,856	14,140
		W69629		3		35.83	64.17		1.28						8,465	15,237
Wilburton, ½ mile west of; sec. 8, T. 5 N., R. 19 E.; New No. 5 mine, Upper Hartshorne bed (face of 12 west entry, where 17 room will be turned).	220	27531	A	1	4.11	37.15	53.34	5.40	.92					2.8	7,527	13,549
Same (face of 2 room, A entry)	220	27532	A	1	3.54	37.73	53.74	4.99	.85					2.1	7,634	13,741
Same (face of 3 room, B entry)	220	27533	A	1	3.35	37.09	54.57	4.99	1.16					2.1	7,649	13,768
Same (face of 15 room, 10 east entry)	220	27534	A	1	3.67	37.86	53.98	4.49	.86					2.3	7,638	13,748
Same (composite of samples 27531 to 27534)	220	27535	A	1	3.68	37.41	53.85	5.06	.96	5.22	75.19	1.65	11.92	2.3	7,604	13,687
				2		38.84	55.91	5.25	1.00	4.99	78.06	1.71	8.99		7,894	14,209
				3		40.99	59.01		1.06	5.27	82.38	1.80	9.49		8,331	14,996
Same (face of 6 east entry)	220	W69509	A	1	3.40	35.84	54.77	5.99	1.01						7,495	13,490
				2		37.10	56.70	6.20	1.05						7,756	13,960
				3		39.55	60.45		1.12						8,272	14,890
Same (face of main east entry)	220	W69510	A	1	3.60	37.98	52.73	5.69	.82						7,483	13,470
				2		39.40	54.70	5.90	.85						7,761	13,970
				3		41.87	58.13		.90						8,245	14,840

a Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

b Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. A asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

c The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

d The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OKLAHOMA—Continued.																
LATIMER COUNTY—continued.																
Wilburton, ½ mile west of; sec. 8, T. 5 N., R. 19 E.; New No. 5 mine, Upper Hartshorne bed (face of 12 west entry).	220	W69513	A	1	3.10	37.69	53.78	5.43	0.82						7,533	13,560
				2		38.90	55.50	5.60	.85						7,772	13,990
				3		41.21	58.79		.90						8,233	14,820
Same (face of 10 east entry)	220	W69516	A	1	3.90	36.90	52.76	6.44	1.15						7,383	13,290
				2		38.40	54.90	6.70	1.20						7,678	13,820
				3		41.16	58.84		1.29						8,239	14,830
Same (face of 10 west entry)	220	W69517	A	1	3.20	37.66	54.49	4.65	.87						7,561	13,610
				2		38.90	56.30	4.80	.90						7,811	14,060
				3		40.86	59.14		.95						8,206	14,770
Same (tipple samples of coal being loaded)	220	W69511, W69512, W69514, W69515	C	1	2.38	37.58	51.57	8.47	.91						7,311	13,159
				2		38.50	52.82	8.68	.93						7,489	13,480
				3		42.16	57.84		1.02						8,201	14,761
LEFLORE COUNTY.																
Bokoshe, ½ mile northeast of; T. 8 N., R. 24 E.; Slope No. 3 mine, Hartshorne bed (face of 5 east entry, slope entry, 1,700 feet east of mine mouth, top bench).	221	26801	B	1	3.15	17.27	76.35	3.23	.54					2.6	8,099	14,578
				2		17.83	78.84	3.33	.56						8,362	15,052
				3		18.44	81.56		.58						8,650	15,570
Same (bottom bench)	221	26802	B	1	3.00	19.19	71.11	6.70	.96					2.6	7,768	13,982
				2		19.78	73.31	6.91	.99						8,008	14,414
				3		21.25	78.75		1.06						8,602	15,484
Calhoun; No. 8 mine, Lower Witteville bed (face of 7 east entry, main slope entry).	222	W69461	A	1	1.50	22.56	62.74	13.20	3.94						7,395	13,310
				2		22.90	63.70	13.40	4.00						7,506	13,510
				3		26.44	73.56		4.62						8,667	15,600
Same (face of 13 west entry, main slope entry)	222	W69468	A	1	1.50	21.77	64.71	12.02	3.84						7,456	13,420
				2		22.10	65.70	12.20	3.90						7,572	13,630
				3		25.17	74.83		4.44						8,622	15,520
Same (face of 12 west entry, main slope entry)	222	W69469	A	1	1.90	21.58	62.59	13.93	3.53						7,256	13,060
				2		22.00	63.80	14.20	3.60						7,400	13,320
				3		25.64	74.36		4.20						8,628	15,530

Same (face of 11 west entry, main slope entry)	222	W69470	A	1	1.90	21.97	62.59	13.54	3.78	......	......	......	......	......	7,267	13,080
				2	......	22.40	63.80	13.80	3.85	......	......	......	......	......	7,406	13,330
				3	......	25.99	74.01	......	4.47	......	......	......	......	......	7,595	15,470
Same (face of 8 east entry, main slope entry)	222	W69473	A	1	1.50	22.56	62.25	13.69	6.25	......	......	......	......	......	8,239	13,030
				2	......	22.90	63.20	13.90	6.35	......	......	......	......	......	7,350	13,230
				3	......	26.60	73.40	......	7.37	......	......	......	......	......	7,539	15,370
Same (tipple samples of lump coal over 8-inch bar screen)	222	W69463, W69483	C	1	.65	22.70	65.67	10.98	3.66	......	......	......	......	......	8,650	13,770
				2	......	22.85	66.10	11.05	3.68	......	......	......	......	......	7,700	13,860
				3	......	25.69	74.31	......	4.14	......	......	......	......	......	8,657	15,582
Same (tipple samples of run-of-mine coal through 8-inch bar screen).	222	W69460, W69462, W69478, W69480	C	1	.78	21.43	60.64	17.15	4.25	......	......	......	......	......	7,080	12,743
				2	......	21.60	61.12	17.28	4.28	......	......	......	......	......	7,135	12,843
				3	......	26.11	73.89	......	5.17	......	......	......	......	......	8,626	15,526
Howe, 3 miles southwest of; No. 3 mine, Lower Hartshorne bed; (face of 4 west entry, main slope entry).	223	W69464	A	1	3.50	18.53	69.96	8.01	.77	......	......	......	......	......	7,628	13,730
				2	......	19.20	72.50	8.30	.80	......	......	......	......	......	7,906	14,230
				3	......	20.94	79.06	......	.87	......	......	......	......	......	8,622	15,520
Same (face of 6 west entry)	223	W69465	A	1	3.80	18.66	70.23	7.31	.82	......	......	......	......	......	7,633	13,740
				2	......	19.40	73.00	7.60	.85	......	......	......	......	......	7,933	14,280
				3	......	21.00	79.00	......	.92	......	......	......	......	......	8,583	15,450
Same (face of 30 room, 5 entry, main slope entry)	223	W69482	A	1	2.50	19.11	71.66	6.73	.54	......	......	......	......	......	7,800	14,040
				2	......	19.60	73.50	6.90	.55	......	......	......	......	......	8,000	14,400
				3	......	21.05	78.95	......	.59	......	......	......	......	......	8,595	15,470
Same (tipple samples of run-of-mine coal)	223	W69466, W69467, W69479, W69485	C	1	3.05	18.64	64.54	13.77	.73	......	......	......	......	......	7,057	12,703
				2	......	19.23	66.57	14.20	.75	......	......	......	......	......	7,280	13,103
				3	......	22.41	77.59	......	.87	......	......	......	......	......	8,485	15,272
Williams, 1 mile west of: No. 1 mine, Lower Hartshorne bed (face of 6 west entry, main slope entry).	224	W69409	A	1	1.80	16.50	73.94	7.76	.54	......	......	......	......	......	7,980	14,040
				2	......	16.80	75.30	7.90	.55	......	......	......	......	......	7,939	14,290
				3	......	18.24	81.76	......	.60	......	......	......	......	......	8,617	15,510
Same (face of 7 west entry, main slope entry)	224	W69410	A	1	1.90	17.27	73.08	7.75	.59	......	......	......	......	......	7,783	14,010
				2	......	17.60	74.50	7.90	.60	......	......	......	......	......	7,939	14,290
				3	......	19.11	80.89	......	.65	......	......	......	......	......	8,622	15,520
Same (face of 8 west entry, main slope entry)	224	W69411	A	1	1.90	16.87	73.97	7.26	.64	......	......	......	......	......	7,833	14,100
				2	......	17.20	75.40	7.40	.65	......	......	......	......	......	7,989	14,380
				3	......	18.57	81.43	......	.70	......	......	......	......	......	8,628	15,530
Same (tipple samples of lump coal over 2½-inch screen)	224	W69407, W69408	C	1	1.70	17.35	71.76	9.19	.59	......	......	......	......	......	7,676	13,816
				2	......	17.65	73.00	9.35	.60	......	......	......	......	......	7,808	14,055
				3	......	19.47	80.53	......	.66	......	......	......	......	......	8,614	15,505
Same (tipple samples of nut coal through 2½-inch and over 1½-inch screen).	224	W69406, W69420	C	1	1.95	15.49	59.13	23.43	.81	......	......	......	......	......	6,251	11,251
				2	......	15.80	60.30	23.90	.83	......	......	......	......	......	6,375	11,475
				3	......	20.76	79.24	......	1.09	......	......	......	......	......	8,377	15,079
Same (tipple samples of slack coal through 1½-inch screen)	224	W69413, W69414	C	1	1.95	16.82	68.24	12.99	.62	......	......	......	......	......	7,283	13,109
				2	......	17.15	69.60	13.25	.63	......	......	......	......	......	7,428	13,370
				3	......	19.77	80.23	......	.73	......	......	......	......	......	8,562	15,412

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OKLAHOMA—Continued.																
PITTSBURG COUNTY.																
Alderson, ½ mile southwest of; sec. 22, T. 5 N., R. 15 E.; Rock Island No. 5 mine, McAlester bed (face of 5 east entry, main west slope entry).	225	30660	A	1	2.92	37.53	54.32	5.23	0.53					0.9	7,645	13,761
Same (face of 5 west entry, main west slope entry)	225	30661	A	1	2.59	38.28	54.59	4.54	.80					.9	7,746	13,943
Same (face of 7 east entry, main west slope entry)	225	30662	A	1	2.92	37.42	52.63	7.03	.57					1.1	7,479	13,462
Same (face of 3 west entry, main west slope entry)	225	30663	A	1	2.70	39.52	53.44	4.34	.88					1.0	7,758	13,964
Same (face of 9 west entry, main west slope entry)	225	30664	A	1	2.79	39.81	53.08	4.32	.65					1.0	7,760	13,968
Same (face of 4 west entry, 1 east slope entry)	225	30665	A	1	2.70	38.87	54.24	4.19	.57					.8	7,777	13,999
Same (face of 5 east entry, 1 east slope entry)	225	30666	A	1	2.90	37.77	54.47	4.86	.94					1.0	7,712	13,882
Same (composite of samples 30660 to 30666)	225	30667	A	1	2.73	38.20	54.15	4.92	.71	5.35	77.35	1.93	9.74	1.0	7,704	13,867
				2		39.27	55.67	5.06	.73	5.19	79.52	1.98	7.52		7,920	14,256
				3		41.36	58.64		.77	5.47	83.76	2.09	7.91		8,342	15,016
½ mile east of; secs. 24 and 19, T. 5 N., R. 15 and 16 E.; Rock Island No. 38 mine, McAlester bed (face of 9 west entry, main slope entry).	226	30656	A	1	2.86	37.24	54.64	5.26	.57					1.0	7,659	13,786
Same (face of 6 east entry, main slope entry)	226	30657	A	1	3.26	37.48	55.02	4.24	.51					1.3	7,706	13,871
Same (face of main east entry, main slope entry)	226	30658	A	1	2.57	38.27	54.62	4.54	.52					.6	7,732	13,918
Same (composite of samples 30656 to 30658)	226	30659	A	1	2.76	37.79	54.62	4.83	.52	5.31	77.44	1.89	10.01	1.0	7,691	13,844
				2		38.86	56.17	4.97	.53	5.14	79.64	1.94	7.78		7,909	14,236
				3		40.89	59.11		.56	5.41	83.81	2.04	8.18		8,323	14,981
Buck, 1 mile east of; sec. 12, T. 5 N., R. 15 E.; Buck No. 22 mine, Upper Hartshorne bed (face of 1 east bottom entry, 6 feet from face of slope).	226	26150	A	1	5.32	32.90	57.25	4.53	1.59					3.6	7,548	13,586
				2		34.75	60.47	4.78	1.68						7,972	14,350
				3		36.49	63.51		1.76						8,372	15,070
Carbon, 1 mile east of; Carbon No. 2 mine, McAlester bed (face of 5 west entry, main slope entry).	227	W69527	A	1	3.10	32.56	56.68	7.66	.39						7,295	13,130
				2		33.60	58.50	7.90	.40						7,522	13,540
				3		36.48	63.52		.43						8,167	14,700
Same (face of 7 east entry, main slope entry)	227	W69535	A	1	2.80	34.70	57.35	5.15	.39						7,600	13,680
				2		35.70	59.00	5.30	.40						7,822	14,080
				3		37.70	62.30		.42						8,261	14,870
Same (face of 6 west entry, main slope entry)	227	W69546	A	1	2.90	34.08	57.49	5.53	.53						7,572	13,630
				2		35.10	59.20	5.70	.55						7,795	14,030
				3		37.22	62.78		.58						8,207	14,880

Same (tipple samples of lump coal over 2½-inch screen)	227	W69529, W69531	C	1	2.80	34.26	57.89	5.05	.52						7,630	13,734
				2		35.25	59.55	5.20	.53						7,850	14,130
				3		37.19	62.81		.56						8,281	14,905
Same (tipple samples of nut coal through 2½-inch and over 1¼-inch screen).	227	W69528, W69534	C	1	2.65	33.73	54.18	9.44	.49						7,277	13,098
				2		34.65	55.65	9.70	.50						7,475	13,455
				3		38.37	61.63		.55						8,278	14,900
Same (tipple samples of chestnut coal through 1¼-inch and over ¾-inch screen).	227	W69545, W69562	C	1	2.85	32.79	52.56	11.80	.56						7,025	12,644
				2		33.75	54.10	12.15	.58						7,231	13,015
				3		38.42	61.58		.66						8,231	14,815
Same (tipple samples of slack coal through ¾-inch screen.)	227	W69540, W69554	C	1	4.00	30.96	46.85	18.19	.80						6,277	11,299
				2		32.25	48.80	18.95	.83						6,539	11,770
				3		39.79	60.21		1.02						8,068	14,522
Haileyville, 1 mile south of; T. 5 N., R. 17 E.; Hailey No. 2 mine, Upper Hartshorne bed (face of 1 south entry, main slope entry).	228	30398	A	1	4.96	36.31	51.61	7.12	1.65					2.4	7,173	12,911
Same (face of 1 north entry, main slope entry)	228	30399	A	1	5.04	35.35	50.57	9.04	1.87					2.6	7,045	12,681
Same (composite of samples 30398 and 30399)	228	30400	A	1	4.94	36.05	50.96	8.05	1.75	5.27	71.72	1.88	11.33	2.5	7,122	12,820
				2		37.92	53.61	8.47	1.84	4.97	75.45	1.98	7.29		7,492	13,486
				3		41.43	58.57		2.01	5.43	82.43	2.16	7.97		8,185	14,733
1½ miles south of; Blue Creek No. 7 mine, Lower Hartshorne bed (face of 1 south entry, main slope entry).	229	30401	A	1	4.87	36.19	52.79	6.15	1.97					2.3	7,384	13,291
Same (face of 1 north entry, main slope entry)	229	30402	A	1	5.33	37.09	52.31	5.27	2.40					2.8	7,370	13,266
Same (composite of samples 30401 and 30402)	229	30403	A	1	5.06	36.66	52.61	5.67	2.22	5.36	73.54	1.94	11.27	2.6	7,370	13,266
				2		38.61	55.42	5.97	2.34	5.06	77.46	2.04	7.13		7,763	*13,973
				3		41.06	58.94		2.49	5.38	82.38	2.17	7.58		8,256	14,861
Krebs, 1½ miles northwest of; Osage No. 5 mine, McAlester bed (face of 8 west entry, east slope entry).	229	W69549	A	1	2.60	35.45	56.30	5.65	.54						7,589	13,660
				2		36.40	57.80	5.80	.55						7,789	14,020
				3		38.64	61.36		.58						8,267	14,880
Same (face of 2 west entry, west slope entry)	229	W69550	A	1	3.40	34.97	55.06	6.57	.53						7,395	13,310
				2		36.20	57.00	6.80	.55						7,650	13,770
				3		38.84	61.16		.59						8,206	14,770
Same (face of 6 east entry, east slope entry)	229	W69556	A	1	2.80	35.67	55.99	5.54	.44						7,550	13,590
				2		36.70	57.60	5.70	.45						7,767	13,980
				2		38.92	61.08		.48						8,233	14,820
Same (tipple samples of lump coal over 2½-inch screen)	229	W69553, W69557	C	1	2.55	35.81	57.01	4.63	.42						7,658	13,784
				2		36.75	58.50	4.75	.43						7,858	14,145
				3		38.58	61.42		.45						8,250	14,850
Same (tipple samples of nut coal through 2½-inch screen)	229	W69555, W69561	C	1	2.55	34.59	56.33	6.53	.42						7,498	13,497
				2		35.50	57.80	6.70	.43						7,695	13,850
				3		38.05	61.95		.46						8,247	14,845
Same (tipple samples of pea coal through ¾-inch screen)	229	W69559, W69563	C	1	2.50	34.52	53.91	9.07	.47						7,286	13,114
				2		35.40	55.30	9.30	.48						7,472	13,450
				3		39.03	60.97		.53						8,238	14,829
Same (tipple samples of slack coal through ¾-inch screen)	229	W69551, W69558	C	1	2.65	34.36	53.64	9.35	.56						7,201	12,962
				2		35.30	55.10	9.60	.58						7,397	13,315
				3		39.05	60.95		.64						8,183	14,729

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No.b	Sample. Kind.c	Sample. Condition.d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OKLAHOMA—Continued.																
PITTSBURG COUNTY—continued.																
Ridgeway, ½ mile east of; sec. 33, T. 5 N., R. 17 E.; Rock Island No. 10 mine, Lower Hartshorne bed (face of main east entry).	230	30222	A	1	3.14	37.50	50.26	9.10	1.57					1.7	7,238	13,028
Same (face of main west entry)	230	30223	A	1	3.36	37.26	50.76	8.62	1.84					1.8	7,341	13,214
Same (face of 27 room, main west entry)	230	30224	A	1	2.84	39.70	49.94	7.52	1.67					1.4	7,469	13,444
Same (face of east air course, main north entry)	230	30225	A	1	5.84	36.80	51.38	5.98	1.60					4.2	7,309	13,156
Same (face of 6 east entry, main south entry)	230	30226	A	1	2.88	38.88	51.97	6.27	1.53					1.3	7,542	13,576
Same (composite of samples 30222 to 30226)	230	30227	A	1	3.77	38.00	50.61	7.62	1.71	5.35	73.84	1.85	9.63	2.1	7,380	13,284
				2		39.49	52.59	7.92	1.78	5.12	76.73	1.92	6.53		7,669	13,804
				3		42.89	57.11		1.93	5.56	83.33	2.09	7.09		8,329	14,992
SEQUOYAH COUNTY.																
Hanson, 1 mile north of; sec. 6, T. 11, R. 25 E.; Brewer strip pit (face of north edge of pit).	231	26800	B	1	5.30	16.78	72.47	5.45	1.72					4.9	7,769	13,984
				2		17.72	76.52	5.76	1.82						8,204	14,767
				3		18.80	81.20		1.93						8,705	15,669
WAGONER COUNTY.																
Redbird, 1¼ miles northeast of; Kirk strip pit (face of stripping)	231	26348	B	1	3.86	36.14	46.34	13.66	6.53					2.3	6,842	12,316
				2		37.59	48.20	14.21	6.79						7,117	12,811
				3		43.81	56.19		7.91						8,296	14,933
OREGON.																
COOS COUNTY.																
Beaver Hill; sec. 17, T. 27 S., R. 13 W.; Beaver Hill mine, Newport bed (face of 8 north gangway).	231	*27951	A	1	16.77	33.43	40.15	9.65	.78					7.0	5,233	9,419
				2		40.17	48.24	11.59	.94						6,287	11,317
				3		45.44	54.56		1.06						7,111	12,800
Henryville; Henryville mine, Newport bed (face of 2 south gangway)	232	*27956	A	1	16.17	34.96	40.66	8.21	.72					5.1	5,416	9,749
				2		41.70	48.51	9.79	.86						6,461	11,630
				3		46.22	53.78		.95						7,162	12,892

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ALLEGHENY COUNTY.

Creighton; Creighton mine, Upper and Lower Freeport beds (rib of 1 room, 100 feet from chute, between 10 entry and line air course).	233	26932	A	1	3.23	35.19	54.23	7.35	.67	......	......	......	......	2.0	7,586	13,655
Same (rib of 1 crosscut, 10 room, 15 entry)	233	26933	A	1	2.74	33.10	52.19	11.97	1.04	......	......	......	......	1.5	7,215	12,987
Same (face of 2 room, 150 feet from 21 entry)	233	26990	A	1	2.76	33.23	53.62	10.39	1.17	......	......	......	......	1.5	7,320	13,176
Same (face of 1 room, 10½ entry, 20 feet inby 1 crosscut)	233	26991	A	1	2.84	34.24	51.92	11.00	1.69	......	......	......	......	1.8	7,311	13,160
Same (composite of samples 26932, 26933, 26990, and 26991)	233	26992	A	1	2.86	33.83	53.11	10.20	1.12	5.25	73.77	1.45	8.21	1.7	7,343	13,217
				2	......	34.82	54.68	10.50	1.15	5.07	75.94	1.49	5.85	......	7,559	13,606
				3	......	38.90	61.10	......	1.28	5.66	84.85	1.66	6.55	......	8,446	15,203
Same (rib of 5 room, 19 entry, main entry)	233	26934	A	1	2.98	32.73	53.23	11.06	1.48	......	......	......	......	1.7	7,262	13,072
				2	......	33.73	54.87	11.40	1.53	......	......	......	......	......	7,485	13,473
				3	......	38.07	61.93	......	1.73	......	......	......	......	......	8,448	15,206
Same (C face, 300 feet inby old 8 right entry; cannel coal)	233	27088	A	1	.85	28.94	35.31	35.20	.95	4.02	54.07	1.06	4.70	.2	5,437	9,787
				2	......	29.19	35.31	35.50	.96	3.96	54.54	1.07	3.97	......	5,484	9,871
				3	......	45.26	54.74	......	1.49	6.14	84.56	1.66	6.15	......	8,502	15,304
ARMSTRONG COUNTY.																
Applewold, opposite Kittanning; Snyder mine, Lower Kittanning bed (1,200 feet southwest of mine mouth).	234	28664	B	1	3.11	36.63	49.98	10.28	4.20	......	......	......	......	2.3	7,290	13,122
Same (1,125 feet north-northwest from mine mouth)	234	28665	B	1	2.86	40.47	46.82	9.85	3.98	......	......	......	......	2.0	7,350	13,230
Same (composite of samples 28664 and 28665)	234	28666	B	1	3.09	38.18	48.73	10.00	4.05	5.37	72.05	1.20	7.33	2.2	7,323	13,181
				2	......	39.40	50.28	10.32	4.18	5.19	74.35	1.24	4.72	......	7,557	13,603
				3	......	43.93	56.07	......	4.66	5.79	82.91	1.38	5.26	......	8,427	15,169
Ford City, 1 mile southwest of; Campbell mine, Upper Kittanning bed (face of 2 right entry, 50 feet from main entry).	234	30289	A	1	2.14	31.65	50.09	16.12	4.45	......	......	......	......	1.1	6,810	12,258
Same (face of main entry, 250 feet from mine mouth)	234	30290	A	1	2.31	31.51	47.60	18.58	5.29	......	......	......	......	1.3	6,547	11,785
Same (face of 3 right entry, 20 feet from main entry)	234	30291	A	1	2.36	31.62	49.94	16.08	4.56	......	......	......	......	1.2	6,817	12,271
Same (composite of samples 30289 to 30291)	234	30292	A	1	2.26	31.45	49.27	17.02	4.67	4.55	66.62	1.11	6.03	1.2	6,715	12,087
				2	......	32.18	50.41	17.41	4.78	4.40	68.16	1.14	4.11	......	6,870	12,366
				3	......	38.96	61.04	......	5.79	5.33	82.53	1.38	4.97	......	8,318	14,972
Logansport; Raridan mine, Upper Freeport bed (face of main entry, 1,200 feet east from mouth).	235	28667	B	1	3.38	35.24	51.17	10.21	3.15	......	......	......	......	2.3	7,226	13,007
Same (face of main entry, 3,600 feet northeast of mine mouth)	235	28668	B	1	2.66	35.04	51.56	10.74	3.23	......	......	......	......	1.5	7,237	13,027
Same (composite of samples 28667 and 28668)	235	28669	B	1	3.16	34.84	51.47	10.53	3.23	5.17	71.02	1.25	8.80	1.9	7,233	13,019
				2	......	35.98	53.15	10.87	3.34	4.98	73.34	1.29	6.18	......	7,469	13,444
				3	......	40.37	59.63	......	3.75	5.59	82.29	1.45	6.92	......	8,380	15,084
Montgomeryville; Montgomeryville mine, Middle Kittanning bed (face of 6 room, 1 left entry, cannel coal).	235	28774	B	1	1.69	33.06	36.97	28.28	3.40	......	......	......	......	.6	5,856	10,541
Same (face of crosscut, 2 left entry)	235	28775	B	1	1.79	32.78	37.12	28.31	3.90	......	......	......	......	.7	5,809	10,456
Same (composite of samples 28774 and 28775)	235	28776	B	1	1.75	32.81	37.26	28.18	3.65	4.54	56.88	1.11	5.64	.7	5,812	10,462
				2	......	33.39	37.93	28.68	3.71	4.43	57.89	1.13	4.16	......	5,915	10,647
				3	......	46.82	53.18	......	5.20	6.21	81.17	1.58	5.84	......	8,293	14,927

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
ARMSTRONG COUNTY—continued.																
West Kittanning, 1 mile north of; Neal's mine, Lower Freeport bed (face of right entry, main entry).	236	28721	B	1	3.33	34.69	50.95	11.03	3.53	......	......	......	......	1.9	7,129	12,832
Same (face of main entry)	236	28722	B	1	3.50	36.32	51.78	8.40	2.81	......	......	......	......	2.2	7,378	13,280
Same (composite of samples 28721 and 28722)	236	28723	B	1	3.43	35.53	51.32	9.72	3.09	5.33	71.39	1.34	9.13	2.1	7,243	13,037
				2	......	36.79	53.14	10.07	3.20	5.13	73.92	1.39	6.29	......	7,500	13,500
				3	......	40.91	59.09	......	3.56	5.70	82.20	1.55	6.99	......	8,340	15,012
Yatesboro; Cowanshannoc No. 2 mine, Lower Freeport bed (face of 1 left entry) 2.	236	8672	B	1	3.05	33.53	52.85	10.57	3.38	......	......	......	......	2.2	7,320	13,176
Same (face of 1 right entry)	236	28673	B	1	2.90	33.64	52.92	10.54	2.82	......	......	......	......	2.0	7,325	13,185
Same (composite samples 28672 and 28673)	236	28674	B	1	3.03	33.46	52.94	10.57	3.02	5.17	71.81	1.21	8.22	2.1	7,350	13,230
				2	......	34.50	54.60	10.90	3.11	4.98	74.05	1.25	5.71	......	7,579	13,642
				3	......	38.72	61.28	......	3.49	5.59	83.11	1.40	6.41	......	8,506	15,311
BEAVER COUNTY.																
Smiths Ferry, 2 miles north of: Island Run mine, Upper Freeport bed (¾ mile east of mine mouth).	237	25587	B	1	4.39	37.21	53.53	4.87	1.39	5.35	75.44	1.99	10.96	1.9	7,585	13,653
				2	......	38.92	55.99	5.09	1.45	5.08	78.90	2.08	7.40	......	7,933	14,279
				3	......	41.01	58.99	......	1.53	5.35	83.13	2.19	7.80	......	8,358	15,044
BLAIR COUNTY.																
Glen White, 1 mile from; Glen White No. 2 mine, Upper Freeport bed (on rib, 65 room, 6 right entry, 10 feet from entry).	237	30830	A	1	2.96	31.85	57.84	7.35	2.57	......	......	......	......	2.1	7,738	13,928
Same (on rib, 1 slant entry, 1 left entry, 40 feet inside of entry)	237	30831	A	1	2.15	29.65	62.24	5.96	1.14	......	......	......	......	1.3	7,941	14,294
Same (on rib, main slope entry, 6 right entry, 70 feet from face)		30832	A	1	3.41	28.46	61.41	6.72	1.98	......	......	......	......	2.5	7,773	13,991
Same (composite of samples 30830 to 30832)		30833	A	1	2.75	29.97	60.60	6.68	1.86	5.06	78.80	1.41	6.19	2.0	7,813	14,063
	237			2	......	30.82	62.31	6.87	1.91	4.88	81.03	1.45	3.86	......	8,034	14,461
	237			3	......	33.09	66.91	......	2.05	5.24	87.01	1.56	4.14	......	8,627	15,529
Same (tipple sample of coal being loaded)	237	30834	C	1	2.08	28.22	60.29	9.41	1.92	......	......	......	......	1.1	7,677	13,819
				2	......	28.82	61.57	9.61	1.96	......	......	......	......	......	7,840	14,112
				3	......	31.88	68.12	......	2.17	......	......	......	......	......	8,673	15,611

BUTLER COUNTY.																
Evans City, 6 miles north of; Young Shaft mine, Upper Freeport bed (200 feet northwest of shaft)	238	25823	B	1	3.46	41.43	49.75	5.36	3.58	5.38	74.84	1.16	9.68	2.1	7,585	13,653
				2	......	42.91	51.54	5.55	3.71	5.18	77.52	1.20	6.84	......	7,857	14,143
				3	......	45.43	54.57	......	3.93	5.48	82.08	1.27	7.24	......	8,319	14,974
Goff Station, 1 mile east of; Annandale No. 2 mine, Brookville bed (face of 2 main entry).	238	26241	A	1	2.98	36.87	44.07	16.08	3.84	......	......	......	......	1.5	6,673	12,011
Same (face of 3 room, 2 right main entry)	238	26242	A	1	2.92	37.66	46.46	12.96	3.22	......	......	......	......	1.3	6,950	12,510
Same (face of 5 left entry, 20 feet inby 14 room, 39 sec.)	238	26243	A	1	3.45	37.20	44.38	14.97	3.91	......	......	......	......	1.7	6,714	12,085
Same (face of 3 room, 3 right entry, 1 sec.)	238	26244	A	1	3.45	37.46	47.54	11.55	3.22	......	......	......	......	1.7	7,025	12,645
Same (composite of samples 26241 to 26244)	238	26245	A	1	3.19	37.39	45.61	13.81	3.48	4.94	67.48	1.03	9.26	1.5	6,830	12,294
				2	......	38.62	47.11	14.27	3.59	4.74	69.71	1.06	6.63	......	7,055	12,699
				3	......	45.05	54.95	......	4.19	5.53	81.32	1.24	7.72	......	8,230	14,814
Harmony Junction; North Pittsburgh Realty Co. mine, Middle Kittanning bed (face of 3 room, 2 entry).	239	25615	B	1	5.78	37.92	45.59	10.71	4.28	5.73	68.61	1.20	9.47	4.6	6,917	12,451
				2	......	40.24	48.39	11.37	4.54	5.40	72.82	1.27	4.60	......	7,341	13,214
				3	......	45.40	54.60	......	5.12	6.09	82.16	1.43	5.19	......	8,282	14,908
Nealey; Nealey drift mine, Middle Kittanning bed (at face, 700 feet north of mine mouth).	239	25822	B	1	5.32	36.53	47.95	10.20	3.71	5.35	69.44	1.18	10.12	3.7	6,990	12,582
				2	......	38.58	50.65	10.77	3.92	5.03	73.34	1.25	5.69	......	7,383	13,289
				3	......	43.24	56.76	......	4.39	5.64	82.19	1.40	6.38	......	8,274	14,893
CAMBRIA COUNTY.																
Bakerton, ½ mile east of; Sterling No. 1 mine, Lower Kittanning bed (face of 1 room, 3 cross entry, 7 left entry, 3 dip entry).	240	W69680	A	1	2.70	22.48	68.88	5.94	1.56	......	......	......	......	......	7,945	14,300
				2	......	23.10	70.80	6.10	1.60	......	......	......	......	......	8,161	14,690
				3	......	24.60	75.40	......	1.70	......	......	......	......	......	8,695	15,650
Same (No. 3 pillar, Gypsy cross heading, 2 dip entry)	240	W69681	A	1	1.60	22.73	69.18	6.49	1.33	......	......	......	......	......	7,978	14,360
				2	......	23.10	70.30	6.60	1.35	......	......	......	......	......	8,111	14,600
				3	......	24.73	75.27	......	1.45	......	......	......	......	......	8,683	15,630
Same (face of 4 dip entry, main entry)	240	W69682	A	1	3.40	22.09	67.43	6.18	1.26	......	......	......	......	......	7,889	14,200
				2	......	23.80	69.80	6.40	1.30	......	......	......	......	......	8,161	14,690
				3	......	25.43	74.57	......	1.39	......	......	......	......	......	8,717	15,690
Same (tipple samples of run-of-mine coal)	240	W69982 W69983	C	1	1.70	21.77	68.57	7.96	1.77	......	......	......	......	......	7,848	14,126
				2	......	22.15	69.75	8.10	1.80	......	......	......	......	......	7,983	14,370
				3	......	24.10	75.90	......	1.96	......	......	......	......	......	8,687	15,637
Sterling No. 3 mine, Lower Kittanning bed (face of 40 room, machine heading).	240	W69686	A	1	1.70	25.95	66.45	5.90	1.52	......	......	......	......	......	7,995	14,390
				2	......	26.40	67.60	6.00	1.55	......	......	......	......	......	8,128	14,630
				3	......	28.08	71.92	......	1.65	......	......	......	......	......	8,645	15,560
Same (face of Sharkey heading)	240	W69687	A	1	2.60	25.62	65.55	6.23	1.36	......	......	......	......	......	7,900	14,220
				2	......	26.30	67.30	6.40	1.40	......	......	......	......	......	8,111	14,600
				3	......	28.10	71.90	......	1.50	......	......	......	......	......	8,667	15,600
Same (face of 6 left entry)	240	W69688	A	1	1.80	25.92	66.19	6.09	1.08	......	......	......	......	......	8,000	14,400
				2	......	26.40	67.40	6.20	1.10	......	......	......	......	......	8,167	14,700
				3	......	28.15	71.85	......	1.17	......	......	......	......	......	8,706	15,670

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.
[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).
[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.
[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
CAMBRIA COUNTY—continued.																
Bakerton; Sterling No. 5 mine, Lower Kittanning bed (face of main pillar, 1 left entry).	240	W69679	A	1	2.20	22.69	69.34	5.77	1.17	......	......	......	......	......	8,000	14,400
				2	......	23.20	70.90	5.90	1.20	......	......	......	......	......	8,178	14,720
				3	......	24.65	75.35	......	1.28	......	......	......	......	......	8,695	15,650
Same (rib, 10 room, 5 left entry)	240	W69683	A	1	3.10	21.90	67.25	7.75	2.03	......	......	......	......	......	7,750	13,950
				2	......	22.60	69.40	8.00	2.10	......	......	......	......	......	7,995	14,390
				3	......	24.57	75.43	......	2.28	......	......	......	......	......	8,689	15,640
Same (face of 4 right main entry, 1 entry)	240	W69684	A	1	2.30	23.45	67.70	6.55	1.56	......	......	......	......	......	7,889	14,200
				2	......	24.00	69.30	6.70	1.60	......	......	......	......	......	8,072	14,530
				3	......	25.72	74.28	......	1.71	......	......	......	......	......	8,656	15,580
Same (tipple samples of run-of mine coal, Sterling Nos. 3 and 5 mines).	240	W69984, W69985	C	1	2.00	22.88	66.54	8.58	1.65	......	......	......	......	......	7,756	13,960
				2	......	23.35	67.90	8.75	1.68	......	......	......	......	......	7,914	14,245
				3	......	25.59	74.41	......	1.84	......	......	......	......	......	8,673	15,611
½ mile south of; Sterling No. 6 mine, Lower Kittanning bed (10 feet from face of 4 right main entry, on left rib).	242	W69685	A	1	2.20	22.20	70.32	5.28	1.08	......	......	......	......	......	8,033	14,460
				2	......	22.70	71.90	5.40	1.10	......	......	......	......	......	8,217	14,790
				3	......	24.00	76.00	......	1.16	......	......	......	......	......	8,689	15,640
Same (25 feet from face of 17 left heading, on right rib)	242	W69689	A	1	2.50	22.33	69.81	5.36	1.02	......	......	......	......	......	8,000	14,400
				2	......	22.90	71.60	5.50	1.05	......	......	......	......	......	8,211	14,780
				3	......	24.23	75.77	......	1.11	......	......	......	......	......	8,689	15,640
Same (face of 12 right heading)	212	W69690	A	1	2.40	22.25	69.30	6.05	1.07	......	......	......	......	......	7,961	14,330
				2	......	22.80	71.00	6.20	1.10	......	......	......	......	......	8,156	14,680
				3	......	24.31	75.69	......	1.17	......	......	......	......	......	8,695	15,650
Same (face of 2 right entry, 8 left entry)	242	W69691	A	1	3.00	22.60	69.84	4.56	.68	......	......	......	......	......	8,039	14,470
				2	......	23.30	72.00	4.70	.70	......	......	......	......	......	8,283	14,910
				3	......	24.45	75.55	......	.73	......	......	......	......	......	8,689	15,640
Beaverdale; Pennsylvania No. 15 mine, Lower Kittanning bed (tipple samples of run-of-mine coal.)	242	W69505, W69506, W59507, W69508	C	1	1.65	17.95	71.22	9.18	1.95	......	......	......	......	......	7,710	13,877
				2	......	18.25	72.42	9.33	1.98	......	......	......	......	......	7,839	14,110
				3	......	20.13	79.87	......	2.18	......	......	......	......	......	8,646	15,562

Cassandra, 1 mile east of; Hughes No. 2 mine, Lower Kittanning bed (face of C heading).	243	W69573	A	1	3.80	17.80	71.47	6.93	.58						7,722	13,900
				2		18.50	74.30	7.20	.60						8,028	14,450
				3		19.94	80.06		.65						8,645	15,560
Same (face of S-65 room, main slope entry)	243	W69574	A	1	2.30	17.68	74.16	5.86	.83						7,956	14,320
				2		18.10	75.90	6.00	.85						8,145	14,660
				3		19.25	80.75		.90						8,661	15,590
Same (face of F heading)	243	W69575	A	1	4.00	17.95	71.52	6.53	.86						7,772	13,990
				2		18.70	74.50	6.80	.90						8,095	14,570
				3		20.07	79.93		.97						8,689	15,640
Same (tipple samples of run-of-mine coal)	243	W69576, W69577, W69578, W69579	C	1	1.73	17.93	73.04	7.30	.92						7,912	14,242
				2		18.25	74.32	7.43	.94						8,052	14,493
				3		19.72	80.28		1.02						8,698	15,656
Dunlo; Yellow Run mine, Lower Kittanning bed (face of 36½ room, 8 right heading).	244	W69439	A	1	1.70	17.50	74.90	5.90	.59						8,039	14,470
				2		17.80	76.20	6.00	.60						8,178	14,720
				3		18.94	81.06		.64						8,700	15,660
Same (53 stump, 4 right heading)	244	W69440	A	1	1.50	18.81	74.27	5.42	.54						8,072	14,530
				2		19.10	75.40	5.50	.55						8,195	14,750
				3		20.21	79.79		.58						8,672	15,610
Same (face of 8 left entry)	244	W69441	A	1	2.10	18.21	72.25	7.44	2.45						7,845	14,120
				2		18.60	73.80	7.60	2.50						8,017	14,430
				3		20.13	79.87		2.71						8,678	15,620
Same (face of 10 right entry)	244	W69442	A	1	3.00	16.10	75.85	5.04	.73						7,983	14,370
				2		16.60	78.20	5.20	.75						8,233	14,820
				3		17.51	82.49		.79						8,683	15,630
Same (tipple samples of run-of-mine coal)	244	W69443, W69444, W69445, W69446	C	1	1.55	17.62	74.04	6.79	1.09						7,977	14,359
				2		17.90	75.20	6.90	1.11						8,103	14,585
				3		19.23	80.77		1.19						8,703	15,666
Gallitzin; Gallitzin shaft mine, Upper Freeport bed (on rib, 20 room, 10 right entry, 70 feet from entry).	244	30824	A	1	2.55	26.36	64.59	6.50	1.41					1.7	7,906	14,231
Same (on rib, 55 room, 12 left entry, 200 feet from entry)	244	30825	A	1	2.65	25.80	65.48	6.07	1.38					1.8	7,932	14,278
Same (on rib, 5 room, 1 dip on motor road, 60 feet from entry)	244	30826	A	1	2.85	26.26	65.31	5.58	1.26					1.9	7,969	14,344
Same (on rib, 65 room, 9 right entry, 20 feet from entry)	244	30827	A	1	2.75	26.50	64.51	6.24	1.49					2.1	7,890	14,202
Same (composite of samples 30824 to 30827)	244	30828	A	1	2.73	26.04	65.05	6.18	1.39	4.98	80.35	1.46	5.64	1.9	7,927	14,269
				2		26.77	66.88	6.35	1.43	4.81	82.61	1.50	3.30		8,150	14,670
				3		28.59	71.41		1.53	5.14	88.21	1.60	3.52		8,703	15,665
Same (tipple sample of run-of-mine coal)	244	30829	C	1	1.79	26.10	63.48	8.63	1.44					.9	7,786	14,015
				2		26.58	64.63	8.79	1.47						7,928	14,270
				3		29.14	70.86		1.61						8,692	15,646
Lilly, 1 mile east of; Sonman No. 2 mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	245	W69599, W69600, W69601	C	1	1.97	19.93	71.31	6.79	.62						7,892	14,205
				2		20.33	72.74	6.93	.63						8,050	14,490
				3		21.84	78.16		.68						8,650	15,569

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.
[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).
[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.
[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
CAMBRIA COUNTY—continued.																
Llanfair, 1 mile south of; Henriette No. 2 mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	246	W69435, W69438	C	1	1.55	17.38	74.35	6.72	0.79	......	......	......	......	......	7,957	14,323
				2	......	17.65	75.52	6.83	.80	......	......	......	......	......	8,082	14,548
				3	......	18.94	81.06	......	.86	......	......	......	......	......	8,675	15,614
Nanty Glo, 2 3/10 miles north of; Cardiff No. 1 mine, Lower Kittanning bed (face of 4 room, 12 right entry, main heading).	246	W69696	A	1	2.40	21.08	70.27	6.25	1.90	......	......	......	......	......	7,928	14,270
				2	......	21.60	72.00	6.40	1.95	......	......	......	......	......	8,128	14,630
				3	......	23.08	76.92	......	2.08	......	......	......	......	......	8,683	15,630
Same (face of 11 left entry, 14 room, main entry)	246	W69697	A	1	2.50	19.99	71.46	6.05	1.90	......	......	......	......	......	7,989	14,380
				2	......	20.50	73.30	6.20	1.95	......	......	......	......	......	8,195	14,750
				3	......	21.86	78.14	......	2.08	......	......	......	......	......	8,739	15,730
Same (face of 3 left entry, main entry)	246	W69698	A	1	2.80	20.80	69.89	6.51	1.94	......	......	......	......	......	7,883	14,190
				2	......	21.40	71.90	6.70	2.00	......	......	......	......	......	8,106	14,590
				3	......	22.94	77.06	......	2.14	......	......	......	......	......	8,689	15,640
Same (face of 21 left entry, main entry)	246	W69699	A	1	2.70	20.82	70.45	6.03	1.85	......	......	......	......	......	7,950	14,310
				2	......	21.40	72.40	6.20	1.90	......	......	......	......	......	8,167	14,700
				3	......	22.81	77.19	......	2.03	......	......	......	......	......	8,706	15,670
Same (tipple samples of run-of-mine coal)	246	W69931, W69932, W69933	C	1	1.77	21.44	69.55	7.24	2.18	......	......	......	......	......	7,901	14,221
				2	......	21.83	70.80	7.37	2.22	......	......	......	......	......	8,043	14,477
				3	......	23.57	76.43	......	2.40	......	......	......	......	......	8,683	15,629
1 mile east of; Springfield No. 1 mine, Lower Kittanning bed (face of 7 left entry).	247	W69612	A	1	2.20	19.07	72.96	5.77	1.52	......	......	......	......	......	8,028	14,450
				2	......	19.50	74.60	5.90	1.55	......	......	......	......	......	8,211	14,780
				3	......	20.72	79.28	......	1.65	......	......	......	......	......	8,728	15,710
Same (face of main dip entry)	247	W69614	A	1	2.90	18.06	73.02	6.02	1.75	......	......	......	......	......	7,933	14,280
				2	......	18.60	75.20	6.20	1.80	......	......	......	......	......	8,167	14,700
				3	......	19.83	80.17	......	1.92	......	......	......	......	......	8,706	15,670
Same (face of main heading)	247	W69616	A	1	2.00	19.60	73.11	5.29	1.42	......	......	......	......	......	8,078	14,540
				2	......	20.00	74.60	5.40	1.45	......	......	......	......	......	8,245	14,840
				3	......	21.14	68.86	......	1.53	......	......	......	......	......	8,717	15,690

Same (pillar, 1 room, 4 heading)	247	W69618	A	1	1.60	18.01	70.65	9.74	3.84						7,767	13,980
				2		18.30	71.80	9.90	3.90						7,895	14,210
				3		20.31	79.69		4.33						8,761	15,770
Same (tipple samples of run-of-mine coal)	247	W69923, W69924, W69925, W69926	C	1	1.50	19.50	71.98	7.02	1.58						7,962	14,331
				2		19.80	73.07	7.13	1.60						8,083	14,550
				3		21.32	78.68		1.72						8,704	15,667
½ mile east of Springfield No. 3 mine Lower Kittanning bed (face of main B heading).	248	W69625	A	1	2.20	20.54	69.24	8.02	2.00						7,806	14,050
				2		21.00	70.80	8.20	2.05						7,983	14,370
				3		22.88	77.12		2.23						8,695	15,650
Same (face of main C heading)	248	W69626	A	1	2.40	19.23	72.03	6.34	2.00						7,967	14,340
				2		19.70	73.80	6.50	2.05						8,156	14,680
				3		21.07	78.93		2.19						8,722	15,700
Same (tipple samples of run-of-mine coal)	248	W69927, W69928, W69929, W69930	C	1	1.25	20.10	70.90	7.75	2.70						7,908	14,235
				2		20.35	71.80	7.85	2.73						8,008	14,415
				3		22.08	77.92		2.96						8,691	15,643
Sonman, 1 mile east of Portage; Sonman shaft mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	249	W69602, W69604	C	1	1.80	17.80	71.10	9.30	1.26						7,713	13,883
				2		18.13	72.40	9.47	1.28						7,854	14,137
				3		20.03	79.97		1.41						8,676	15,616
Sonman slope mine, Upper Freeport bed (face of 2 left entry, south dip entry).	249	26398	A	1	3.03	18.14	71.91	6.92	2.33					2.5	7,842	14,116
Same (at intersection of 3 right air course, with south dip entry, 100 feet from face of south dip entry).	249	26399	A	1	3.54	18.65	72.18	5.63	1.70					2.9	7,927	14,269
Same (face of 2 right entry, south dip entry, 20 feet from face)	249	26400	A	1	3.45	17.73	72.51	6.31	2.05					2.9	7,889	14,200
Same (face of 13 room, 1 right entry, north dip entry)	249	26401	A	1	3.60	19.54	71.04	5.82	1.32					3.0	7,896	14,213
Same (face of 1 cut-through of 4 room, 2 left entry, north dip entry).	249	26402	A	1	3.08	18.91	70.80	7.21	2.13					2.5	7,796	14,033
Same (face of north dip entry, 20 feet from face)	249	26403	A	1	3.39	18.95	71.54	6.12	1.39					2.8	7,895	14,211
Same (composite of samples 26398 to 26403)	249	26404	A	1	3.32	18.25	72.03	6.40	1.77	4.73	80.66	1.42	5.02	2.8	7,873	14,171
				2		18.88	74.50	6.62	1.83	4.51	83.43	1.47	2.14		8,143	14,657
				3		20.22	79.78		1.96	4.83	89.35	1.57	2.29		8,720	15,696
South Fork; Argyle No. 1 mine, Lower Kittanning bed (face of 3 north entry, 6 entry).	250	W69453	A	1	1.70	17.99	75.00	5.31	.69						8,072	14,530
				2		18.30	76.30	5.40	.70						8,211	14,780
				3		19.34	80.66		.74						8,683	15,630
Same (at split in pillar between 5 and 6 north entry)	250	W69455	A	1	1.80	18.17	74.73	5.30	1.08						8,100	14,580
				2		18.50	76.10	5.40	1.10						8,245	14,840
				3		19.56	80.44		1.16						8,717	15,690
Same (face of main heading, 1 mile from mine mouth)	250	W69456	A	1	2.10	17.23	73.52	7.15	1.13						7,861	14,150
				2		17.60	75.10	7.30	1.15						8,028	14,450
				3		18.99	81.01		1.24						8,661	15,590
Same (tipple samples of run-of mine-coal)	250	W69903, W69904, W69905, W69906	C	1	1.78	17.63	74.55	6.04	1.04						8,043	14,478
				2		17.95	75.90	6.15	1.06						8,189	14,740
				3		19.13	80.87		1.13						8,726	15,706

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[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample: Laboratory No.[b]	Sample: Kind.[c]	Sample: Condition.[d]	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
CAMBRIA COUNTY—continued.																
Argyle No. 2 mine, Lower Kittanning bed (7 right entry, 10 feet from face of 10 room).	251	W69451	A	1	2.20	17.80	72.96	7.04	2.20	......	......	......	......	......	7,872	14,170
				2	......	18.20	74.60	7.20	2.25	......	......	......	......	......	8,045	14,480
				3	......	19.61	80.39	......	2.42	......	......	......	......	......	8,667	15,600
Same (face of 6 room, chain pillar, 5 left entry)	251	W69452	A	1	2.80	17.98	71.74	7.48	2.28	......	......	......	......	......	7,795	14,030
				2	......	18.50	73.80	7.70	2.35	......	......	......	......	......	8,017	14,430
				3	......	20.04	79.96	......	2.55	......	......	......	......	......	8,683	15,630
Same (2 right entry, 9 entry, 1 rib)	251	W69454	A	1	1.90	18.84	74.26	5.00	1.47	......	......	......	......	......	8,083	14,550
				2	......	19.20	75.70	5.10	1.50	......	......	......	......	......	8,239	14,830
				3	......	20.23	79.77	......	1.58	......	......	......	......	......	8,683	15,630
Same (tipple samples of run-of-mine coal)	251	W69907, W69908, W69909, W69910	C	1	1.85	17.89	73.26	7.00	1.94	......	......	......	......	......	7,942	14,296
				2	......	18.23	74.64	7.13	1.98	......	......	......	......	......	8,092	14,565
				3	......	19.63	80.37	......	2.13	......	......	......	......	......	8,713	15,683
¾ mile west of; Stineman No. 2 mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	251	W69391, W69394, W69395, W69396	C	1	1.00	18.64	73.63	6.73	1.51	......	......	......	......	......	8,002	14,403
				2	......	18.83	74.37	6.80	1.53	......	......	......	......	......	8,082	14,548
				3	......	20.20	79.80	......	1.64	......	......	......	......	......	8,672	15,609
¼ mile from; Stineman No. 4 mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	252	W69447, W69448, W69449, W69450	C	1	1.20	16.38	74.39	8.03	.74	......	......	......	......	......	7,877	14,178
				2	......	16.58	75.29	8.13	.75	......	......	......	......	......	7,972	14,350
				3	......	18.05	81.95	......	.82	......	......	......	......	......	8,678	15,620
St. Michael, ½ mile west of; Maryland Shaft mine, Miller, B, or Lower Kittanning bed (face of 7 left main entry).	252	25717	A	1	3.35	15.36	76.27	5.02	.89	......	......	......	......	2.5	8,036	14,465
Same (face of 2 longwall)	252	25718	A	1	2.38	15.46	76.94	5.22	.66	......	......	......	......	1.5	8,101	14,582
Same (face of 2 left entry, south main entry)	252	25719	A	1	2.89	15.58	75.07	6.46	1.29	......	......	......	......	2.1	7,916	14,249
Same (face of 7 left entry, south main entry)	252	25720	A	1	3.52	15.24	73.45	7.79	1.31	......	......	......	......	2.6	7,738	13,928
Same composite of samples 25717 to 25720)	252	25721	A	1	3.06	15.35	75.45	6.14	1.02	4.40	81.72	1.31	5.41	2.2	7,913	14,243
				2	......	15.84	77.83	6.33	1.05	4.19	84.30	1.35	2.78	......	8,163	14,693
				3	......	16.91	83.09	......	1.12	4.47	90.00	1.44	2.97	......	8,715	15,687

Same (6 right north entry, 19 pillar, pillar sample)	252	25722	A	1	2.12	15.66	76.74	5.48	.64					1.3	8,108	14,594
				2		16.00	78.40	5.60	.65						8,284	14,911
				3		16.95	83.05		.69						8,775	15,795
Same (face of 3 right dip entry)	252	W68185	A	1	3.10	15.50	75.90	5.50	.68						7,950	14,310
Same (face of C heading, on longwall)	252	W68187	A	1	2.70	15.90	74.90	6.50	.97						7,928	14,270
Same (face of 6 longwall)	252	W68193	A	1	2.10	15.50	76.40	6.00	1.03						8,018	14,432
Same (face of 2 right entry, 3 right entry)	252	W68219	A	1	2.50	14.90	77.20	5.40	.83						8,012	14,422
Same (face of south main entry)	252	W68220	A	1	2.80	14.60	76.40	6.20	.78						7,945	14,301
Same (composite of samples W68185, W68187, W68193, W68219, and W68220).	252	30152	A	1	2.60	15.50	75.96	5.94	.96	4.41	82.68	1.31	4.70		7,938	14,288
				2		15.91	77.99	6.10	.99	4.23	84.89	1.34	2.45		8,150	14,670
				3		16.94	83.06		1.05	4.50	90.41	1.43	2.61		8,680	15,624
Same (composite of samples W68201, W68202, W68210, and W68212, tipple samples of run-of-mine coal).	252	30153	A	1	2.15	14.80	76.31	6.74	.94	4.33	82.34	1.32	4.33		7,946	14,303
				2		15.13	77.98	6.89	.96	4.18	84.15	1.35	2.47		8,121	14,618
				3		16.25	83.75		1.03	4.49	90.38	1.45	2.65		8,722	15,700
Vintondale, ½ mile northwest of; Vinton No. 1 mine, Lower Kittanning bed (left rib of 8 room, 1 left entry, 3 sec., 10 feet from face)	254	W69729	A	1	2.00	20.29	72.42	5.29	1.32						8,089	14,560
				2		20.70	73.90	5.40	1.35						8,250	14,850
				3		21.88	78.12		1.43						8,722	15,700
Same (face of 7 left entry, 5 butt entry, 2 sec.)	254	W69730	A	1	2.90	19.03	69.72	8.35	2.77						7,745	13,940
				2		19.60	71.80	8.60	2.85						7,978	14,360
				3		21.44	78.56		3.12						8,728	15,710
Same (face of 34 room, 1 break-through, 9 left entry, 1 sec.)	254	W69733	A	1	1.80	22.59	67.95	7.66	2.26						7,872	14,170
				2		23.00	69.20	7.80	2.30						8,017	14,430
				3		24.95	75.05		2.49						8,695	15,650
Same (face of 9 room, 8 left entry, 2 sec.)	254	W69734	A	1	1.70	20.35	68.81	9.14	3.15						7,767	13,980
				2		20.70	70.00	9.30	3.20						7,900	14,220
				3		22.82	77.18		3.53						8,711	15,680
Same, Lower Kittanning bed (tipple samples of run-of-mine coal).	254	W70030, W70031, W70032, W70033	C	1	2.30	20.74	68.85	8.11	3.01						7,822	14,008
				2		21.23	70.47	8.30	3.08						7,966	14,338
				3		23.15	76.85		3.36						8,687	15,636
At Vintondale, Vinton No. 6 mine, Lower Kittanning bed (on rib, 1 right entry, butt entry, 13 right entry, 2 slope entry).	254	W69736	A	1	2.40	19.03	69.79	8.78	3.37						7,706	13,870
				2		19.50	71.50	9.00	3.45						7,900	14,220
				3		21.43	78.57		3.79						8,678	15,620
Same (on rib, 10 feet from face of 1 left entry, 1 slope entry)	254	W69737	A	1	2.50	19.31	70.19	8.00	3.12						7,778	14,000
				2		19.80	72.00	8.20	3.20						7,972	14,350
				3		21.57	78.43		3.49						8,683	15,630
Same (on rib, 100 feet from face of 15 right entry, 3 slope entry).	254	W69731	A	1	2.50	19.79	71.37	6.34	2.10						7,972	14,350
				2		20.30	73.20	6.50	2.15						8,172	14,710
				3		21.71	78.29		2.30						8,739	15,730
Same (face of 13 right entry, 3 slope entry)	254	W69735	A	1	2.20	19.56	71.39	6.85	2.15						7,928	14,270
				2		20.00	73.00	7.00	2.20						8,106	14,590
				3		21.51	78.49		2.37						8,711	15,680
Same (face of 4 right main entry, 15 left entry, 2 slope entry)	254	W69738	A	1	4.80	18.56	65.79	10.85	5.05						7,261	13,070
				2		19.50	69.10	11.40	5.30						7,622	13,720
				3		22.01	77.99		5.98						8,606	15,490

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[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.
[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
CAMBRIA COUNTY—continued.																
Windber, 1½ miles northwest of; Eureka No. 40 mine, Lower Kittanning bed (face of 25 room, left main entry).	255	W68179	A	1	2.40	16.10	74.40	7.10	1.17						7,888	14,200
Same (face of main heading, 600 feet inby 26 left entry)	255	W68190	A	1	3.10	15.90	75.30	5.70	1.16						7,958	14,324
Same (face of 4 room, main entry, 14 right entry)	255	W68191	A	1	3.00	15.50	75.40	6.10	.97						7,917	14,255
Same (face of 19 right main entry)	255	W68222	A	1	2.00	16.10	74.50	7.40	.78						7,898	14,216
Same (composite of samples W68179, W68190, W68191, and W68222).	255	30173	A	1	2.60	17.02	73.67	6.71	1.19	4.46	81.68	1.29	4.67		7,912	14,242
				2		17.47	75.64	6.89	1.22	4.28	83.86	1.32	2.43		8,123	14,621
				3		18.76	81.24		1.31	4.60	90.07	1.42	2.60		8,724	15,703
Same (tipple sample of run-of-mine coal)	255	W68204	C	1	1.80	16.10	73.90	8.20	1.33						7,844	14,119
Same (tipple sample of run-of-mine coal)	255	W68206	C	1	1.80	16.20	74.20	7.80	1.42						7,864	14,155
Same (tipple sample of run-of-mine coal)	255	W68207	C	1	1.70	17.10	73.40	7.80	1.33						7,872	14,170
Same (tipple sample of run-of-mine coal)	255	W68208	C	1	1.80	16.00	74.40	7.80	1.42						7,843	14,117
Same (composite of samples W68204, W68206, W68207, and W68208).	255	30174	C	1	1.78	16.89	73.49	7.84	1.50	4.38	80.89	1.17	4.22		7,863	14,153
				2		17.20	74.82	7.98	1.53	4.26	82.36	1.19	2.68		8,005	14,409
				3		18.69	81.31		1.66	4.63	89.50	1.29	2.92		8,699	15,658
CLEARFIELD COUNTY.																
Munson; Ghem mine, Lower Kittanning bed (face of 9 right heading)	256	26306	A	1	2.92	23.03	64.69	9.36	2.66					2.5	7,612	13,702
Same (20 feet from face of 2 main entry)	256	26307	A	1	3.68	21.97	64.63	9.72	3.19					3.3	7,495	13,491
Same (face of 2 room, 3 right back heading)	256	26308	A	1	2.61	24.61	62.95	9.83	3.18					2.2	7,575	13,635
Same (25 feet from face of 8 right heading)	256	26309	A	1	2.77	22.84	65.60	8.79	2.99					2.3	7,646	13,763
Same (composite of samples 26306, 26307, 26308, and 26309)	256	26310	A	1	3.01	22.84	64.62	9.53	3.09	4.71	76.69	1.31	4.67	2.6	7,570	13,626
				2		23.55	66.62	9.83	3.19	4.52	79.07	1.35	2.04		7,805	14,049
				3		26.12	73.88		3.54	5.01	87.69	1.50	2.26		8,656	15,581
Same (face of 2 room, 3 right back heading; roof coal)	256	26311	A	1	1.97	23.86	55.28	18.89	6.42					1.6	6,758	12,164
				2		24.34	56.39	19.27	6.55						6,894	12,409
				3		30.15	69.85		8.11						8,540	15,372
Same (25 feet from face of 8 right heading; roof coal)	256	26312	A	1	2.61	21.42	57.99	17.98	7.62					2.3	6,754	12,157
				2		21.99	59.55	18.46	7.82						6,935	12,483
				3		26.97	73.03		9.59						8,505	15,309

JEFFERSON COUNTY.																
Punxsutawney, 8½ miles north of; Eleanora mine, Lower Freeport bed (face of 12 left entry, 1,000 feet inby main slope entry).	257	26827	A	1	3.02	29.95	60.84	6.19	1.37					2.3	7,765	13,977
Same (face of 8 west entry, 4 face entry)	257	26828	A	1	2.41	30.53	57.78	9.28	2.91					1.8	7,586	13,655
Same (face of 2 room, 4 west butt entry, 14 west entry)	257	26829	A	1	2.18	30.74	59.03	8.05	1.81					1.8	7,713	13,883
Same (face of 2 west butt entry, 14 left entry)	257	26830	A	1	2.80	28.99	60.92	7.29	1.66					2.2	7,719	13,894
Same (face of 1 left entry, 12 south entry)	257	26831	A	1	2.56	29.75	59.60	8.09	2.17					2.0	7,686	13,835
Same (composite of samples 26827 to 26831)	257	26832	A	1	2.60	30.41	59.05	7.94	2.00	5.05	76.62	1.23	7.16	2.0	7,698	13,856
				2		31.22	60.63	8.15	2.05	4.89	78.67	1.26	4.99		7,904	14,227
				3		33.99	66.01		2.23	5.32	85.65	1.37	5.43		8,605	15,489
SOMERSET COUNTY.																
Cairnbrook; Loyal Hanna No. 6 mine, Lower Kittanning bed (tipple samples of run-of-mine coal).	258	W69564, W69565	C	1	1.60	16.43	74.29	7.68	.82						7,870	14,165
				2		16.70	75.50	7.80	.83						7,997	14,395
				3		18.11	81.89		.90						8,674	15,613
½ mile west of; Reitz No. 2 mine, Lower Kittanning bed (face of 38 room, 6 left entry, 10 feet from entry).	259	W69678	A	1	2.30	17.88	70.54	9.28	1.03						7,628	13,730
				2		18.30	72.20	9.50	1.05						7,806	14,050
				3		20.22	79.78		1.16						8,622	15,520
Same (face of 28 room, 8 left entry, 10 feet from entry)	259	W69591	A	1	2.60	17.24	71.20	8.96	1.51						7,628	13,730
				2		17.70	73.10	9.20	1.55						7,828	14,090
				3		19.49	80.51		1.71						8,622	15,520
Same (face of 31 room, 6 right entry, 150 feet from entry)	259	W69592	A	1	2.20	17.51	73.05	7.24	.64						7,839	14,110
				2		17.90	74.70	7.40	.65						8,017	14,430
				3		19.33	80.67		.70						8,661	15,590
Same (face of main heading)	259	W69593	A	1	2.80	17.79	67.55	11.86	1.85						7,350	13,230
				2		18.30	69.50	12.20	1.90						7,556	13,600
				3		20.84	79.16		2.16						8,606	15,490
Same (face of 18 room, 8 right entry, 15 feet from entry)	259	W69594	A	1	2.80	17.30	71.64	8.26	1.60						7,706	13,870
				2		17.80	73.70	8.50	1.65						7,922	14,260
				3		19.45	80.55		1.80						8,656	15,580
Same (tipple samples of run-of-mine coal)	259	W69566, W69567, W69568	C	1	2.67	17.78	70.21	9.34	1.19						7,613	13,704
				2		18.27	72.13	9.60	1.22						7,822	14,080
				3		20.21	79.79		1.35						8,653	15,575
2½ miles west of; Scalp Level No. 3 mine, Lower Kittanning bed (face of 5 room, 3 left entry).	259	W69595	A	1	2.10	17.43	71.66	8.81	1.32						7,689	13,840
				2		17.80	73.20	9.00	1.35						7,856	14,140
				3		19.56	80.44		1.48						8,633	15,540
Same (face of right main heading)	259	W69596	A	1	2.40	17.28	71.54	8.78	1.02						7,667	13,800
				2		17.70	73.30	9.00	1.05						7,856	14,140
				3		19.45	80.55		1.15						8,628	15,530
Same (face of 12 room, 3 right entry, 30 feet from entry)	259	W69597	A	1	2.30	18.07	70.35	9.28	1.37						7,617	13,710
				2		18.50	72.00	9.50	1.40						7,795	14,030
				3		20.44	79.56		1.55						8,617	15,510
Same (face of 6 room, 4 left entry)	259	W69598	A	1	2.10	18.41	70.68	8.81	1.37						7,706	13,870
				2		18.80	72.20	9.00	1.40						7,872	14,170
				3		20.66	79.34		1.54						8,650	15,570

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page.)	Sample: Laboratory No.[b]	Sample: Kind.[c]	Sample: Condition.[d]	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PENNSYLVANIA—Continued.																
SOMERSET COUNTY—continued.																
Elk Lick, 1 mile south of; Boynton No. 9 mine, Lower Freeport bed (face of 3 right entry, main entry).	260	W71065	A	1	2.85	17.34	70.13	9.68	1.30	......	......	......	......	......	7,632	13,738
				2	......	17.85	72.19	9.96	1.34	......	......	......	......	......	7,856	14,140
				3	......	19.82	80.18	......	1.49	......	......	......	......	......	8,725	15,704
Same (face of main heading)	260	W71066	A	1	3.39	16.23	68.58	11.80	1.34	......	......	......	......	......	7,363	13,254
				2	......	16.80	70.99	12.21	1.39	......	......	......	......	......	7,622	13,719
				3	......	19.14	80.86	......	1.58	......	......	......	......	......	8,682	15,627
Same (car samples of run-of-mine coal)	260	W71103, W71106	C	1	2.60	17.78	67.10	12.52	1.98	......	......	......	......	......	7,357	13,242
				2	......	18.25	68.90	12.85	2.03	......	......	......	......	......	7,553	13,595
				3	......	20.94	79.06	......	2.33	......	......	......	......	......	8,667	15,600
2½ miles east of; Boynton Smokeless mine, Upper Kittanning bed (face of main heading).	261	W71067	A	1	3.67	17.15	70.07	9.11	.85	......	......	......	......	......	7,559	13,606
				2	......	17.80	72.74	9.46	.88	......	......	......	......	......	7,847	14,124
				3	......	19.66	80.34	......	.97	......	......	......	......	......	8,667	15,600
1 mile north northwest of; Chapman No. 3 mine, Pittsburgh bed (face of 2 right entry, main entry).	251	W71063	A	1	2.67	20.91	70.29	6.13	.83	......	......	......	......	......	7,977	14,359
				2	......	21.48	72.22	6.30	.85	......	......	......	......	......	8,196	14,753
				3	......	22.92	77.08	......	.91	......	......	......	......	......	8,747	15,745
Same (face of main heading)	261	W71064	A	1	2.85	21.28	69.01	6.86	.81	......	......	......	......	......	7,927	14,269
				2	......	21.90	71.04	7.06	.83	......	......	......	......	......	8,160	14,688
				3	......	23.56	76.44	......	.89	......	......	......	......	......	8,780	15,803
Same (car samples of run-of-mine coal)	261	W71107, W71110	C	1	4.53	21.10	67.75	6.62	.73	......	......	......	......	......	7,601	13,681
				2	......	22.10	70.97	6.93	.76	......	......	......	......	......	7,961	14,330
				3	......	23.75	76.25	......	.82	......	......	......	......	......	8,554	15,397
Seanor Station, ¼ mile south of; Eureka No. 39 mine, Upper Kittanning bed (face of 6 left entry, 9 left main entry).	261	W68200	A	1	2.10	16.10	73.20	8.60	1.62	......	......	......	......	......	7,783	14,009
Same (face of 11 right entry, 9 left main entry)	261	W68205	A	1	3.00	17.30	71.00	8.70	2.52	......	......	......	......	......	7,655	13,779
Same (face of 9 right entry, 9 left main entry)	261	W68214	A	1	2.10	15.90	72.50	9.50	2.40	......	......	......	......	......	7,657	13,783
Same (composite of samples W68200, W68205, and W68214)	262	30161	A	1	2.40	17.25	71.36	8.99	2.54	4.28	78.50	1.20	4.49	......	7,632	13,738
				2	......	17.67	73.12	9.21	2.60	4.11	80.43	1.23	2.42	......	7,820	14,076
				3	......	19.46	80.54	......	2.86	4.53	88.59	1.35	2.67	......	8,613	15,503

Same (tipple samples of run-of-mine coal)	262	W68183 W68188 W68194 W68223	C	1	1.95	16.06	71.03	10.96	1.66	......	......	......	......	......	7,538	13,568
				2	......	16.38	72.44	11.18	1.69	......	......	......	......	......	7,688	13,838
				3	......	18.44	81.56	......	1.90	......	......	......	......	......	8,656	15,580
TENNESSEE.																
MORGAN COUNTY.																
Catoosa, 3 miles from Nemo; Flat Rock No. 3 mine, Catoosa bed (face of 4 cross entry, 1 right main entry).	263	29556	A	1	2.27	32.80	58.55	6.38	2.16	......	......	......	......	1.6	7,842	14,116
Same (face of 1 cross entry, 3 right main entry)	263	29557	A	1	1.85	32.81	58.26	7.08	2.59	......	......	......	......	1.3	7,822	14,080
Same (face of main north entry)	263	29558	A	1	2.13	31.73	58.72	7.42	2.85	......	......	......	......	1.5	7,782	14,008
Same (composite of samples 29556 to 29558)	263	29559	A	1	2.19	32.53	58.25	7.03	2.52	5.28	78.24	1.61	5.32	1.5	7,838	14,108
				2	......	33.26	59.55	7.19	2.58	5.15	79.99	1.65	3.44	......	8,014	14,425
				3	......	35.84	64.16	......	2.78	5.55	86.19	1.78	3.70	......	8,635	15,543
TEXAS.																
WEBB COUNTY.																
Dolores, 23 miles northwest of Laredo; Dolores mine, Santo Tomas bed (face of 20 room, N entry; cannel coal).	263	29021	B	1	4.42	46.04	30.53	19.01	2.07	5.76	59.32	1.15	12.69	.6	6,147	11,065
				2	......	48.17	31.94	19.89	2.17	5.51	62.06	1.20	9.17	......	6,431	11,576
				3	......	60.13	39.87	......	2.71	6.88	77.47	1.50	11.44	......	8,028	14,450
Same, Dolores mine, San Pedro bed (face of I entry; cannel coal)	263	29022	B	1	3.98	48.87	34.91	12.24	1.96	6.25	65.54	1.27	12.74	.4	6,793	12,227
				2	......	50.90	36.35	12.75	2.04	6.05	68.26	1.32	9.58	......	7,075	12,735
				3	......	58.34	41.66	......	2.34	6.93	78.23	1.51	10.99	......	8,109	14,596
Between Dolores and Darwin; Hunt mine, Santo Tomas bed (30 feet from mine mouth; cannel coal, weathered).	264	29023	B	1	3.64	31.61	20.96	43.79	1.35	4.36	38.98	.65	10.87	.5	4,019	7,234
				2	......	32.80	21.75	45.45	1.40	4.11	40.45	.67	7.92	......	4,171	7,508
				3	......	60.13	39.87	......	2.57	7.53	74.15	1.23	14.52	......	7,646	13,762
Santo Tomas, 27½ miles northwest of Laredo; Santo Tomas mine, Santo Tomas bed (at breakthrough between 118 and 119 rooms; cannel coal).	264	29024	B	1	4.45	44.20	33.65	17.70	1.70	......	......	......	......	.7	6,237	11,227
				2	......	46.26	35.22	18.52	1.78	......	......	......	......	......	6,528	11,750
				3	......	56.77	43.23	......	2.18	......	......	......	......	......	8,012	14,422
VIRGINIA.																
LEE COUNTY.																
Peckett, 2 miles east of; Reed Creeks mine (face of 1 slant entry)	265	29684	A	1	1.78	39.41	50.23	8.58	3.39	......	......	......	......	.7	7,528	13,550
Same (face of 3 slant entry)	265	29685	A	1	2.10	39.65	48.90	9.35	3.65	......	......	......	......	1.1	7,389	13,300
Same (composite of samples 29684 and 29685)	265	29686	A	1	1.94	39.87	49.24	8.95	3.53	5.36	73.14	1.48	7.54	.9	7,466	13,439
				2	......	40.66	50.21	9.13	3.60	5.24	74.59	1.51	5.93	......	7,614	13,705
				3	......	44.75	55.25	......	3.96	5.77	82.09	1.66	6.52	......	8,379	15,082

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
VIRGINIA—Continued.																
MONTGOMERY COUNTY.																
Blacksburg, 3½ miles north of; Slusser mine, "Big Vein" bed (220 feet down slope, 100 feet northeast of slope on level).	265	30689	B	1	2.14	13.89	68.67	15.30	0.55	......	......	......	......	1.4	7,006	12,611
Same (225 feet down slope, 200 feet southwest of slope, on level).	265	30690	B	1	1.70	14.15	69.40	14.75	.51	......	......	......	......	1.0	7,138	12,848
Same (composite of samples 30689 and 30690)	265	30691	B	1	1.92	14.04	68.89	15.15	.52	3.57	75.30	0.89	4.57	1.2	7,077	12,739
				2	......	14.32	70.23	15.45	.53	3.43	76.78	.91	2.90		7,216	12,989
				3	......	16.94	83.06		.63	4.06	90.81	1.08	3.42	......	8,534	15,361
Merrimac Mines; Merrimac mine, "Big Vein" bed (4 level, 2,150 feet west of slope).	266	30692	B	1	3.57	9.53	67.55	19.35	.46	......	......	......	......	2.7	6,584	11,851
				2	......	9.88	70.05	20.07	.48	......	......	......	......	......	6,828	12,290
				3	......	12.36	87.64	......	.60	......	......	......	......	......	8,543	15,377
Same (grab sample from car of so-called "sand coal")	266	30697	C	1	2.20	9.96	81.63	6.21	.47	3.65	84.95	.92	3.80	1.3	7,929	14,272
				2	......	10.18	83.47	6.35	.48	3.49	86.86	.94	1.88	......	8,107	14,593
				3	......	10.87	89.13	......	.51	3.73	92.75	1.00	2.01	......	8,657	15,583
Prospect; "Little" bed (20 feet from mouth of Prospect drift; weathered coal).	266	30693	B	1	4.03	10.07	65.47	20.43	.47	......	......	......	......	3.1	6,412	11,542
				2	......	10.49	68.22	21.29	.49	......	......	......	......	......	6,681	12,026
				3	......	13.33	86.67	......	.62	......	......	......	......	......	8,488	15,278
PULASKI COUNTY.																
Gunton Park; Summit mine, Upper bed (face of room west of slope, 250 feet from mine mouth).	266	30696	B	1	3.82	9.37	62.20	24.61	.75	......	......	......	......	3.1	6,086	10,955
				2	......	9.74	64.67	25.59	.78	......	......	......	......	......	6,328	11,390
				3	......	13.09	86.91	......	1.05	......	......	......	......	......	8,504	15,307
Parrott; Parrott mine, "Big Vein" bed (on level, 150 feet west of slope).	267	30694	B	1	1.58	13.29	61.54	23.59	.67	3.25	67.41	.79	4.29	1.0	6,335	11,403
				2	......	13.50	62.53	23.97	.68	3.12	68.50	.80	2.93	......	6,437	11,587
				3	......	17.76	82.24	......	.89	4.10	90.10	1.05	3.86	......	8,467	15,241
Pulaski, 5 miles northeast of; Langhorne (wagon) mine, "Little" bed (face of main left entry).	267	30695	B	1	3.09	9.79	69.88	17.24	1.07	......	......	......	......	2.2	6,839	12,310
				2	......	10.10	72.11	17.79	1.10	......	......	......	......		7,057	12,708

RUSSELL COUNTY.																
Dante; Clinchfield No. 2 mine, Upper Banner bed (face of 10 right entry, 200 feet from main entry).	268	32168	B	1	2.69	34.82	56.21	6.28	.87					1.6	7,820	14,076
Same (face 4 left entry, main entry, near 20 room)	268	32169	B	1	2.21	35.29	53.40	9.10	.71					1.1	7,584	13,651
Same (face 3 left air course, 7 right entry, near 15 room)	268	32170	B	1	2.51	33.99	56.18	7.32	.52					1.4	7,718	13,892
Same (face 39 room, 4 right cross entry)	268	32171	B	1	2.16	36.20	55.46	6.18	.53					1.1	7,840	14,112
Same (composite of samples 32168 to 32171)	268	32172	B	1	2.38	34.70	55.76	7.16	.58	5.25	78.22	1.51	7.28	1.3	7,738	13,928
				2		35.55	57.12	7.33	.59	5.11	80.13	1.55	5.29		7,927	14,269
				3		38.36	61.64		.64	5.51	86.47	1.67	5.71		8,554	15,397
TAZEWELL COUNTY.																
Bandy, 1 mile west of; Christain mine, Middle Seaboard bed (face of main entry).	268	25913	B	1	3.52	29.19	63.29	4.00	.99					2.5	8,016	14,429
				2		30.26	65.60	4.15	1.03						8,309	14,956
				3		31.57	68.43		1.07						8,669	15,604
1½ miles west of; Patrick mine, Lower Seaboard bed (face of main entry).	269	25912	B	1	3.38	28.13	64.94	3.55	1.10					2.2	8,091	14,564
				2		29.11	67.22	3.67	1.14						8,374	15,078
				3		30.22	69.78		1.18						8,693	15,647
Big Vein; Big Vein No. 1 mine, Pocahontas No. 3 bed (face of 1 room, Balls Hole entry).	269	W67886	A	1	3.20	20.50	73.00	3.30	.58						8,218	14,792
Same (face of 1 room, Balls Hole entry)	269	W67902	A	1	3.30	19.90	72.40	4.40	.58						8,086	14,555
Same (face of 4 room, Cartersville entry)	269	W67889	A	1	3.20	20.10	72.40	4.30	.63						8,123	14,621
Same (face of 4 room, Cartersville entry)	269	W67934	A	1	3.00	20.40	73.50	3.10	.63						8,253	14,855
Same (at split in pillar, dip heading, 60 feet from face)	269	W67951	A	1	3.00	20.30	72.40	4.30	.58						8,099	14,578
Same (composite of samples W67886, W67902, W67889, W67934, and W67951).	269	29908	A	1	3.14	20.52	72.33	4.01	.63	4.73	83.75	1.16	5.72		8,126	14,627
				2		21.19	74.67	4.14	.65	4.52	86.47	1.20	3.02		8,389	15,100
				3		22.11	77.89		.68	4.72	90.21	1.25	3.14		8,751	15,752
Same (car samples of run-of-mine coal)	269	W69458, W69459	C	1	2.75	19.79	71.24	6.22	.56						7,899	14,218
				2		20.35	73.25	6.40	.58						8,122	14,620
				3		21.74	78.26		.62						8,678	15,620
Big Vein No. 2 mine, Pocahontas No. 3 bed (face of 2 right entry, main entry).	269	W67927	A	1	3.30	21.20	71.40	4.20	.58						8,144	14,659
Same (1 room, 5 right entry, 75 feet from face)	269	W67964	A	1	2.40	21.30	71.90	4.40	.59						8,171	14,708
Same (composite of samples W67927 and W67964)	269	29909	A	1	2.85	21.25	71.43	4.47	.59	4.76	83.52	1.13	5.53		8,122	14,620
				2		21.87	73.53	4.60	.61	4.57	85.97	1.16	3.09		8,360	15,048
				3		22.92	77.08		.64	4.79	90.11	1.22	3.24		8,763	15,773
Same (car samples of run-of-mine coal)	269	W69326, W69327	C	1	4.50	20.68	68.71	6.11	.55						7,791	14,024
				2		21.65	71.95	6.40	.58						8,158	14,685
				3		23.13	76.87		.62						8,716	15,689
Boissevain; Boissevain mine, Pocahontas No. 3 bed (face of 9 room, A-1 panel, 5 east entry).	270	W67887	A	1	2.70	20.70	72.70	3.90	.54						8,194	14,750
Same (face of 12 room, C-2 panel, 5 east entry)	270	W67888	A	1	2.40	21.00	72.50	4.10	.54						8,238	14,828
Same (near face of main H-22 entry)	270	W67892	A	1	2.40	21.80	71.90	3.90	.39						8,245	14,841
Same (near face of main H-22 entry)	270	W67900	A	1	2.50	21.10	72.50	3.90	.54						8,216	14,789
Same (face of 10 room, H-23 entry, C-4 entry)	270	W67899	A	1	1.90	20.70	72.40	5.00	.44						8,167	14,701

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No. b	Sample. Kind. c	Sample. Condition. d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
VIRGINIA—Continued.																
TAZEWELL COUNTY—continued.																
Boissevain; Boissevain mine, Pocahontas No. 3 bed (face of 10 room, H-23 entry, C-4 entry).	270	W67904	A	1	2.00	21.10	71.70	5.20	0.49	......	......	......	......	......	8,161	14,690
Same (face of 12 room, C-2 panel, 5 east entry)	270	W67901	A	1	2.60	21.30	72.10	4.00	.44	......	......	......	......	......	8,163	14,693
Same (face of 9 room, A-1 panel, 5 east entry)	270	W67903	A	1	2.70	21.50	71.80	4.00	.58	......	......	......	......	......	8,191	14,744
Same (50 feet from face of 14 triple entry No. 1)	270	W67922	A	1	3.30	20.40	72.20	4.10	.63	......	......	......	......	......	8,136	14,645
Same (50 feet from face of 14 triple entry No. 1)	270	W67960	A	1	3.00	20.50	72.60	3.90	.58	......	......	......	......	......	8,168	14,702
Same (15 feet from face of 1 room, I-17 entry)	270	W67923	A	1	3.00	20.60	73.10	3.30	.53	......	......	......	......	......	8,199	14,758
Same (15 feet from face of 1 room, I-17 entry)	270	W67925	A	1	3.20	21.00	72.30	3.50	.53	......	......	......	......	......	8,206	14,771
Same (on left rib, 30 feet from face of J-3 air course)	270	W67957	A	1	2.90	21.60	72.20	3.30	.39	......	......	......	......	......	8,234	14,821
Same (on left rib, 30 feet from face of J-3 air course)	270	W67971	A	1	2.30	21.30	73.20	3.20	.34	......	......	......	......	......	8,277	14,899
Same (composite of samples W67887, W67888, W67892, W67899, W67900, W67901, W67903, W67904, W67922, W67923, W67925, W67957, W67960, and W67971).	270	29907	A	1	2.63	21.61	71.65	4.11	.50	4.74	84.41	1.14	5.10	......	8,153	14,675
				2	......	22.19	73.59	4.22	.51	4.57	86.69	1.17	2.84	......	8,373	15,071
				3	......	23.17	76.83	......	.53	4.77	90.51	1.22	2.97	......	8,742	15,736
Faraday, ½ mile north of Altizer mine, Pocahontas No. 5 bed (110 feet north of mine mouth).	271	26101	B	1	4.54	18.45	72.06	4.95	.78	......	......	......	......	3.9	7,929	14,272
				2	......	19.33	75.48	5.19	.82	......	......	......	......	......	8,306	14,951
				3	......	20.39	79.61	......	.86	......	......	......	......	......	8,760	15,768
Jewell; Jewell Ridge No. 1 mine, Raven bed (face of 2 right entry, main entry)	271	25651	B	1	3.68	25.94	64.90	5.48	.70	......	......	......	......	3.1	7,962	14,332
Same (face of 6 main entry)	271	25652	B	1	3.09	25.90	65.01	6.00	.79	......	......	......	......	2.5	7,986	14,375
Same (composite of samples 25651 and 25652)	271	25653	B	1	3.36	25.31	65.64	5.69	.73	5.16	80.98	1.29	6.14	2.8	7,978	14,360
				2	......	26.19	67.92	5.89	.76	4.96	83.80	1.33	3.26	......	8,256	14,861
				3	......	27.83	72.17	......	.81	5.27	89.05	1.41	3.46	......	8,773	15,791
Pocahontas; West Pocahontas mine, Pocahontas No. 3 bed (face of 30 room, St. Paul entry, 10 entry).	272	W67910	A	1	3.60	19.60	71.80	5.00	.43	......	......	......	......	......	7,976	14,357
Same (face of 30 room, St. Paul entry, 10 entry)	272	W67954	A	1	3.50	19.10	72.50	4.90	.39	......	......	......	......	......	8,013	14,423
Same (face of 18 room, 34 heading, Newport News district)	272	W67953	A	1	2.00	21.10	72.90	4.00	.44	......	......	......	......	......	8,250	14,850
Same (face of 7 room, 11 right entry, Norton district)	272	W67958	A	1	2.90	21.40	72.10	3.60	.53	......	......	......	......	......	8,234	14,821
Same (composite of samples W67910, W67954, W67953, and [illegible]	272	29912	A	1	3.00	20.25	72.24	4.51	.47	4.05	84.00	1.17	[illegible]	......	[illegible]	[illegible]

Same (car sample of run-of-mine coal from four cars)	272	30264	C	1	2.75	20.39	71.41	5.45	.65	4.65	82.79	1.19	5.27	......	8,020	14,436
				2	......	20.97	73.43	5.60	.67	4.46	85.13	1.22	2.92	......	8,247	14,845
				3	......	22.21	77.79	......	.71	4.72	90.18	1.29	3.10	......	8,736	15,725
½ mile west of; Baby mine, Pocahontas No. 3 bed (face of 19 room, 16 cross entry).	273	W67921	A	1	2.40	21.40	71.30	4.90	.54	......	......	......	......	......	8,129	14,632
Same (75 feet from face of 7 room, 4 sump entry)	273	W67924	A	1	2.90	21.00	71.40	4.70	.58	......	......	......	......	......	8,109	14,596
Same (face of 36 room, West Gurden entry)	273	W67926	A	1	2.70	19.60	74.60	3.10	.44	......	......	......	......	......	8,262	14,872
Same (composite of samples W67921, W67924, and W67926)	273	29906	A	1	2.70	21.10	71.78	4.42	.59	4.75	83.84	1.19	5.21	......	8,138	14,648
				2	......	21.69	73.77	4.54	.61	4.57	86.17	1.22	2.89	......	8,364	15,055
				3	......	22.72	77.28	......	.64	4.79	90.27	1.28	3.02	......	8,762	15,772
Red Ash; Raven Red Ash mine, Raven bed (face of air course, 10 cross heading).	274	25630	B	1	3.14	32.07	58.27	6.52	.57	......	......	......	......	2.0	7,840	14,112
Same (face of air course, 8 main entry)	274	25631	B	1	2.90	31.79	60.26	5.05	.67	......	......	......	......	1.9	8,000	14,400
Same (composite of samples 25630 and 25631)	274	25632	B	1	2.86	32.05	59.36	5.73	.63	5.60	80.18	1.25	6.61	2.0	7,905	14,229
				2	......	32.99	61.11	5.90	.65	5.44	82.54	1.29	4.19	......	8,137	14,647
				3	......	35.06	64.94	......	.69	5.78	87.72	1.37	4.44	......	8,647	15,565
Richlands, 1½ miles west of; East mine, Tiller bed (face of 1 room, main entry).	274	25763	B	1	2.96	30.50	59.05	7.49	.62	......	......	......	......	2.1	7,672	13,810
Same (face of main entry)	274	25764	B	1	2.37	31.31	57.46	8.86	.47	......	......	......	......	1.5	7,501	13,102
Same (composite of samples 25763 amd 25764)	274	25765	B	1	2.67	30.91	58.12	8.30	.59	4.99	77.40	1.35	7.37	1.8	7,578	13,640
				2	......	31.76	59.71	8.53	.61	4.82	79.52	1.39	5.13	......	7,786	14,015
				3	......	34.72	65.28	......	.67	5.27	86.93	1.52	5.61	......	8,512	15,322
½ mile northwest of; Richlands No. 2 mine, Meadow bed (150 feet from face, 560 feet from mine mouth).	274	31414	A	1	2.28	27.25	52.01	18.46	.60	......	......	......	......	1.4	6,744	12,139
Same (at face, 600 feet from mine mouth)	274	31415	A	1	2.25	31.25	59.70	6.80	.63	......	......	......	......	1.4	7,859	14,146
Same (composite of samples 31414 and 31415)	274	31416	A	1	2.23	29.36	55.69	12.72	.61	4.73	74.23	1.11	6.60	1.4	7,297	13,135
				2	......	30.03	56.96	13.01	.62	4.58	75.92	1.14	4.73	......	7,463	13,433
				3	......	34.52	65.48	......	.71	5.27	87.28	1.31	5.43	......	8,579	15,442
Richlands No. 4 mine, Meadow bed (27 feet from face of main entry)	275	31418	A	1	3.47	28.04	58.98	9.51	.50	......	......	......	......	2.9	7,479	13,462
Same (from coal pile outside of mine mouth)	275	31417	A	1	2.95	27.95	56.28	12.82	.68	......	......	......	......	2.3	7,197	12,955
Same (composite of samples 31418 and 31417)	275	31419	A	1	3.30	27.82	57.80	11.08	.63	4.79	75.29	1.07	7.14	2.6	7,340	13,212
				2	......	28.77	59.77	11.46	.65	4.57	77.86	1.11	4.35	......	7,590	13,662
				3	......	32.49	67.51	......	.73	5.16	87.94	1.25	4.92	......	8,572	15,430
1½ miles west of; West mine, Jawbone bed (face of 9 entry, 4 right entry).	276	25757	B	1	1.93	31.14	53.80	13.13	.48	......	......	......	......	1.2	7,212	12,982
Same (face of 1 left entry)	276	25758	B	1	2.22	30.74	56.99	10.05	.47	......	......	......	......	1.3	7,525	13,545
Same (composite of samples 25757 and 25758)	276	25759	B	1	2.06	31.11	55.28	11.55	.48	4.91	75.18	1.39	6.49	1.2	7,369	13,264
				2	......	31.76	56.45	11.79	.49	4.78	76.76	1.42	4.76	......	7,524	13,543
				3	......	36.01	63.99	......	.56	5.42	87.62	1.61	5.39	......	8,530	15,354
2 miles northwest of; Wilson mine, Red Ash bed (face of drift, 100 feet inby mine mouth).	276	W69806	A	1	1.80	31.33	57.05	9.82	.44	......	......	......	......	......	7,628	13,730
				2	......	31.90	58.10	10.00	.45	......	......	......	......	......	7,767	13,980
				3	......	35.44	64.56	......	.50	......	......	......	......	......	8,628	15,530
Same (face of drift, 100 feet inby mine mouth)	276	W69807	A	1	1.70	31.06	57.51	9.73	.44	......	......	......	......	......	7,595	13,670
				2	......	31.60	58.50	9.90	.45	......	......	......	......	......	7,728	13,910
				3	......	35.07	64.93	......	.50	......	......	......	......	......	8,578	15,440

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[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
VIRGINIA—Continued.																
TAZEWELL COUNTY—continued.																
Richlands; 2 miles northwest of; Wilson Mine, Town Hill bed (face of drift, 500 feet from mine mouth).	276	W69808	A	1	3.30	31.33	62.47	2.90	0.39	......	......	......	......	......	8,139	14,650
				2	......	32.40	64.60	3.00	.40	......	......	......	......	......	8,411	15,140
				3	......	33.40	66.60	......	.41	......	......	......	......	......	8,672	15,610
Same (face of drift, 500 feet from mine mouth)	277	W69809	A	1	3.20	30.98	63.01	2.81	.39	......	......	......	......	......	8,133	14,640
				2	......	32.00	65.10	2.90	.40	......	......	......	......	......	8,400	15,120
				3	......	32.96	67.04	......	.41	......	......	......	......	......	8,650	15,570
1½ miles northeast of; Wysor mine, prospect opening; (face of heading).	277	W69802, W69803	A	1	3.85	26.59	66.34	3.22	.87	......	......	......	......	......	8,018	14,432
				2	......	27.65	69.00	3.35	.90	......	......	......	......	......	8,339	15,010
				3	......	28.61	71.39	......	.93	......	......	......	......	......	8,628	15,530
Same (face of heading)	277	W69804, W69805	A	1	3.05	28.60	62.63	5.72	.73	......	......	......	......	......	7,861	14,150
				2	......	29.50	64.60	5.90	.75	......	......	......	......	......	8,108	14,595
				3	......	31.35	68.65	......	.80	......	......	......	......	......	8,617	15,510
Seaboard; Empire No. 6½ mine, Upper Seaboard bed (face of 3 right entry).	277	25760	B	1	2.95	28.72	62.74	5.59	.65	......	......	......	......	2.0	7,962	14,332
Same (face of 2 left entry)	277	25761	B	1	3.15	29.38	60.76	6.71	.50	......	......	......	......	2.1	7,825	14,085
Same (composite of samples 25760 and 25761)	277	25762	B	1	3.13	29.00	61.77	6.10	.58	5.02	80.04	1.38	6.88	2.0	7,894	14,209
				2	......	29.94	63.76	6.30	.60	4.82	82.63	1.42	4.23	......	8,150	14,670
				3	......	31.95	68.05	......	.64	5.14	88.18	1.52	4.52	......	8,698	15,656
WISE COUNTY.																
Josephine; Intermont No. 6 mine, Imboden bed (6 room, 50 feet from face on pillar between 5 and 6 rooms).	278	32067	A	1	2.52	33.73	53.52	10.23	.79	......	......	......	......	.9	7,378	13,280
Same (7 room, 20 feet through pillar from fire)	278	32068	A	1	2.88	33.46	53.94	9.72	.95	......	......	......	......	1.3	7,370	13,266
Same (composite of samples 32067 and 32068)	278	32069	A	1	2.61	33.80	53.56	10.03	.87	5.05	73.73	1.57	8.75	1.0	7,372	13,270
				2	......	34.71	54.99	10.30	.89	4.89	75.71	1.61	6.60	......	7,570	13,626
				3	......	38.69	61.31	......	.99	5.45	84.40	1.79	7.37	......	8,439	15,190

WASHINGTON.

KITTITAS COUNTY.																
Ellensburg, 25 miles northwest of; NW. ¼ sec. 14, T. 18 N., R. 15 E., open prospect (23 feet west from mouth of prospect).	278	26223	B	1	10.34	30.39	43.37	15.90	1.43	5.52	61.31	1.46	14.39	8.9	6,114	11,005
				2	......	33.89	48.38	17.73	1.59	4.89	68.38	1.63	5.78	......	6,819	12,274
				3	......	41.19	58.81	......	1.93	5.92	83.12	1.98	7.05	......	8,288	14,918
LEWIS COUNTY.																
Centralia, 3 miles north of; NW. ¼ sec. 30, T. 15 N., R. 2 W.; Ford's Prairie mine (face of main entry near last plane).	279	*29564	B	1	29.81	32.88	29.49	7.82	.61	6.64	43.97	.75	40.21	21.5	4,193	7,547
				2	......	46.84	42.02	11.14	.87	4.74	62.64	1.07	19.54	......	5,974	10,753
				3	......	52.71	47.29	......	.98	5.33	70.50	1.20	21.99	......	6,723	12,101
6 miles east of; NE. ¼ sec. 17, T. 14 N., R. 1 W.; Monarch mine (face of plane).	279	*29570	B	1	27.82	33.66	29.74	8.78	.99	6.68	45.35	.87	37.33	22.5	4,412	7,942
				2	......	46.63	41.21	12.16	1.37	4.97	62.83	1.21	17.46	......	6,112	11,002
				3	......	53.08	46.92	......	1.56	5.66	71.53	1.38	19.87	......	6,958	12,524
Chehalis; W. ½ sec. 29, T. 14 N., R. 2 W.; Superior mine, Superior No. 2 bed (face of entry, beyond 34 chute).	279	*29568	B	1	30.78	33.06	27.73	8.43	.75	6.81	42.62	.80	40.59	25.3	4,174	7,513
				2	......	47.76	40.06	12.18	1.08	4.90	61.57	1.16	19.11	......	6,030	10,854
				3	......	54.38	45.62	......	1.23	5.58	70.11	1.32	21.76	......	6,866	12,359
2 miles southeast of; NE. ¼ sec. 33, T. 14 N., R. 2 W.; Sheldon mine (face of main entry).	279	*29569	B	1	31.00	32.65	30.55	5.80	.46	6.96	44.76	.76	41.26	22.3	4,286	7,715
				2	......	47.32	44.27	8.41	.67	5.10	64.87	1.10	19.85	......	6,212	11,182
				3	......	51.66	48.34	......	.73	5.57	70.83	1.20	21.67	......	6,782	12,208
Mendota; E. ½ sec. 3, T. 14 N., R. 1 W.; Mendota mine (face of 5 north entry).	280	*29565	B	1	19.75	35.16	31.62	13.47	1.17	6.00	48.60	.92	29.84	12.0	4,820	8,676
				2	......	43.81	39.41	16.78	1.46	4.75	60.56	1.15	15.30	......	6,006	10,811
				3	......	52.64	47.36	......	1.75	5.71	72.77	1.38	18.39	......	7,217	12,991
THURSTON COUNTY.																
Tono; NW. ¼ sec. 21, T. 15 N., R. 1 W.; Hannaford mine (face of 7 room, 2 entry, 2 main slope entry, upper bench).	280	*29566	B	1	21.69	34.77	33.29	10.25	1.24	6.29	48.91	.93	32.38	16.3	4,831	8,696
				2	......	44.40	42.51	13.09	1.58	4.95	62.46	1.19	16.73	......	6,169	11,104
				3	......	51.09	48.91	......	1.82	5.70	71.87	1.37	19.24	......	7,098	12,776
Same (face of 7 room, 2 entry, 2 main entry, mining bench).....	280	*29567	B	1	22.51	33.91	34.69	8.89	.61	6.30	49.87	1.04	33.29	15.1	4,823	8,681
				2	......	43.76	44.77	11.47	.79	4.90	64.36	1.34	17.14	......	6,224	11,203
				3	......	49.43	50.57	......	.89	5.54	72.70	1.51	19.36	......	7,031	12,656
WHATCOM COUNTY.																
Bellingham, 1 mile from; sec. 13, T. 38 N., R. 2 E.; Bellingham mine, No. 1 bed (near foot of slope).	281	*32034	A	1	8.35	34.82	40.32	16.51	.24	5.10	57.33	1.09	19.73	2.3	5,605	10,089
				2	......	37.99	44.00	18.01	.26	4.55	62.55	1.19	13.44	......	6,116	11,009
				3	......	46.34	53.56	......	.32	5.55	76.29	1.45	16.39	......	7,460	13,428

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample: Laboratory No.b	Sample: Kind.c	Sample: Condition.d	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Proximate: Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Air-drying loss.	Calorific value: Calories.	Calorific value: British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA.																
BROOKE COUNTY.																
Collier, 1½ miles west of; Locust Grove Nos. 1 and 2 mines, Pittsburgh bed (face of main entry, on right rib).	281	31627	A	1	4.32	38.14	49.03	8.51	2.32	......	......	......	......	2.6	7,191	12,944
Same (slant at face of 4 face entry)	281	31628	A	1	4.24	37.71	50.28	7.77	2.35	......	......	......	......	2.4	7,264	13,075
Same (face of 1 face entry, on right rib)	281	31629	A	1	4.79	36.53	50.23	8.45	2.65	......	......	......	......	2.9	7,120	12,816
Same (face of 5 face entry, on left rib)	281	31630	A	1	4.35	37.58	50.11	7.96	2.95	......	......	......	......	2.7	7,212	12,982
Same (face of 6 left butt entry, on left rib)	281	31631	A	1	4.43	36.87	50.56	8.14	2.39	......	......	......	......	2.6	7,195	12,951
Same (composite of samples 31627 to 31631)	281	31632	A	1	4.43	37.38	50.11	8.08	2.59	5.30	72.06	1.44	10.53	2.6	7,189	12,940
				2	......	39.11	52.44	8.45	2.71	5.03	75.40	1.51	6.90	......	7,523	13,541
				3	......	42.72	57.28	......	2.96	5.49	82.36	1.65	7.54	......	8,217	14,791
Short Creek, 5 miles south of Wellsburg; Beech Bottom mine, Pittsburgh bed (on left rib, 75 feet in 17 room, 6 west entry, 4 north entry).	282	31597	A	1	4.45	37.14	52.27	6.14	1.41	......	......	......	......	2.5	7,407	13,333
Same (on left rib, face of 3 entry, 4 north entry)	282	31598	A	1	3.88	36.91	48.20	11.01	1.99	......	......	......	......	2.1	7,017	12,631
Same (face of 3 east butt entry, 4 north face entry)	282	31599	A	1	3.31	38.86	50.29	7.54	1.54	......	......	......	......	1.6	7,350	13,230
Same (face of main east entry, on left rib)	282	31600	A	1	2.94	37.29	52.06	7.71	1.81	......	......	......	......	1.1	7,389	13,300
Same (neck of 3 east butt entry, 4 south face entry)	282	31601	A	1	4.54	36.01	52.63	6.82	1.43	......	......	......	......	2.5	7,341	13,214
Same (composite of samples 31597 to 31601)	282	31602	A	1	3.78	37.58	50.91	7.73	1.65	5.26	73.11	1.43	10.82	1.9	7,291	13,124
				2	......	39.06	52.91	8.03	1.71	5.03	75.98	1.49	7.76	......	7,578	13,640
				3	......	42.47	57.53	......	1.86	5.47	82.61	1.62	8.44	......	8,240	14,832
FAYETTE COUNTY.																
Layland, 2 miles north of; Layland Nos. 1, 2, 3, and 4 mines, Fire Creek bed (face of 8 left entry, 4 main entry).	282	W68180	A	1	2.40	21.10	71.40	5.10	.68	......	......	......	......	......	8,045	14,481
Same (face of 11 left entry, 3 main entry)	282	W68186	A	1	2.80	19.40	71.90	5.90	.49	......	......	......	......	......	7,931	14,276
Same (face of 1 room, 26 left entry, 2 main entry)	282	W68196	A	1	3.10	19.20	74.20	3.50	.73	......	......	......	......	......	8,169	14,704
Same (face of 7 left entry, main tunnel entry)	282	W68224	A	1	2.40	20.90	70.90	5.80	.54	......	......	......	......	......	8,032	14,458
Same (face of 8 room, 17 left entry, 1 main entry)	282	W68225	A	1	2.50	19.00	73.90	4.60	.78	......	......	......	......	......	8,110	14,598
Same (composite of samples W68180, W68186, W68196, W68224, and W68225).	282	30147	A	1	2.60	18.78	73.55	5.07	.75	4.69	82.79	1.56	5.14	......	8,031	14,456
				2	......	19.28	75.51	5.21	.77	4.52	85.00	1.60	2.90	......	8,245	14,841
				3	......	20.34	79.66	......	.81	4.77	89.68	1.69	3.05	......	8,698	[illegible]

Same (car samples of run-of-mine coal)	283	W69233, W69234	C	1	1.75	19.94	72.37	5.94	.62	......	......	......	......	......	7,980	14,364
				2	......	20.30	73.65	6.05	.63	......	......	......	......	......	8,122	14,620
				3	......	21.61	78.39	......	.67	......	......	......	......	......	8,645	15,561
Minden; Minden No. 2 mine, Sewell bed (face of 15 room, 1 crosscut, 10 left entry, 2 main entry).	284	W68113	A	1	2.40	24.70	69.70	3.20	.93	......	......	......	......	......	8,194	14,749
Same (face of 12 room, 2 main entry)	284	W68127	A	1	2.10	25.20	70.10	2.60	.54	......	......	......	......	......	8,267	14,881
Same (face of 1 crosscut, 13 left entry, 1 main entry)	284	W68133	A	1	2.80	24.60	69.00	3.60	.44	......	......	......	......	......	8,143	14,657
Same (composite of samples W68113, W68127, and W68133)	284	30149	A	1	2.40	24.87	69.58	3.15	.75	5.04	83.53	1.67	5.86	......	8,194	14,749
				2	......	25.48	71.29	3.23	.77	4.89	85.58	1.71	3.82	......	8,395	15,111
				3	......	26.33	73.67	......	.80	5.05	88.44	1.77	3.94	......	8,675	15,615
Minden No. 3 mine, Sewell bed (face of 20 room, 10 right entry, 2 main entry).	284	30046	A	1	2.30	25.10	69.81	2.79	.55	5.02	84.35	1.72	5.57	......	8,255	14,859
				2	......	25.69	71.45	2.86	.56	4.87	86.34	1.76	3.61	......	8,449	15,208
				3	......	26.45	73.55	......	.58	5.01	88.88	1.81	3.72	......	8,697	15,655
Minden No. 4 mine, Sewell bed (in break-through 11 entry, left entry, 3 main north entry).	284	W68124	A	1	2.40	25.00	68.90	3.70	.39	......	......	......	......	......	8,158	14,684
Same (face of 21 room, 9 left entry, 2 main entry)	284	W68125	A	1	2.90	25.00	70.40	1.70	.49					......	8,267	14,881
Same (head of straight main entry)	284	W68131	A	1	2.40	25.30	70.20	2.10	.39	......	......	......	......	......	8,315	14,967
Same (composite of samples W68124, W68125, and W68131	284	30150	A	1	2.57	25.34	68.94	3.15	.50	5.06	83.86	1.68	5.75	......	8,216	14,789
				2	......	26.01	70.76	3.23	.51	4.90	86.07	1.72	3.57	......	8,433	15,179
				3	......	26.88	73.12	......	.53	5.06	88.94	1.78	3.69	......	8,715	15,687
Minden No. 5 mine, Sewell bed (19 right entry, 1 main entry)	284	W68116	A	1	2.70	24.70	70.70	1.90	.44	......	......	......	......	......	8,296	14,933
Same (10 right entry, 3 main entry)	284	W68119	A	1	2.90	24.10	71.10	1.90	.53	......	......	......	......	......	8,262	14,872
Same (face of 15 room, 1 right entry, 2 main entry)	284	W68120	A	1	2.80	24.60	69.20	3.40	1.07	......	......	......	......	......	8,166	14,699
Same (face of 1 main entry)	284	W68121	A	1	3.50	24.40	67.30	4.80	1.35	......	......	......	......	......	7,920	14,256
Same (composite of samples W68116, W68119, W68120, and W68121).	284	30151	A	1	2.97	23.73	69.93	3.37	1.04	5.01	83.12	1.67	5.79	......	8,119	14,614
				2	......	24.46	72.07	3.47	1.07	4.82	85.66	1.72	3.26	......	8,367	15,061
				3	......	25.34	74.66	......	1.11	4.99	88.74	1.78	3.38	......	8,667	15,601
Minden Nos. 2, 3, 4, and 5 mines, Sewell bed (car samples of run-of-mine coal from 12 cars).	284	W69231, W69232	C	1	2.00	23.77	69.72	4.51	.57	......	......	......	......	......	8,082	14,548
				2	......	24.25	71.15	4.60	.58	......	......	......	......	......	8,247	14,845
				3	......	25.42	74.58	......	.61	......	......	......	......	......	8,645	15,561
1½ miles northeast of; Rock Lick No. 4 mine, Sewell bed (face of 4 main entry).	285	W68114	A	1	3.00	25.80	68.70	2.50	.44	......	......	......	......	......	8,178	14,720
Same (face of 2 main entry)	285	W68126	A	1	2.60	24.50	70.80	2.10	.44	......				......	8,256	14,861
Same (face of straight main entry)	285	W68132	A	1	2.20	25.40	70.00	2.40	.44	......	......	......	......	......	8,275	14,895
Same (composite of samples W68114, W68126, and W68132)	285	30157	A	1	2.60	25.45	69.39	2.56	.47	4.99	83.96	1.66	6.36	......	8,234	14,821
				2	......	26.13	71.24	2.63	.48	4.83	86.20	1.70	4.16	......	8,454	15,217
				3	......	26.84	73.16	......	.49	4.96	88.53	1.75	4.27	......	8,682	15,628
Same (tipple samples of run-of-mine coal)	285	W70120, W70123	C	1	1.83	25.21	68.98	3.98	.48	......	......	......	......	......	8,182	14,728
				2	......	25.68	70.27	4.05	.49	......	......	......	......	......	8,335	15,003
				3	......	26.76	73.24	......	.51	......	......	......	......	......	8,687	15,636
Same (car samples of loaded run-of-mine coal, Rock Lick Nos. 2 and 4 mines).	285	W69293, W69294	C	1	2.15	24.41	70.06	3.38	.47	......	......	......	......	......	8,173	14,712
				2	......	24.95	71.60	3.45	.48	......	......	......	......	......	8,353	15,035
				3	......	25.84	74.16	......	.50	......	......	......	......	......	8,651	15,572

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
FAYETTE COUNTY—continued.																
Thurmond, 1 mile north of; Rock Lick No. 2 mine, Fire Creek bed (face of 2 left heading).	286	W68128	A	1	2.10	21.70	72.70	3.50	0.88						8,237	14,827
Same (face of 2 room, 2 left entry)	286	W68129	A	1	2.30	21.50	72.10	4.10	.64						8,153	14,675
Same (face of parting being cut on 2 left entry)	286	W68130	A	1	2.90	21.40	69.00	3.70	.49						7,840	14,112
Same (composite of samples W68128, W68129, and W68130)	286	30158	A	1	2.43	21.91	70.84	4.82	.72	4.81	82.74	1.65	5.26		8,035	14,463
				2		22.46	72.60	4.94	.74	4.65	84.80	1.69	3.18		8,235	14,823
				3		23.63	76.37		.78	4.89	89.21	1.78	3.34		8,663	15,593
Same (tipple samples of run-of-mine coal)	286	W70127, W70128, W70129, W70130	C	1	2.10	21.42	70.09	6.39	.50						7,998	14,396
				2		21.88	71.59	6.53	.51						8,170	14,705
				3		23.41	76.59		.55						8,741	15,733
GRANT COUNTY.																
Bismarck, ¾ mile east of; Cosner mine, Thomas bed (face of entry, outcrop mine).	286	W69068	B	1	3.00	16.68	71.01	9.31	2.72						7,550	13,590
				2		17.20	73.20	9.60	2.80						7,783	14,010
				3		19.03	80.97		3.10						8,606	15,490
1¾ miles east of; Hamline mine, Davis bed (face of room being driven to west).	286	W69069	B	1	4.90	18.07	63.53	13.50	2.23						6,967	12,540
				2		19.00	66.80	14.20	2.35						7,322	13,180
				3		22.14	77.86		2.74						8,533	15,360
¾ mile west of; outcrop mine, Falls bed (face of outcrop at water's edge at falls of Stony River).	287	W69073	B	1	5.30	16.10	68.56	10.04	3.31						7,267	13,080
				2		17.00	72.40	10.60	3.50						7,672	13,810
				3		19.02	80.98		3.92						8,583	15,450
Same (from stock pile of coal dug from bed of river; weathered	287	W69066	C	1	2.50	18.62	63.86	15.02	1.51						7,028	12,650
				2		19.10	65.50	15.40	1.55						7,206	12,950
				3		22.58	77.42		1.83						8,522	15,340
Hartmonsville, 2 miles southwest of; Kitzmiller mine, Barton bed (face of main entry).	287	W69065	B	1	3.80	15.58	72.64	7.98	1.54						7,589	13,660
				2		16.20	75.50	8.30	1.60						7,883	14,190
				3		17.67	82.33		1.74						8,600	15,480
Henry; Henry or No. 22 mine, Upper Freeport bed (face of 3 left butt heading, Webster heading).	287	26579	B	1	4.18	22.28	67.63	5.91	1.89	5.06	80.04	1.45	5.65	3.6	7,834	14,101
				2		23.25	70.58	6.17	1.97	4.80	83.53	1.51	2.02		8,176	14,717
				3		24.78	75.22		2.10	5.12	89.03	1.61	2.14		8,714	15,685

Mount Storm, 1 mile north of; Koontz mine, Thomas bed (at break-through from 1 right entry).	288	W69070	B	1	3.80	15.68	75.42	5.10	.53	......	......	......	......	......	7,872	14,170
				2	......	16.30	78.40	5.30	.55	......	......	......	......	......	8,178	14,720
				3	......	17.21	82.79	......	.58	......	......	......	......	......	8,639	15,550
Same (at break-through from 1 right entry; bony coal).........	288	W69064	B	1	4.40	13.29	52.00	30.31	.43	......	......	......	......	......	5,428	9,770
				2	......	13.90	54.40	31.70	.45	......	......	......	......	......	5,678	10,220
				3	......	20.35	79.65	......	.66	......	......	......	......	......	8,311	14,960
HANCOCK COUNTY.																
Chester, 2 miles south of; Allison mine, Mahoning bed (60 feet south of entry mouth).	288	25633	B	1	4.19	34.78	54.38	6.65	1.80	5.29	74.20	1.29	10.77	1.4	7,390	13,302
				2	......	36.30	56.76	6.94	1.88	5.03	77.44	1.35	7.36	......	7,713	13,883
				3	......	39.01	60.99	......	2.02	5.41	83.22	1.45	7.90	......	8,288	14,918
½ mile south of; Jones mine, Lower Kittanning bed (65 feet southwest of mine mouth).	288	25635	B	1	3.26	39.35	51.44	5.95	4.49	5.57	74.56	1.23	8.20	1.7	7,566	13,619
				2	......	40.68	53.17	6.15	4.64	5.39	77.07	1.27	5.48	......	7,821	14,078
				3	......	43.34	56.66	......	4.94	5.74	82.12	1.35	5.85	......	8,333	14,999
2 miles northeast of; Line Island mine, Middle Kittanning bed (70 feet south of mine mouth and 15 feet from main entry).	289	25591	B	1	5.10	36.18	48.35	10.37	3.85	5.07	70.71	1.23	8.77	3.0	6,976	12,557
				2	......	38.12	50.95	10.93	4.06	4.74	74.51	1.30	4.47	......	7,351	13,232
				3	......	42.80	57.20	......	4.56	5.32	83.65	1.46	5.01	......	8,253	14,855
1½ miles south of; Sprout's mine, Lower Freeport bed (15 feet southwest from entry mouth).	289	25634	B	1	3.76	37.33	46.83	12.08	4.13	5.40	68.56	1.21	8.62	2.0	6,938	12,488
				2	......	38.79	48.66	12.55	4.29	5.17	71.24	1.26	5.49	......	7,209	12,976
				3	......	44.36	55.64	......	4.91	5.91	81.46	1.44	6.28	......	8,243	14,837
New Cumberland; Crescent (clay mine), Lower Kittanning bed (2,500 feet N. 80° E. from entry mouth).	290	25716	B	1	2.34	39.80	44.53	13.33	8.98	......	......	......	......	.5	6,953	12,515
				2	......	40.76	45.59	13.65	9.20	......	......	......	......	......	7,120	12,816
				3	......	47.20	52.80	......	10.65	......	......	......	......	......	8,246	14,843
1 mile north of; McNeil-Herron mine, Mahoning bed (200 feet N. 22° W. from mine mouth).	290	25715	B	1	4.71	34.22	55.23	5.84	2.05	......	......	......	......	1.8	7,437	13,387
				2	......	35.91	57.96	6.13	2.15	......	......	......	......	......	7,804	14,047
				3	......	38.25	61.75	......	2.29	......	......	......	......	......	8,314	14,965
2 miles northeast of; Martin mine, Mahoning bed (160 feet S. 70° E. from mine mouth).	290	25714	B	1	4.65	35.09	56.32	3.94	1.39	......	......	......	......	1.6	7,624	13,723
				2	......	36.80	59.07	4.13	1.46	......	......	......	......	......	7,996	14,393
				3	......	38.39	61.61	......	1.52	......	......	......	......	......	8,341	15,014
Pughtown, 2½ miles northeast of New Cumberland; Wern's mine, Mahoning bed (110 feet N. 35° E. from mine mouth).	290	25713	B	1	5.31	33.08	56.61	5.00	1.94	......	......	......	......	2.0	7,375	13,275
				2	......	34.94	59.78	5.28	2.05	......	......	......	......	......	7,789	14,020
				3	......	36.89	63.11	......	2.16	......	......	......	......	......	8,223	14,801
MCDOWELL COUNTY.																
Arlington; Arlington mine, Pocahontas No. 3 bed (face of 10 room, 6 entry).	291	W68026	A	1	2.20	18.30	75.20	4.30	.34	......	......	......	......	......	8,160	14,688
Same (on 7 pillar, 16 left entry).........	291	W68031	A	1	2.50	18.20	76.00	3.30	.39	......	......	......	......	......	8,225	14,805
Same (face of 10 room, 12 entry).........	291	W68032	A	1	2.10	18.30	76.20	3.40	.44	......	......	......	......	......	8,262	14,872
Same (composite of samples W68026, W68031, and W68032).....	291	29993	A	1	2.27	18.91	74.85	3.97	.41	4.56	84.90	1.16	5.00	......	8,198	14,756
				2	......	19.35	76.59	4.06	.42	4.41	86.87	1.19	3.05	......	8,388	15,098
				3	......	20.17	79.83	......	.44	4.60	90.54	1.24	3.18	......	8,743	15,737
Same (car sample of loaded coal).........	291	30253	C	1	3.45	17.73	71.46	7.36	.44	4.43	80.98	1.12	5.67	......	7,759	13,966
				2	......	18.36	74.02	7.62	.46	4.19	83.87	1.16	2.70	......	8,036	14,465
				3	......	19.87	80.13	......	.50	4.54	90.79	1.26	2.91	......	8,699	15,658

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.b	Kind.c	Condition.d	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Bear Wallow, ½ mile east (?) of; Roanoke mine, Pocahontas No. 3 bed (face of 20 room, 13 entry).	292	W67990	A	1	2.50	17.80	73.40	6.30	0.44						7,957	14,323
Same (face of 28 room, 2 diagonal entry)	292	W67991	A	1	2.20	17.70	75.20	4.90	.44						8,150	14,670
Same (face of 27 room, 15 entry)	292	W67993	A	1	2.40	17.80	75.50	4.30	.39						8,138	14,648
Same (composite of samples W67990, W67991, and W67993)	292	29917	A	1	2.37	18.47	73.94	5.22	.43	4.52	83.85	1.17	4.81		8,105	14,589
				2		18.92	75.73	5.35	.44	4.36	85.89	1.20	2.76		8,302	14,944
				3		19.99	80.01		.46	4.61	90.74	1.27	2.92		8,771	15,788
Same (car sample of loaded coal from 4 cars)	292	30232	C	1	2.50	16.89	71.23	9.38	.43	4.31	79.97	1.08	4.83		7,677	13,819
				2		17.32	73.06	9.62	.44	4.13	82.02	1.11	2.68		7,874	14,173
				3		19.16	80.84		.49	4.57	90.75	1.23	2.96		8,712	15,682
Berwind, 1½ miles northeast of; Berwind No. 1 mine, Pocahontas No. 3 bed (face of 3 left entry in No. 1½ mine).	293	W68085	A	1	1.50	18.10	74.00	6.40	.94						8,043	14,472
Same (face of main heading in No. 1½ mine)	293	W68091	A	1	2.00	20.20	73.40	4.40	.93						8,189	14,740
Same (1 pillar, 2 left entry, 3 right entry)	293	W68092	A	1	1.50	18.70	75.40	4.40	.79						8,210	14,778
Same (composite of samples W68085, W68091, and W68092)	293	30171	A	1	1.67	19.13	74.06	5.14	1.03	4.54	84.15	1.13	4.01		8,139	14,650
				2		19.45	75.32	5.23	1.05	4.42	85.58	1.15	2.57		8,277	14,899
				3		20.52	79.48		1.11	4.66	90.30	1.21	2.72		8,734	15,721
Same (tipple samples of coal being loaded)	293	W70263, W70264, W70265, W70266	C	1	1.23	18.37	73.78	6.62	.84						8,052	14,494
				2		18.60	74.70	6.70	.85						8,153	14,675
				3		19.94	80.06		.91						8,738	15,729
Berwind No. 2 mine, Pocahontas No. 3 bed (face of 1 left entry, 1 right entry, 4 left entry).	294	W68081	A	1	1.60	19.00	73.30	6.00	.79						8,075	14,535
Same (8 pillar, 3 right entry)	294	W68082	A	1	1.50	18.10	74.20	6.20	.99						8,025	14,445
Same (face of 9 left entry)	294	W68087	A	1	1.40	18.90	69.60	10.10	.79						7,688	13,838
Same (composite of samples W68081, W68082, and W68087)	294	29978	A	1	1.50	18.55	72.66	7.29	.97	4.36	82.62	1.11	3.65		7,966	14,339
				2		18.83	73.77	7.40	.98	4.25	83.88	1.13	2.36		8,087	14,557
				3		20.33	79.67		1.06	4.59	90.58	1.22	2.55		8,733	15,719

Same (car samples of run-of-mine coal)	294	W69133, W69134	C	1	2.90	17.43	69.77	9.90	.78	......	......	......	......	......	7,542	13,575
				2	......	17.95	71.85	10.20	.80	......	......	......	......	......	7,767	13,980
				3	......	19.99	80.01	......	.89	......	......	......	......	......	8,649	15,568
1½ miles east of; Berwind No. 3 mine, Pocahontas No. 3 bed (4 pillar, 5 left entry, main entry).	294	W68070	A	1	1.30	19.40	74.20	5.10	.64	......	......	......	......	......	8,193	14,747
Same (face of main heading)	294	W68073	A	1	1.90	19.30	73.00	5.80	1.18	......	......	......	......	......	8,073	14,531
Same (face of 22 room, 5 left entry, main entry)	294	W68077	A	1	2.10	18.30	73.10	6.50	.78	......	......	......	......	......	8,016	14,429
Same (composite of samples W68070, W68073, and W68077)	294	29982	A	1	1.77	19.16	73.39	5.68	1.00	4.46	83.67	1.12	4.07	......	8,104	14,587
				2	......	19.51	74.71	5.78	1.02	4.34	85.18	1.14	2.54	......	8,250	14,850
				3	......	20.71	79.29	......	1.08	4.61	90.40	1.21	2.70	......	8,756	15,761
Same (car sample from 4½ loaded cars)	294	30234	C	1	2.60	18.65	70.77	7.98	.93	4.57	80.65	1.04	4.83	......	7,816	14,069
				2	......	19.15	72.66	8.19	.95	4.39	82.80	1.07	2.60	......	8,025	14,445
				3	......	20.86	79.14	......	1.03	4.78	90.19	1.17	2.83	......	8,741	15,734
At Berwind; Berwind No. 4 mine, Pocahontas No. 3 bed (face of 2 room, 8 left entry).	295	W68067	A	1	2.50	19.50	72.10	5.90	1.02	......	......	......	......	......	8,015	14,427
Same (face of 5 room, 3 right entry)	295	W68068	A	1	2.00	19.60	73.90	4.50	.83						8,201	14,762
Same (on 4 pillar, 3 left entry)	295	W68074	A	1	2.20	19.60	73.50	4.70	1.08	......	......	......	......	......	8,111	14,600
Same (composite of samples W68067, W68068, and W68074)	295	29979	A	1	2.23	19.61	73.16	5.00	1.15	4.62	83.59	1.12	4.52	......	8,128	14,630
				2	......	20.06	74.83	5.11	1.18	4.47	85.50	1.15	2.59	......	8,313	14,963
				3	......	21.14	78.86	......	1.24	4.71	90.11	1.21	2.73	......	8,761	15,770
Same (car samples of run-of-mine coal)	295	W68907, W68908	C	1	2.85	19.04	70.58	7.53	.78	......	......	......	......	......	7,829	14,092
				2	......	19.60	72.65	7.75	.80	......	......	......	......	......	8,058	14,505
				3	......	21.25	78.75	......	.87	......	......	......	......	......	8,736	15,724
Big Sandy; Big Sandy mine, Sewell bed (face of 3 crosscut, 17 left entry)	296	W68018	A	1	2.90	18.70	75.70	2.70	.49	......	......	......	......	......	8,300	14,940
Same (face of 1 crosscut, 8 right entry)	296	W68021	A	1	2.40	19.00	74.40	4.20	.54	......	......	......	......	......	8,203	14,765
Same (composite of samples W68018 and W68021)	296	29976	A	1	2.65	19.20	74.73	3.42	.68	4.72	84.75	1.42	5.01	......	8,233	14,819
				2	......	19.72	76.77	3.51	.70	4.55	87.06	1.47	2.71	......	8,457	15,223
				3	......	20.44	79.56	......	.73	4.72	90.23	1.52	2.80	......	8,765	15,777
Same (tipple samples of coal being loaded)	296	W70267, W70268, W70269, W70270	C	1	1.75	19.34	73.97	4.94	.55	......	......	......	......	......	8,143	14,657
				2	......	19.68	75.29	5.03	.56	......	......	......	......	......	8,288	14,918
				3	......	20.72	79.28	......	.59	......	......	......	......	......	8,727	15,708
Coalwood, 1½ miles southeast of; Olga mine, Pocahontas No. 4 bed (face of No. 2 development).	296	W68094	A	1	1.00	15.90	77.40	5.70	.89						8,170	14,706
Same (face of 2 left entry, 2 main entry)	296	W68097	A	1	1.00	15.40	77.60	6.00	.64	......	......	......	......	......	8,077	14,539
Same (face of 1 right entry, No. 2 development	296	W68098	A	1	.90	17.00	74.80	7.30	.74	......	......	......	......	......	7,958	14,324
Same (composite of samples W68094, W68097, and W68098)	296	30155	A	1	.97	16.97	76.10	5.96	.79	4.27	84.20	1.22	3.56	......	8,090	14,562
				2	......	17.14	76.84	6.02	.80	4.20	85.02	1.23	2.73	......	8,169	14,704
				3	......	18.24	81.76	......	.85	4.47	90.47	1.31	2.90	......	8,693	15,647
Same (car samples from 9 loaded cars)	296	W68800, W68801	C	1	1.30	16.93	73.08	8.69	.72	......	......	......	......	......	7,830	14,094
				2	......	17.15	74.05	8.80	.73	......	......	......	......	......	7,933	14,280
				3	......	18.80	81.20	......	.80	......	......	......	......	......	8,699	15,658
Same (car samples from 5 loaded cars)	296	W69404, W69405	C	1	1.15	16.46	73.59	8.80	.67	......	......	......	......	......	7,801	14,042
				2	......	16.65	74.45	8.90	.68	......	......	......	......	......	7,892	14,205
				3	......	18.28	81.72	......	.75	......	......	......	......	......	8,663	15,593

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Cooper, 5 miles west of; Tug River mine, Pocahontas No. 3 bed (face of 4 room, 2 crosscut).	297	W67896	A	1	3.10	21.10	72.10	3.70	0.53	......	......	......	......	......	8,136	14,645
Same (face of 46 room, 1 slant entry)	297	W67898	A	1	2.80	21.00	73.80	2.40	.44	......	......	......	......	......	8,340	15,012
Same (face of main heading)	297	W67933	A	1	2.80	20.60	73.90	2.70	.39	......	......	......	......	......	8,319	14,974
Same (composite of samples W67896, W67898, and W67933)	297	29913	A	1	2.90	20.70	73.44	2.96	.50	4.83	85.07	1.19	5.45	......	8,242	14,836
				2	......	21.32	75.63	3.05	.52	4.64	87.61	1.23	2.95	......	8,488	15,278
				3	......	21.99	78.01	......	.54	4.79	90.37	1.27	3.03	......	8,755	15,759
Same (car samples of run-of-mine coal from 10 loaded cars)	297	W69053, W69054	C	1	3.25	19.79	71.74	5.22	.56	......	......	......	......	......	7,995	14,391
				2	......	20.45	74.15	5.40	.58	......	......	......	......	......	8,272	14,890
				3	......	21.62	78.38	......	.61	......	......	......	......	......	8,745	15,740
Davy, ½ mile southeast of; Blackstone mine, Sewell bed (in break-through between main entry and air course).	298	29880	A	1	3.30	18.65	74.68	3.37	.52	4.73	83.95	1.42	6.01	......	8,137	14,647
				2	......	19.29	77.23	3.48	.54	4.51	86.81	1.47	3.19	......	8,415	15,147
				3	......	19.99	80.01	......	.56	4.67	89.94	1.52	3.31	......	8,719	15,694
1½ miles southeast of; Cletus mine, Sewell bed (head of 1 crosscut, 3 main entry).	299	29892	A	1	2.50	20.09	74.81	2.60	.50	4.75	85.71	1.45	4.99	......	8,319	14,974
				2	......	20.60	76.73	2.67	.51	4.58	87.91	1.49	2.84	......	8,532	15,358
				3	......	21.16	78.84	......	.52	4.71	90.32	1.53	2.92	......	8,766	15,779
Same (car samples of run-of-mine coal from 5 loaded cars)	299	W69496, W69497	C	1	2.25	17.94	73.46	6.35	.47	......	......	......	......	......	7,931	14,276
				2	......	18.35	75.15	6.50	.48	......	......	......	......	......	8,114	14,605
				3	......	19.63	80.37	......	.51	......	......	......	......	......	8,678	15,620
½ mile north of; Davy Crockett No. 2 mine, Sewell bed (face of 11 cross entry of old hallway).	299	29891	A	1	2.80	18.68	72.04	6.48	.70	4.57	81.75	1.35	5.15	......	7,923	14,261
				2	......	19.22	74.11	6.67	.72	4.38	84.10	1.39	2.74	......	8,151	14,672
				3	......	20.59	79.41	......	.77	4.69	90.11	1.49	2.94	......	8,734	15,721
Same (tipple samples of coal being loaded)	299	W70215, W70216, W70217, W70218	C	1	1.73	18.55	70.60	9.12	.58	......	......	......	......	......	7,757	13,962
				2	......	18.88	71.84	9.28	.59	......	......	......	......	......	7,893	14,208
				3	......	20.81	79.19	......	.65	......	......	......	......	......	8,701	15,661
Same (car samples from 8 loaded cars)	299	W69328, W69348	C	1	2.45	19.02	70.29	8.24	.57	......	......	......	......	......	7,750	13,950
				2	......	19.50	72.05	8.45	.58	......	......	......	......	......	7,945	14,300
				3	......	21.30	78.70	......	.63	......	......	......	......	......	8,678	15,620

½ mile west of; Helena mine, Sewell bed (head of 23 entry)	300	29886	A	1	2.10	20.17	74.62	3.11	.57	4.70	85.44	1.43	4.75	......	8,296	14,933
				2	......	20.60	76.22	3.18	.58	4.57	87.27	1.46	2.94	......	8,474	15,253
				3	......	21.28	78.72	......	.60	4.72	90.13	1.51	3.04	......	8,752	15,754
1 mile west of; Helena or Superior No. 3 mine, Sewell bed (face of 5 heading)	301	W70212	A	1	2.50	19.50	74.00	4.00	.68	......	......	......	......	......	8,189	14,740
				2	......	20.00	75.90	4.10	.70	......	......	......	......	......	8,395	15,110
				3	......	20.86	79.14	......	.73	......	......	......	......	......	8,756	15,760
Same (face of 15 cross entry, 3 left entry)	301	W70213	A	1	1.70	20.35	71.07	6.88	.59	......	......	......	......	......	7,967	14,340
				2	......	20.70	72.30	7.00	.60	......	......	......	......	......	8,106	14,590
				3	......	22.26	77.74	......	.65	......	......	......	......	......	8,717	15,690
Same (face of 23 left entry, main entry)	301	W70214	A	1	1.90	19.91	73.19	5.00	.98	......	......	......	......	......	8,117	14,610
				2	......	20.30	74.60	5.10	1.00	......	......	......	......	......	8,272	14,890
				3	......	21.39	78.61	......	1.05	......	......	......	......	......	8,722	15,700
Same (tipple samples of coal being loaded)	301	W70219, W70220, W70221, W70222	C	1	2.13	19.53	71.95	6.39	.69	......	......	......	......	......	7,983	14,370
				2	......	19.95	73.52	6.53	.70	......	......	......	......	......	8,157	14,683
				3	......	21.34	78.66	......	.75	......	......	......	......	......	8,727	15,709
Eckman, 1 mile east of; Pulaski No. 2 mine, Pocahontas No. 3 bed (on pillar, 3 left entry, 34 cross entry)	302	26615	A	1	2.83	18.46	74.32	4.39	.60	......	......	......	......	2.3	8,155	14,679
Same (on pillar of 4 room, 1 dip entry)	302	26616	A	1	3.04	16.74	75.64	4.58	.58	......	......	......	......	2.5	8,122	14,560
Same (composite of samples 26615 and 26616)	302	26617	A	1	2.90	17.34	75.29	4.47	.60	4.45	83.89	1.09	5.50	2.4	8,131	14,636
				2	......	17.86	77.54	4.60	.62	4.25	86.40	1.12	3.01	......	8,374	15,073
				3	......	18.72	81.28	......	.65	4.45	90.56	1.17	3.17	......	8,778	15,800
Same (on left, inby rib of 3 cross entry, 36 right cross entry, between 10 and 11 rooms)	302	26618	A	1	3.05	17.70	74.67	4.58	.59	......	......	......	......	2.5	8,088	14,620
Same (1 room, opposite 1 break-through, milk-dairy entry)	302	26619	A	1	3.51	17.14	75.08	4.27	.56					2.9	8,055	14,499
Same (neck of 23 room, 2 cross entry, 36 cross entry)	302	26620	A	1	2.99	18.32	74.06	4.63	.59	......	......	......	......	2.6	8,110	14,598
Same (face of 12 room, 20 feet from 1 left entry, 34 cross entry)	302	26621	A	1	3.65	17.29	75.11	3.95	.56	......	......	......	......	3.1	8,069	14,524
Same (face of 5 room, 90 feet from slant entry, 5 cross entry, 36 left entry)	302	26622	A	1	2.50	19.04	74.35	4.11	.65	......	......	......	......	2.1	8,178	14,720
Same (composite of samples 26618, 26619, 26620, 26621, and 26622)	302	26623	A	1	3.14	17.74	74.85	4.27	.59	4.61	83.76	1.15	5.62	2.6	8,095	14,571
				2	......	18.31	77.28	4.41	.61	4.40	86.47	1.19	2.92	......	8,357	15,043
				3	......	19.15	80.85	......	.64	4.60	90.46	1.24	3.06	......	8,742	15,736
Same (face of 1 room, 3 crosscut, 36 left entry)	303	W67929	A	1	2.80	16.90	75.60	4.70	.53	......	......	......	......	......	8,138	14,648
Same (face of 8 room, 2 crosscut, 34 entry)	303	W67956	A	1	2.30	17.10	75.80	4.80	.44	......	......	......	......	......	8,166	14,699
Same (face of 12 room, 37 entry, 2 main entry)	303	W68011	A	1	2.30	18.00	75.80	3.90	.49	......	......	......	......	......	8,213	14,783
Same (composite of samples W67929, W67956, and W68011)	303	29987	A	1	2.47	17.57	75.62	4.34	.58	4.51	84.77	1.16	4.64	......	8,155	14,679
				2	......	18.01	77.54	4.45	.59	4.35	86.92	1.19	2.50	......	8,362	15,052
				3	......	18.85	81.15	......	.62	4.55	90.97	1.25	2.61	......	8,752	15,754
Same (car samples of loaded run-of-mine coal from 9 cars)	302	W69014, W69015	C	1	2.35	16.99	73.78	6.88	.52	......	......	......	......	......	7,866	14,159
				2	......	17.40	75.55	7.05	.53	......	......	......	......	......	8,056	14,500
				3	......	18.72	81.28	......	.57	......	......	......	......	......	8,667	15,600

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Pulaski No. 3 mine, Pocahontas No. 3 bed (on rib of 1 left entry, 1,350 feet from main entry).	303	26610	A	1	377	17.47	75.23	3.53	0.57	......	......	......	......a	3.2	8,136	14,645
Same (face of 19 room, 80 feet from 4 left cross entry)	303	26611	A	1	3.24	17.34	74.85	4.57	.62	......	......	......	......	2.9	8,095	14,571
Same (on rib of 3 left entry, 1,800 feet from main entry)	303	26612	A	1	3.81	17.83	74.68	3.68	.61	......	......	......	......	3.1	8,098	14,576
Same (face of main entry, between 4 and 5 cross entries)	303	26613	A	1	2.85	18.30	73.97	4.88	.63	......	......	......	......	2.4	8,075	14,535
Same (composite of samples 26610, 26611, 26612, and 26613)	303	26614	A	1	3.35	17.84	74.63	4.18	.63	4.62	83.52	1.00	6.05	2.9	8,108	14,585
				2	......	18.46	77.21	4.33	.65	4.40	86.42	1.03	3.17	......	8,384	15,091
				3	......	19.30	80.70	......	.68	4.00	90.33	1.08	3.31	......	8,764	15,775
Shawnee mine, Pocahontas No. 3 bed (on 31 pillar, 4 right entry)	304	W67935	A	1	1.60	17.00	76.60	4.80	.49	......	......	......	......	......	8,167	14,701
Same (face of 8 room, 2 main entry)	304	W67937	A	1	1.90	17.00	75.80	5.30	.49	......	......	......	......	......	8,131	14,636
Same (on 24 pillar, 2 right entry)	304	W67938	A	1	1.60	17.10	74.70	6.60	.54	......	......	......	......	......	8,018	14,432
Same (composite of samples W67935, W67937, and W67938)	304	29915	A	1	1.70	17.72	74.83	5.75	.58	4.39	84.27	1.15	3.86	......	8,099	14,578
				2	......	18.03	76.12	5.85	.59	4.27	85.73	1.17	2.39	......	8,239	14,830
				3	......	19.15	80.85	......	.63	4.54	91.05	1.24	2.54	......	8,751	15,752
Same (car samples of run-of-mine coal from 8 loaded cars)	304	W68839, W68840	C	1	2.80	16.23	71.44	9.53	.52	......	......	......	......	......	7,620	13,715
				2	......	16.70	73.50	9.80	.53	......	......	......	......	......	7,839	14,110
				3	......	18.51	81.49	......	.59	......	......	......	......	......	8,691	15,643
Elkhorn; Houston No. 1 mine, Pocahontas No. 3 bed (on 21 pillar, 40 cross entry).	305	W67955	A	1	2.50	18.50	74.40	4.60	.49	......	......	......	......	......	8,167	14,701
Same (on 16 pillar, 39 entry)	305	W67959	A	1	3.00	17.80	74.00	4.30	.44	......	......	......	......	......	8,099	14,578
Same (composite of samples W67955 and W67959)	305	29989	A	1	2.75	18.67	74.11	4.47	.48	4.55	84.29	1.21	5.00	......	8,099	14,578
				2	......	19.20	76.20	4.60	.49	4.36	86.67	1.24	2.64	......	8,328	14,990
				3	......	20.13	79.87	......	.51	4.57	90.85	1.30	2.77	......	8,729	15,712
Houston No. 2 mine, Pocahontas No. 3 bed (face of 3 room, 44 cross entry).	305	W67962	A	1	2.60	17.50	74.50	5.40	.49	......	......	......	......	......	8,074	14,533
Same (on 6 pillar, 24 cross entry)	305	W67969	A	1	2.10	18.20	74.80	4.90	.44	......	......	......	......	......		
Same (on 5 pillar, 38 cross entry)	305	W67970	A	1	2.60	17.60	75.40	4.40	.39	......	......	......	......	......	8,118	14,612
Same (composite of samples W67962, W67969, and W67970)	305	29990	A	1	2.43	18.41	74.20	4.93	.47	4.51	84.19	1.18	4.72	......	8,129	14,632
				2	......	18.90	76.05	5.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......	8,099	14,578

Same (car samples of run-of-mine coal from 9 loaded cars, Houston Nos. 1 and 2 mines).	305	W68802, W68803	C	1	2.75	16.58	69.29	11.38	.44						7,453	13,416
				2		17.05	71.25	11.70	.45						7,664	13,795
				3		19.31	80.69		.51						8,680	15,628
Faraday; 4 miles east of; Pressly mine, Pocahontas No. 5 bed (face of 3 room, on right of main entry).	306	26159	B	1	3.26	22.05	71.70	2.99	.53					2.9	8,290	14,922
				2		22.79	74.12	3.09	.55						8,569	15,424
				3		23.52	76.48		.57						8,842	15,916
Gilliam; Gilliam mine, Pocahontas No. 3 bed (face of 28 room, 6 crosscut)	306	W68000	A	1	1.70	17.60	74.90	5.80	.44						8,078	14,540
Same (face of 6 room, 3 crosscut)	306	W68022	A	1	1.90	18.00	74.60	5.50	.49						8,113	14,603
Same (face of 2 main entry, 3 crosscut)	306	W68023	A	1	2.30	17.00	76.00	4.70	.39						8,175	14,715
Same (composite of samples W68000, W68022, and W68023)	306	29992	A	1	1.97	18.40	74.65	4.98	.42	4.47	84.36	1.10	4.67		8,125	14,625
				2		18.77	76.15	5.08	.43	4.34	86.06	1.12	2.97		8,288	14,918
				3		19.77	80.23		.45	4.57	90.66	1.18	3.14		8,731	15,716
Same (car sample of run-of-mine coal from 4 loaded cars)	306	30238	C	1	2.30	16.61	73.23	7.86	.43	4.37	80.75	1.14	5.45		7,838	14,108
				2		17.00	74.95	8.05	.44	4.21	82.65	1.17	3.48		8,023	14,441
				3		18.49	81.51		.48	4.58	89.88	1.27	3.79		8,725	15,705
Hartwell, ¾ mile southwest of; Berwind No. 5 mine, Pocahontas No. 3 bed (face of main heading).	307	W68069	A	1	3.80	20.80	71.30	4.10	.77						8,107	14,593
Same (on chain pillar, between 3 and 4 rooms, 3 left entry)	307	W68072	A	1	2.10	20.30	73.90	3.70	.83						8,272	14,890
Same (face of 2 right entry)	307	W68076	A	1	3.00	18.00	74.70	4.30	.82						8,134	14,641
Same (composite of samples W68069, W68072, and W68076)	307	29980	A	1	2.97	20.20	72.75	4.08	.98	4.71	83.65	1.14	5.44		8,157	14,683
				2		20.82	74.98	4.20	1.01	4.51	86.21	1.17	2.90		8,407	15,133
				3		21.73	78.27		1.05	4.71	89.90	1.22	3.03		8,775	15,795
Same (car sample of run-of-mine coal from 4 loaded cars)	307	30263	C	1	2.15	18.67	69.84	9.34	.94	4.34	80.01	1.01	4.36		7,689	13,858
				2		19.08	71.37	9.55	.96	4.19	81.77	1.03	2.50		7,868	14,162
				3		21.09	78.91		1.06	4.63	90.40	1.14	2.77		8,699	15,658
Havaco; Havaco mine, Pocahontas No. 3 bed (face of 1 main entry)	307	W67996	A	1	1.30	14.80	78.90	5.00	.71						8,175	14,715
Same (face of 8 right entry, main entry)	307	W68019	A	1	2.40	14.90	76.80	5.90	.59						8,018	14,432
Same (face of 15 right entry, 1 left entry, main entry)	307	W68020	A	1	2.00	15.80	77.00	5.20	.69						8,126	14,627
Same (composite of samples W67996, W68019, and W68020)	307	29991	A	1	1.90	15.45	77.36	5.35	.75	4.24	84.51	1.13	4.02		8,090	14,562
				2		15.75	78.80	5.45	.76	4.11	86.15	1.15	2.38		8,247	14,845
				3		16.66	83.34		.80	4.35	91.11	1.22	2.52		8,722	15,700
Same (car sample of run-of-mine coal from 8 loaded cars)	307	30237	C	1	2.75	15.02	74.27	7.96	.79	4.20	81.12	1.10	4.83		7,743	13,937
				2		15.44	76.37	8.19	.81	4.00	83.41	1.13	2.46		7,962	14,332
				3		16.82	83.18		.88	4.36	90.85	1.23	2.68		8,672	15,610
Hemphill, ½ mile west of Welch; Welch mine, Welch bed (face of 14 left entry, main entry, just inby 35 room).	308	26582	A	1	4.46	17.48	71.53	6.53	.70					3.9	7,796	14,033
Same (face of last cut-through to air course in 25 room, 200 feet from 15 left air course).	308	26583	A	1	2.80	18.28	71.59	7.33	.59					2.3	7,864	14,165
Same (face of 1 right entry, main tunnel entry)	308	26584	A	1	2.52	19.36	70.43	7.69	.59					2.0	7,857	14,143
Same (face of main entry, 400 feet inby 16 entry)	308	26585	A	1	2.40	18.78	70.58	8.24	.54					1.9	7,793	14,027
Same (composite of samples 26582 to 26585)	308	26586	A	1	3.01	18.18	71.42	7.39	.63	4.65	81.57	1.28	4.48	2.5	7,823	14,081
				2		18.74	73.64	7.62	.65	4.45	84.10	1.32	1.86		8,066	14,519
				3		20.29	79.71		.70	4.82	91.04	1.43	2.01		8,731	15,716
Same (on pillar of 14 room, 13 entry, 150 feet from 13 entry)	308	26587	A	1	3.82	19.48	70.57	6.13	.57					2.4	7,712	13,882
				2		20.25	73.38	6.37	.59						8,018	14,432
				3		21.63	78.37		.63						8,563	15,413

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample: Laboratory No. [b]	Kind. [c]	Condition. [d]	Proximate: Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate: Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value: Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Jenkinjones; Jenkinjones No. 6 mine, Pocahontas No. 3 bed (face of 29 room, 14 double entry).	309	W68083	A	1	2.30	22.30	72.10	3.30	0.49						8,248	14,846
Same (face of 3 room, K-10 entry)	309	W68090	A	1	2.30	22.30	72.10	3.30	.49						8,237	14,827
Same (19 pillar, M-13 entry)	309	W68096	A	1	1.70	21.90	72.30	4.10	.49						8,236	14,825
Same (composite of samples W68083, W68090, and W68096)	309	30160	A	1	2.10	22.12	72.21	3.57	.46	4.76	85.07	1.20	4.94		8,207	14,773
				2		22.59	73.76	3.65	.47	4.63	86.89	1.23	3.13		8,383	15,089
				3		23.45	76.55		.49	4.81	90.18	1.28	3.24		8,701	15,662
Same (car samples from 8 loaded cars)	309	30256	C	1	2.80	20.80	70.23	6.17	.50	4.72	82.43	1.15	5.08		7,939	14,290
				2		21.40	72.25	6.35	.51	4.54	84.80	1.18	2.62		8,168	14,702
				3		22.85	77.15		.54	4.85	90.55	1.26	2.80		8,722	15,700
Jenkinjones No. 7 mine, Pocahontas No. 3 bed (face of 1 room, 1 right air course).	310	W67985	A	1	2.20	22.60	70.90	4.30	.44						8,192	14,746
Same (face of 11 room, D-4 main entry)	310	W67987	A	1	2.00	21.70	72.00	4.30	.44						8,213	14,783
Same (face of dip entry, near cross entry; screened bone coal)	310	W68028	A	1	1.20	17.20	64.50	17.10	.35						7,095	12,771
Same (face of dip entry, near 1 cross entry)	310	W68029	A	1	2.50	22.50	70.80	4.20	.39						8,191	14,744
Same (face of 11 room, D-4 main entry)	310	W68099	A	1	2.10	22.90	71.30	3.70	.44						8,220	14,796
Same (composite of samples W67985, W67987, W68028, W68029, and W68099).	310	30170	A	1	2.00	21.23	70.12	6.65	.47	4.64	82.30	1.02	4.92		7,970	14,346
				2		21.66	71.55	6.79	.48	4.51	83.98	1.04	3.20		8,133	14,639
				3		23.24	76.76		.51	4.84	90.09	1.12	3.44		8,725	15,705
Same (car sample of run-of-mine coal from 3½ loaded cars)	310	30244	C	1	3.25	21.00	68.90	6.85	.53	4.71	81.04	1.12	5.75		7,845	14,121
				2		21.71	71.21	7.08	.55	4.50	83.76	1.16	2.95		8,109	14,596
				3		23.36	76.64		.59	4.84	90.14	1.25	3.18		8,727	15,709
Jenkinjones No. 8 mine, Pocahontas No. 3 bed (face of right air course, G triple entry).	311	W68088	A	1	2.30	23.20	70.70	3.80	.59						8,221	14,798
Same (face of G-3 heading)	311	W68089	A	1	1.80	23.10	69.80	5.30	.54						8,134	14,641
Same (face of G-4 heading)	311	W68093	A	1	2.10	23.00	69.50	5.40	.54						8,009	14,524
Same (face of 18 room, G-2 entry, 7-1 mine, 8 entry)	311	W68095	A	1	2.00	20.90	73.10	4.00	.44						8,193	14,747
Same (composite of samples W68088, W68089, W68093, and W68095).	311	30172	A	1	2.05	22.61	70.60	4.74	.58	4.79	83.80	1.15	4.94		8,138	14,648
				2		23.08	72.08	4.84	.59	4.66	85.55	1.17	3.19		8,308	14,954
				3		24.25	75.75		.62	4.90	89.90	1.23	3.35		8,731	15,716

Same (car sample of run-of-mine coal from 3½ loaded cars)	311	30239	C	1	3.40	21.80	68.15	6.65	.52	4.76	80.77	1.10	6.20		7,836	14,150
				2		22.57	70.55	6.88	.54	4.53	83.61	1.14	3.30		8,112	14,602
				3		24.24	75.76		.58	4.86	89.79	1.22	3.55		8,711	15,680
Kimball, 2 miles from; Carswell Shaft mine, Pocahontas Nos. 3 and 4 beds (face of 3 right entry, 350 feet from main west entry).	312	W68033	A	1	1.20	15.80	75.30	7.70	.44						7,915	14,247
Same (face of 3 right entry, main east entry), 400 feet from shaft.	312	W68034	A	1	1.80	16.80	75.80	5.60	.49						8,056	14,501
Same (face of 4 left entry, 500 feet from main west entry)	312	W68035	A	1	2.00	16.60	75.70	5.70	.49						8,058	14,504
Same (composite of samples W68033 to W68035)	312	30006	A	1	1.67	16.50	76.00	5.83	.53	4.31	84.14	1.11	4.08		8,062	14,494
				2		16.78	77.29	5.93	.54	4.19	85.57	1.13	2.64		8,189	14,740
				3		17.84	82.16		.57	4.45	90.96	1.20	2.82		8,705	15,669
Same (car sample of run-of-mine coal from 6 loaded cars	312	30591	C	1	2.55	16.36	72.84	8.25	.58	4.21	81.19	1.09	4.68		7,739	13,930
				2		16.79	74.74	8.47	.60	4.03	83.31	1.12	2.47		7,941	14,294
				3		18.34	81.66		.66	4.40	91.02	1.22	2.70		8,676	15,617
Lick Branch, ½ mile east of; Delta mine, Pocahontas No. 3 bed (face of 1 left main heading).	313	W67891	A	1	2.40	18.30	76.10	3.20	.44						8,284	14,911
Same (face of 2 room, 3 left cross entry)	313	W67894	A	1	2.30	18.50	74.60	4.60	.44						8,136	14,645
Same (face of 8 room, 10–5 left entry)	313	W67967	A	1	2.50	18.40	74.30	4.80	.44						8,133	14,639
Same (composite of samples W67981, W67984, and W67967)	313	29911	A	1	2.40	18.73	74.68	4.19	.45	4.51	84.66	1.17	5.02		8,168	14,702
				2		19.19	76.52	4.29	.46	4.34	86.74	1.20	2.97		8,369	15,064
				3		20.05	79.95		.48	4.53	90.63	1.25	3.11		8,744	15,739
Same (car sample from 11 loaded cars)	313	30260	C	1	3.20	17.19	72.15	7.46	.48	4.49	80.78	1.16	5.63		7,780	14,004
				2		17.76	74.53	7.71	.50	4.27	83.45	1.20	2.87		8,037	14,467
				3		19.24	80.76		.54	4.63	90.42	1.30	3.11		8,708	15,674
Marytown; Marytown mine, Sewell bed (face of 6 crosscut, 14 left entry).	314	W68002	A	1	2.10	18.40	72.50	7.00	.59						7,958	14,324
Same (in 4 crosscut, 1 main entry)	314	W68003	A	1	2.70	18.10	68.70	10.50	.88						7,575	13,635
Same (composite of samples W68002 and W68003)	314	29918	A	1	2.40	18.61	70.76	8.23	.84	4.52	80.28	1.37	4.76		7,765	13,977
				2		19.07	72.50	8.43	.86	4.35	82.25	1.41	2.70		7,956	14,321
				3		20.83	79.17		.94	4.75	89.83	1.54	2.94		8,689	15,640
Same (tipple samples of coal being loaded)	314	W70195, W70196, W70197, W70198	C	1	2.30	18.15	73.39	6.16	.61						7,979	14,362
				2		18.58	75.12	6.30	.62						8,167	14,700
				3		19.83	80.17		.66						8,716	15,688
McDowell, 1 mile east of; McDowell mine, Pocahontas No. 3 bed (8 pillar, Spain heading, Pennsylvania main).	314	W68006	A	1	2.10	17.90	76.40	3.60	.49						8,249	14,848
Same (face of 8 room, Bluefield heading, Ohio district)	314	W68007	A	1	2.00	18.20	75.50	4.30	.39						8,224	14,803
Same (face of Egypt cross heading, Germany main, Pennsylvania district).	314	W68010	A	1	2.00	18.60	75.80	3.60	.39						8,278	14,900
Same (composite of samples W68006, W68007, and W68010)	314	29988	A	1	2.03	18.51	75.54	3.92	.49	4.60	85.29	1.14	4.56		8,229	14,812
				2		18.89	77.11	4.00	.50	4.46	87.06	1.16	2.82		8,399	15,118
				3		19.68	80.32		.52	4.65	90.69	1.21	2.93		8,749	15,748
Same (car samples from 11 loaded cars)	314	W68645, W68646	C	1	2.45	17.46	70.09	10.00	.47						7,633	13,740
				2		17.90	71.85	10.25	.48						7,825	14,085
				3		19.94	80.06		.53						8,719	15,694

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Newhall, ½ mile northwest of: Berwind No. 6 mine, Pocahontas No. 3 bed (face of 1 right entry).	315	W68066	A	1	2.60	17.30	75.80	4.30	0.68						8,148	14,666
Same (face of 1 left entry)	315	W68075	A	1	2.70	16.80	75.20	5.30	.54						8,034	14,461
Same (composite of samples W68066 and W68075)	315	29981	A	1	2.07	17.68	75.40	4.85	.66	4.38	84.32	1.21	4.58		8,173	14,711
				2		18.05	77.00	4.95	.67	4.24	86.10	1.24	2.80		8,346	15,023
				3		18.99	81.01		.70	4.46	90.59	1.30	2.95		8,781	15,806
Same (car sample of run-of-mine coal from 9 loaded cars)	315	30235	C	1	2.60	16.06	72.06	9.28	.78	4.35	79.61	1.08	4.90		7,673	13,811
				2		16.49	73.98	9.53	.80	4.17	81.74	1.11	2.65		7,878	14,180
				3		18.23	81.77		.88	4.61	90.35	1.23	2.93		8,708	15,674
¾ mile southeast of; Berwind No. 7 mine, Pocahontas No. 3 bed (face of main entry, 12 feet from 5 right entry).	316	W68146	A	1	3.00	17.70	75.50	3.80	.58						8,183	14,729
Same (face of 3 right entry, opposite 12 room)	316	W68164	A	1	2.60	17.30	75.90	4.20	.63						8,166	14,699
Same (neck of 11 room, 2 left entry)	316	W68148	A	1	3.20	16.60	75.70	4.50	.63						8,137	14,647
Same (composite of samples W68146, W68148, and W68164)	316	30168	A	1	2.93	17.33	75.55	4.19	.69	4.61	84.25	1.18	5.08		8,127	14,629
				2		17.85	77.83	4.32	.71	4.41	86.79	1.22	2.55		8,372	15,070
				3		18.66	81.34		.74	4.61	90.71	1.28	2.66		8,750	15,750
Same (car sample of run-of-mine coal)	316	30259	C	1	2.50	17.09	70.54	9.87	.99	4.35	78.91	1.10	4.78		7,603	13,685
				2		17.53	72.35	10.12	1.02	4.17	80.93	1.13	2.63		7,798	14,036
				3		19.50	80.50		1.13	4.64	90.04	1.26	2.93		8,676	15,617
1½ miles east of; Berwind No. 8 mine, Pocahontas No. 3 bed (face of 1 right entry).	317	W68071	A	1	2.80	17.20	75.10	4.90	.63						8,132	14,638
Same (face of 3 right entry)	317	W68078	A	1	2.80	16.80	77.00	3.40	.53						8,244	14,839
Same (face of main heading)	317	W68079	A	1	2.80	17.30	75.20	4.70	.73						8,092	14,566
Same (composite of samples W68071, W68078, and W68079)	317	29977	A	1	2.80	17.80	75.02	4.38	.69	4.59	84.19	1.22	4.93		8,141	14,654
				2		18.31	77.18	4.51	.71	4.40	86.62	1.25	2.51		8,375	15,075
				3		19.17	80.83		.74	4.61	90.71	1.31	2.63		8,770	15,786
Same (car sample of run-of-mine coal from 8 loaded cars)	317	30262	C	1	2.55	18.68	71.37	7.40	.68	4.39	81.54	1.17	4.82		7,853	14,135
				2		19.17	73.24	7.59	.70	4.22	83.67	1.20	2.62		8,059	14,506
				3		20.74	79.26		.76	4.57	90.54	1.30	2.83		8,721	15,698

Roderfield; Premier Pocahontas No. 1 mine, Welch bed (car samples from 7 loaded cars).	318	W69658, W69659	C	1	2.05	17.53	70.43	9.99	.49	......	......	......	......	......	7,607	13,693
				2	......	17.90	71.90	10.20	.50	......	......	......	......	......	7,767	13,980
				3	......	19.93	80.07	......	.56	......	......	......	......	......	8,649	15,568
Premier Pocahontas No. 2 mine, Welch bed (car samples from 7 loaded cars).	318	W69492, W69493	C	1	2.10	18.16	73.57	6.17	.52	......	......	......	......	......	7,968	14,342
				2	......	18.55	75.15	6.30	.53	......	......	......	......	......	8,139	14,650
				3	......	19.80	80.20	......	.57	......	......	......	......	......	8,686	15,635
Premier Pocahontas No. 3 mine, Welch bed (car samples from 8 loaded cars).	318	W69020, W69021	C	1	2.85	17.78	72.73	7.14	.63	......	......	......	......	......	7,823	14,082
				2	......	18.30	74.35	7.35	.65	......	......	......	......	......	8,053	14,495
				3	......	19.75	80.25	......	.70	......	......	......	......	......	8,692	15,645
5 miles east of; Premier No. 4 mine, Welch bed (face of 3 left air course).	318	W70223	A	1	2.00	18.83	72.52	7.15	.49	......	......	......	......	......	7,917	14,250
				2	......	18.70	74.00	7.30	.50	......	......	......	......	......	8,078	14,540
				3	......	20.17	79.83	......	.54	......	......	......	......	......	8,717	15,690
Same (face of 1 left entry, 1 right entry)	318	W70224	A	1	1.80	18.46	72.67	7.07	.39	......	......	......	......	......	7,945	14,300
				2	......	18.80	74.00	7.20	.40	......	......	......	......	......	8,089	14,560
				3	......	20.26	79.74	......	.43	......	......	......	......	......	8,717	15,690
Same (tipple samples of coal being loaded)	318	W70225, W70226, W70227, W70228	C	1	1.98	18.07	73.24	6.71	.47	......	......	......	......	......	7,985	14,373
				2	......	18.43	74.72	6.85	.48	......	......	......	......	......	8,146	14,663
				3	......	19.78	80.22	......	.52	......	......	......	......	......	8,745	15,741
Same (car sample from 5 loaded cars)	318	30590	C	1	3.60	17.90	70.80	7.70	.55	4.50	80.27	1.34	5.64	......	7,738	13,928
				2	......	18.57	73.44	7.99	.57	4.25	83.27	1.39	2.53	......	8,027	14,449
				3	......	20.18	79.82	......	.62	4.62	90.50	1.51	2.75	......	8,724	15,703
Twin Branch, 1 mile north of; J. B. B. Nos. 1, 2, 3, 4, and 5 mines, Sewell bed (face of 4 northwest entry, No. 1 mine).	318	W68001	A	1	2.50	19.80	74.70	3.00	.54	......	......	......	......	......	8,288	14,918
Same (face of 3 right entry, left entry, 2 main entry, No. 2 mine).	318	W68004	A	1	2.30	19.70	73.70	4.30	.54	......	......	......	......	......	8,152	14,674
Same (face of 2 right entry, 4 main entry, No. 3 mine)	318	29681	A	1	2.98	20.02	71.89	5.11	.74	......	......	......	......	2.6	8,034	14,461
Same (face of 5 room, 3 left entry, 13 right entry, No. 4 mine)	318	W67998	A	1	2.00	20.50	74.60	2.90	.54	......	......	......	......	......	8,334	15,001
Same (face of 13 left entry, straight entry, No. 4 mine)	318	W67999	A	1	2.50	19.90	72.50	5.10	.83	......	......	......	......	......	8,057	14,503
Same (face of 3 right entry, main entry, No. 5 mine)	318	W67997	A	1	4.00	19.20	73.90	2.90	.53	......	......	......	......	......	8,148	14,666
Same (composite of samples W68001, W68004, 29681, W67998, W67999, and W67997).	318	29919	A	1	2.72	19.87	73.57	3.84	.69	4.70	84.48	1.41	4.88	......	8,184	14,731
				2	......	20.43	75.62	3.95	.71	4.52	86.84	1.45	2.53	......	8,413	15,143
				3	......	21.27	78.73	......	.74	4.71	90.41	1.51	2.63	......	8,759	15,766
Same (car samples from 7 loaded cars from No. 1 mine)	318	W68905, W68906	C	1	2.60	19.09	71.74	6.57	.61	......	......	......	......	......	7,914	14,245
				2	......	19.60	73.65	6.75	.63	......	......	......	......	......	8,125	14,625
				3	......	21.02	78.98	......	.68	......	......	......	......	......	8,713	15,684
Same (car samples from 7 loaded cars from No. 3 mine)	318	W69039, W69040	C	1	3.15	18.06	72.79	6.00	.61	......	......	......	......	......	7,928	14,271
				2	......	18.65	75.15	6.20	.63	......	......	......	......	......	8,186	14,735
				3	......	19.88	80.12	......	.67	......	......	......	......	......	8,727	15,709
Same (car sample from 8 loaded cars from No. 4 mine)	318	30243	C	1	3.95	19.35	72.03	4.67	.72	4.80	82.44	1.33	6.04	......	7,981	14,366
				2	......	20.15	74.99	4.86	.75	4.54	85.83	1.38	2.64	......	8,309	14,956
				3	......	21.18	78.82	......	.79	4.77	90.22	1.45	2.77	......	8,734	15,721
Same (tipple samples of coal being loaded, Nos. 1, 2, 4, and 5 mines.	318	W70275, W70276, W70277, W70278	C	1	1.63	19.53	73.89	4.95	.62	......	......	......	......	......	8,183	14,729
				2	......	19.85	75.12	5.03	.63	......	......	......	......	......	8,318	14,973
				3	......	20.90	79.10	......	.66	......	......	......	......	......	8,759	15,766

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample. Laboratory No.[b]	Kind.[c]	Condition.[d]	Proximate. Moisture.	Volatile matter.	Fixed carbon.	Ash.	Ultimate. Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Air-drying loss.	Calorific value. Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MCDOWELL COUNTY—continued.																
Vivian; King mine, Pocahontas No. 3 bed (face 6 north entry, 12 heading).	319	W68024	A	1	2.40	16.50	75.70	5.40	0.49						8,034	14,461
Same (face of 5 room, 8 cross entry)	319	W68025	A	1	2.40	16.30	76.10	5.20	.49						8,035	14,463
Same (face of 9 room, 9 cross entry, main entry, and 12 heading, 6 north entry; bone coal).	319	W68027	A	1	1.00	13.50	47.70	37.80	.30						5,030	9,054
Same (face of 9 room, 9 cross entry, main entry)	319	W68030	A	1	1.90	16.90	76.60	4.60	.44						8,165	14,697
Same (composite of samples W68024, W68025, W68027, and W68030).	319	29974	A	1	1.93	15.88	68.76	13.43	.47	4.03	76.43	0.99	4.65		7,300	13,140
				2		16.19	70.12	13.69	.48	3.90	77.93	1.01	2.99		7,444	13,399
				3		18.76	81.24		.56	4.52	90.29	1.17	3.46		8,625	15,525
Same (car sample from 11 loaded cars)	319	30261	C	1	1.95	16.45	73.71	7.89	.55	4.30	81.79	1.10	4.37		7,831	14,096
				2		16.78	75.17	8.05	.56	4.16	83.42	1.12	2.69		7,987	14,377
				3		18.25	81.75		.61	4.52	90.72	1.22	2.93		8,686	15,635
Tidewater mine, Pocahontas No. 3 bed (face of main heading, 23 cross entry).	320	W68005	A	1	1.50	15.40	76.40	6.70	.64						8,012	14,422
Same (5 pillar, 12 cross entry, 6 north entry)	320	W68008	A	1	1.60	16.00	76.90	5.50	.44						8,138	14,648
Same (face of 26 room, 11 cross entry)	320	W68009	A	1	1.60	17.20	76.80	4.40	.54						8,243	14,837
Same (composite of samples W68005, W68008, and W68009)	320	29974	A	1	1.57	16.96	76.02	5.45	.65	4.30	84.46	1.13	4.01		8,140	14,652
				2		17.23	77.23	5.54	.66	4.20	85.81	1.15	2.64		8,270	14,886
				3		18.24	81.76		.70	4.45	90.84	1.22	2.79		8,755	15,759
Same (car sample of run-of-mine coal from 15 cars)	320	30236	C	1	1.65	16.78	73.16	8.41	.54	4.23	81.30	1.11	4.41		7,812	14,062
				2		17.06	74.39	8.55	.55	4.12	82.66	1.13	2.99		7,943	14,297
				3		18.66	81.34		.60	4.51	90.39	1.24	3.26		8,686	15,635
MARION COUNTY.																
Chiefton, 1 mile from; Consolidation No. 47 mine, Pittsburgh bed (pillar in 16 room, 4 right entry, main south entry; roof coal).	321	28570	A	1	2.38	39.06	50.64	7.93	3.03					1.2	7,521	13,538
				2		40.00	51.88	8.12	3.10						7,705	13,869
				3		43.54	56.46		3.37						8,386	15,095
Same (pillar in 9 room, 3 right entry, 4 south entry)	321	28571	A	1	2.09	39.61	50.53	7.77	2.61					1.0	7,546	13,583
Same (pillar in 16 room, 4 right entry, main south entry)	321	28572	A	1	2.27	39.19	51.67	6.87	2.70					1.1	7,630	13,734
Same (face of 5 south entry, inby 6 right entry)	321	28573	A	1	2.64	40.69	49.54	7.13	3.[illegible]					1.8	7,577	13,639
Same (face of 22 room, 1 left entry, 5 south entry)	321	28574	A	1	2.7[illegible]	40.63	49.80	6.81	[illegible]					1.[illegible]	[illegible]	[illegible]

Same (face of 3 room, 10 left entry, main south face heading)	321	28575	A	1	2.15	39.91	51.13	6.81	2.75					1.3	7,637	13,747
Same (composite of samples 28571 to 28575)	321	28576	A	1	2.41	40.22	50.34	7.03	2.86	5.65	75.32	1.45	7.69	1.4	7,606	13,691
				2		41.21	51.59	7.20	2.93	5.51	77.18	1.49	5.69		7,794	14,029
				3		44.41	55.59		3.16	5.94	83.17	1.61	6.12		8,399	15,118
Fairmont, 1 mile north of; Consolidation No. 38 mine, Pittsburgh bed (face of main butt, main north heading).	322	28106	A	1	1.87	38.17	53.58	6.38	2.05					.9	7,776	13,997
Same (face of 9 right entry, main north heading)	322	28107	A	1	1.86	38.66	52.58	6.90	2.50					.9	7,733	13,919
Same (face of 4 room, 1 left entry, 3 left level, main dip heading)	322	28108	A	1	2.19	39.16	51.46	7.19	2.52					1.1	7,691	13,844
Same (face of 2 room, 1 right entry, 3 north entry, main dip entry).	322	28109	A	1	2.21	39.80	51.13	6.86	2.38					1.2	7,712	13,882
Same (composite of samples 28106 to 28109)	321	28110	A	1	1.91	39.19	52.04	6.86	2.35	5.37	76.94	1.46	7.02	1.0	7,716	13,889
				2		39.95	53.06	6.99	2.40	5.26	78.44	1.49	5.42		7,866	14,159
				3		42.95	57.05		2.58	5.66	84.34	1.60	5.82		8,458	15,224
Same (in 2 cut-through, between 3 and 4 rooms, 8 right entry, 2 left heading, main dip entry; pillar coal).	321	28111	A	1	2.18	38.79	51.81	7.22	2.17					1.0	7,657	13,783
				2		39.66	52.96	7.38	2.22						7,828	14,090
				3		42.82	57.18		2.40						8,452	15,214
Farmington, 1 mile from; Consolidation No. 87 mine, Pittsburgh bed (face of 3 right entry, back switch entry).	323	28505	A	1	2.36	38.06	50.42	9.16	2.09					1.0	7,393	13,307
Same (southeast side of mine, loading haulage way, main heading).	323	28506	A	1	2.71	36.90	55.25	5.14	.66					1.1	7,743	13,937
Same (face of 1 heading, 2 right entry, "No. 1 top right")	323	28507	A	1	2.52	37.02	54.87	5.59	.84					1.0	7,736	13,925
Same (last crosscut between 2 and 3 left entry, back switch entry).	323	28508	A	1	2.74	38.14	53.23	5.89	1.20					1.2	7,674	13,813
Same (composite of samples 28505 to 28508)	323	28509	A	1	2.51	37.66	53.25	6.58	1.20	5.44	76.66	1.50	8.62	1.1	7,652	13,774
				2		38.63	54.62	6.75	1.23	5.29	78.63	1.54	6.56		7,849	14,128
				3		41.43	58.57		1.32	5.67	84.32	1.65	7.04		8,417	15,151
Hutchinson; Consolidation No. 84 mine, Pittsburgh bed (near face of 7 left entry, opposite 5 room neck, 3 south heading).	324	28432	A	1	2.66	36.75	53.41	7.18	1.65					1.5	7,503	13,505
Same (neck of 4 room, 7 right entry, 2 north face entry)	324	28433	A	1	2.19	38.29	52.72	6.80	2.77					1.1	7,590	13,662
Same (neck of 12 room, 8 left entry, 2 south face entry)	324	28434	A	1	2.85	36.62	54.16	6.37	1.10					1.6	7,559	13,606
Same (7 room crosscut, 2 right entry, 2 north face entry; pillar sample).	324	28435	A	1	2.85	36.74	53.58	6.83	1.32					1.5	7,539	13,570
Same (near face of air course, 4 south entry)	324	28469	A	1	2.44	37.95	52.46	7.15	2.31					1.3	7,577	13,639
Same (face of main entry, manway)	324	28470	A	1	2.25	39.11	51.32	7.32	2.42					1.2	7,563	13,613
Same (composite of samples 28432 to 28435, 28469, and 28470)	324	28440	A	1	2.48	37.44	53.10	6.98	1.91	5.54	75.76	1.51	8.30	1.4	7,563	13,613
				2		38.39	54.45	7.16	1.96	5.39	77.68	1.55	6.26		7,755	13,959
				3		41.35	58.65		2.11	5.81	83.67	1.67	6.74		8,353	15,035
Monongah; Consolidation No. 43 mine, Pittsburgh bed (face of 11 room, 6 butt entry, 4 north entry).	324	28209	A	1	2.50	36.55	54.33	6.62	.87					1.1	7,620	13,716
Same (pillar of 5 room, 4 left entry, 5 south entry)	324	28210	A	1	2.62	37.27	54.49	5.62	1.17					1.5	7,655	13,779
Same (face of air course, 2 right entry, 5 north entry)	324	28211	A	1	2.72	37.00	54.78	5.50	.87					1.4	7,709	13,876
Same (pillar of 4 room, 2 right entry, 4 south entry)	324	28225	A	1	2.61	37.95	53.21	6.23	.86					1.4	7,639	13,750
Same (face of main right butt entry, 3 north entry, 1,400 feet from 3 north entry).	324	28226	A	1	2.42	37.32	54.18	6.08	1.51					1.2	7,679	13,822
Same (barrier pillar, between 10 and 11 rooms, 2 right entry)	324	28227	A	1	2.52	38.68	52.17	6.63	.99					1.3	7,613	13,703

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MARION COUNTY—continued.																
Monongah; Consolidation No. 48 Mine, Pittsburg bed (composite of samples 28209 to 28211, and 28225 to 28227).	324	28212	A	1	2.48	37.27	54.10	6.15	1.06	5.52	77.15	1.55	8.57	1.3	7,651	13,772
				2		38.22	55.47	6.31	1.09	5.37	79.11	1.59	6.53		7,845	14,121
				3		40.80	59.20		1.16	5.73	84.44	1.70	6.97		8,374	15,073
Consolidation No. 63 mine, Pittsburgh bed (pillar of 8 room, 2 south entry, main entry).	325	28322	A	1	3.21	37.21	54.32	5.26	.79					1.7	7,710	13,878
Same (pillar of 8 room, 3 right entry, 4 north entry, main entry).	325	28323	A	1	2.50	37.74	54.07	5.69	1.21					1.1	7,723	13,901
Same (last breakthrough between entry and air course, 5 south entry, main entry).	325	28324	A	1	2.73	37.27	54.63	5.37	1.30					1.2	7,712	13,882
Same (face of 2 room, 7 left entry, 4 south entry, main entry)	325	28325	A	1	2.88	37.07	54.23	5.82	1.14					1.4	7,661	13,790
Same (neck of 8 room, 2 right entry, 5 north entry, main entry).	325	28326	A	1	2.47	38.20	53.12	6.21	1.30					1.1	7,654	13,777
Same (16 room, 50 feet back from fall in crosscut, 2 left entry, 3 south entry, main entry).	325	28327	A	1	2.84	37.16	54.77	5.23	.95					1.3	7,705	13,869
Same (composite of samples 28322 to 28327)	325	28328	A	1	2.73	37.50	54.11	5.66	1.14	5.64	77.32	1.52	8.72	1.3	7,701	13,862
				2		38.55	55.63	5.82	1.17	5.49	79.49	1.56	6.47		7,917	14,251
				3		40.93	59.07		1.24	5.83	84.40	1.66	6.87		8,406	15,131
Watson; Consolidation No. 26 mine, Pittsburgh bed (face of 14 room, 4 right butt entry, 5 north entry).	326	28139	A	1	2.21	37.99	53.23	6.57	2.18					1.1	7,710	13,878
Same (face of 6 north entry, river heading)	326	28140	A	1	2.33	37.94	52.56	7.17	2.81					1.2	7,622	13,720
Same (face of 8 room, 2 butt entry, 8½ south entry, main entry).	326	28141	A	1	2.58	37.28	54.42	5.72	1.08					1.3	7,725	13,905
Same (face of 15 room, 4 left butt entry, 7 south entry, main entry).	326	28142	A	1	2.32	38.26	52.63	6.79	2.28					1.1	7,665	13,797
Same (composite of samples 28139 to 28142)	326	28143	A	1	2.27	37.67	53.39	6.67	2.15	5.51	76.94	1.47	7.26	1.2	7,673	13,811
				2		38.54	54.64	6.82	2.20	5.38	78.73	1.50	5.37		7,851	14,132
				3		41.36	58.64		2.36	5.77	84.49	1.61	5.77		8,426	15,167
Same (left rib, 21 room, 5 left butt entry, 8 south entry, main entry, 75 feet from face).	326	28144	A	1	2.35	36.95	54.49	6.21	.80					1.1	7,685	13,833
				2		37.84	55.80	6.36	.82						7,870	14,166
				3		40.41	59.59		.88						8,404	15,127

Worthington, 4 miles north of; Consolidation No. 86 mine, Pittsburgh bed (near 2 face of east main entry, inby first turned face entry).	327	28535	A	1	2.25	38.02	53.59	6.14	.85	......	......	......	......	.9	7,674	13,818
Same (junction of 4 and 5 west main airways)	327	28536	A	1	2.73	36.92	54.34	6.01	.85	......	......	......	......	1.6	7,621	13,718
Same (1 south face, main west heading)	327	28537	A	1	3.32	37.14	53.27	6.27	.67	......	......	......	......	2.1	7,554	13,597
Same (2 face of north faces, east main entries, inby 2 pair of butts).	327	28538	A	1	2.63	37.30	54.57	5.50	.73	......	......	......	......	1.4	7,675	13,815
Same (composite of samples 28535 to 28538)	327	28539	A	1	2.77	37.04	54.18	6.01	.79	5.61	76.19	1.55	9.85	1.5	7,626	13,727
				2	......	38.10	55.72	6.18	.81	5.45	78.36	1.59	7.61	......	7,843	14,117
				3	......	40.61	59.39	......	.86	5.81	83.52	1.69	8.12	......	8,360	15,048
MARSHALL COUNTY.																
Benwood, 1 mile south of; Hitchman mine, Pittsburgh (No. 8) bed (face of 14 north entry, 50 feet inby 8 east entry).	328	25606	A	1	3.46	41.17	47.36	8.01	4.53	......	......	......	......	1.7	7,285	13,113
Same (face of 9 west entry, 14 south entry, 12 feet from 14 south entry).	328	25607	A	1	3.54	40.84	47.72	7.90	3.85	......	......	......	......	1.8	7,373	13,271
Same (face of 16 south entry, 30 feet from 2 main entry)	328	25608	A	1	3.08	41.86	47.22	7.84	4.54	......	......	......	......	1.4	7,324	13,183
Same (face of 4 room, 18 west entry, 12 south entry)	328	25609	A	1	3.03	42.41	46.40	8.16	4.54	......	......	......	......	1.5	7,302	13,144
Same (rib of 1 room, 1 east entry, 14 north entry)	328	25610	A	1	2.91	40.38	48.17	8.54	4.99	......	......	......	......	1.2	7,258	13,064
Same (composite of samples 25606 to 25610)	328	25611	A	1	3.16	41.61	47.28	7.95	4.48	5.27	71.65	1.08	9.57	1.5	7,311	13,160
				2	......	42.97	48.82	8.21	4.63	5.08	73.99	1.12	6.97	......	7,549	13,588
				3	......	46.81	53.19	......	5.04	5.53	80.60	1.22	7.61	......	8,224	14,803
MERCER COUNTY.																
Coaldale, ½ mile west of; Coaldale mine, Pocahontas No. 3 bed (face of Statley entry, 7 left entry).	329	W67890	A	1	2.40	19.00	74.10	4.50	.73	......	......	......	......	......	8,204	14,767
Same (face of Keystone entry, 7 left entry)	329	W67897	A	1	1.60	20.00	74.70	3.70	.74	......	......	......	......	......	8,309	14,956
Same (face of 5 entry, main entry)	329	W67905	A	1	2.10	19.30	74.90	3.70	.59	......	......	......	......	......	8,319	14,974
Same (composite of samples W67890, W67897, and W67905)	329	29923	A	1	2.03	20.29	73.73	3.95	.76	4.73	84.85	1.12	4.59	......	8,230	14,814
				2	......	20.71	75.26	4.03	.78	4.59	86.61	1.14	2.85	......	8,401	15,122
				3	......	21.58	78.42	......	.81	4.78	90.25	1.19	2.97	......	8,754	15,757
Sample (tipple samples of run-of-mine coal being loaded)	329	W70271 W70272 W70273 W70274	C	1	2.78	19.33	71.64	6.25	.62	......	......	......	......	......	7,940	14,291
				2	......	19.88	73.69	6.43	.64	......	......	......	......	......	8,167	14,700
				3	......	21.25	78.75	......	.68	......	......	......	......	......	8,728	15,710
Crystal, 1 mile north of; Crystal No. 1 mine, Pocahontas No. 3 bed (face of 2 room, 3 cross entry, left entry).	329	W67984	A	1	2.20	17.90	75.30	4.60	.59	......	......	......	......	......	8,156	14,681
Same (face of 14 room, 1 right entry)	329	W67986	A	1	2.40	18.30	75.90	3.40	.49	......	......	......	......	......	8,268	14,882
Same (on chain pillar, 20 room, haulway, 1 cross entry)	329	W67988	A	1	1.50	18.20	75.30	5.00	.54	......	......	......	......	......	8,184	14,731
Same (composite of samples W67984, W67986, and W67988)	329	29920	A	1	2.03	19.13	74.30	4.54	.57	4.56	84.96	1.12	4.25	......	8,183	14,729
				2	......	19.53	75.84	4.63	.58	4.42	86.72	1.14	2.51	......	8,353	15,035
				3	......	20.48	79.52	......	.61	4.63	90.93	1.20	2.63	......	8,758	15,764
Same (car sample of picked egg coal)	329	29653	C	1	2.22	16.23	71.27	10.28	.59	......	......	......	......	1.8	7,613	13,703
				2	......	16.60	72.89	10.51	.60	......	......	......	......	......	7,786	14,015
				3	......	18.55	81.45	......	.67	......	......	......	......	......	8,700	15,660

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[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MERCER COUNTY—continued.																
Crystal, 1½ miles from; Crystal No. 2 mine, Pocahontas No. 3 bed (face of 34 room, 6 entry).	330	W68014	A	1	3.30	17.50	74.80	4.40	0.68	......	......	......	......	......	8,111	14,600
Same (in split on 1 pillar, 7 entry)	330	W68015	A	1	2.50	17.60	75.70	4.20	.59	......	......	......	......	......	8,206	14,771
Same (face of 25 room, 6 entry)	330	W68017	A	1	2.70	18.00	74.90	4.40	.63	......	......	......	......	......	8,166	14,699
Same (composite of samples W68014, W68015, and W68017)	330	29975	A	1	2.83	18.23	74.49	4.45	.82	4.56	84.12	1.08	4.97	......	8,142	14,656
				2	......	18.76	76.66	4.58	.84	4.37	86.57	1.11	2.53	......	8,379	15,082
				3	......	19.66	80.34	......	.88	4.58	90.73	1.16	2.65	......	8,781	15,806
Same (car sample of picked run-of-mine coal)	330	29655	C	1	2.59	17.10	68.60	11.71	.77	......	......	......	......	2.2	7,469	13,444
				2	......	17.55	70.43	12.02	.79	......	......	......	......	......	7,668	13,802
				3	......	19.95	80.05	......	.90	......	......	......	......	......	8,715	15,687
McComas, ½ mile from; Sagamore No. 1 mine, Pocahontas No. 3 bed (face of crooked entries, 15 feet from face).	331	W67911	A	1	2.50	18.10	75.10	4.30	.49	......	......	......	......	......	8,187	14,737
Same (at breakthrough, 10 feet from face of 2 angle entry)	331	W67928	A	1	2.10	17.60	76.10	4.20	.54	......	......	......	......	......	8,198	14,756
Same (face of left rib, 5 entry)	331	W67952	A	1	3.70	18.30	73.50	4.50	.43	......	......	......	......	......	8,040	14,472
Same (composite of samples W67911, W67928, and W67952)	331	29985	A	1	2.77	18.86	74.14	4.23	.53	4.55	84.71	1.15	4.83	......	8,158	14,684
				2	......	19.40	76.25	4.35	.55	4.36	87.12	1.18	2.44	......	8,390	15,102
				3	......	20.28	79.72	......	.58	4.56	91.08	1.23	2.55	......	8,772	15,790
Sagamore No. 2 mine, Pocahontas No. 3 bed (in last breakthrough, F-6 heading).	331	W68012	A	1	2.20	18.70	75.30	3.80	.44	......	......	......	......	......	8,250	14,850
Same (neck of 8 room, H-9 entry)	331	W68013	A	1	2.70	18.00	75.40	3.90	.39	......	......	......	......	......	8,189	14,740
Same (face of 20 room, G-8 entry)	331	W68016	A	1	2.20	18.50	75.70	3.60	.44	......	......	......	......	......	8,246	14,843
Same (composite of samples W68012, W68013, and W68016)	331	29986	A	1	2.37	18.79	74.94	3.90	.56	4.64	84.84	1.14	4.92	......	8,205	14,769
				2	......	19.25	76.76	3.99	.57	4.49	86.90	1.17	2.88	......	8,404	15,127
				3	......	20.05	79.95	......	.59	4.68	90.52	1.22	2.99	......	8,754	15,757
Same (car samples of loaded coal from Sagamore Nos. 1 and 2 mines.	331	W69016, W69017	C	1	4.85	17.41	71.27	6.47	.52	......	......	......	......	......	7,700	13,859
				2	......	18.30	74.90	6.80	.55	......	......	......	......	......	8,092	14,565
				3	......	19.64	80.36	......	.59	......	......	......	......	......	8,682	15,628
Thomas No. 1 mine, Pocahontas No. 3 bed (on 13 pillar, 22 entry)	332	W67906	A	1	2.30	17.90	73.80	6.00	.54	......	......	......	......	......	8,053	14,495
Same (face of pinnacle heading)	332	W67907	A	1	2.40	17.40	75.60	4.60	.54	......	......	......	......	......	8,128	14,630

Same (face of 11 room, 2 entry, 20 heading)	332	W67908	A	1	2.40	16.70	76.20	4.70	.54	......	......	......	......	......	8,140	14,652
Same (face of 3 room, 18 heading, 22 main entry)	332	W67912	A	1	2.10	16.80	77.10	4.00	.49	......	......	......	......	......	8,226	14,807
Same (on 7 pillar, 16 heading, 2 main entry)	332	W67914	A	1	2.30	16.20	74.90	6.60	.54	......	......	......	......	......	7,973	14,351
Same (composite of samples W67906 to W67908, W67912, and W67914).	332	29916	A	1	2.30	18.36	73.81	5.53	.53	4.45	84.10	1.11	4.28	......	8,077	14,539
				2	......	18.79	75.55	5.66	.54	4.29	86.08	1.14	2.29	......	8,267	14,881
				3	......	19.92	80.08	......	.57	4.55	91.24	1.21	2.43	......	8,763	15,775
Same (car sample of screened run-of-mine coal)	332	29657	C	1	2.40	16.38	70.11	11.11	.62	......	......	......	......	2.1	7,525	13,545
				2	......	16.78	71.84	11.38	.64	......	......	......	......	......	7,710	13,878
				3	......	18.93	81.07	......	.72	......	......	......	......	......	8,700	15,660
Matoaka, 2 miles west of; Thomas No. 2 mine, Pocahontas No. 3 bed (face of E entry, B entry).	333	W67909	A	1	2.40	17.20	75.90	4.50	.54	......	......	......	......	......	8,115	14,607
Same (face of 4 heading)	333	W67913	A	1	1.80	17.60	75.90	4.70	.54	......	......	......	......	......	8,154	14,677
Same (on rib of A heading)	333	W67963	A	1	2.20	18.00	74.40	5.40	.49	......	......	......	......	......	8,096	14,573
Same (face of D entry, B entry)	333	W67968	A	1	3.50	17.50	74.30	4.70	.48	......	......	......	......	......	8,025	14,445
Same (composite of samples W67909, W67913, W67963, and W67968).	333	29983	A	1	2.48	17.82	74.75	4.95	.58	4.49	83.83	1.10	5.05	......	8,093	14,567
				2	......	18.27	76.65	5.08	.59	4.32	85.96	1.13	2.92	......	8,299	14,938
				3	......	19.25	80.75	......	.62	4.55	90.56	1.19	3.08	......	8,743	15,737
Same (car sample of loaded coal)	333	29659	C	1	3.15	16.11	65.70	15.04	.50	......	......	......	......	2.9	7,104	12,787
				2	......	16.63	67.84	15.53	.52	......	......	......	......	——	7,335	13,203
				3	......	19.69	80.31	......	.62	......	......	......	......	——	8,684	15,631
Simmons, 2 miles northwest of; Booth-Bowen mine, Pocahontas No. 3 bed (face of 10 room, northwest cross air course).	334	W67895	A	1	2.20	18.80	75.00	4.00	.49	......	......	......	......	......	8,233	14,819
Same (in new drift section, room pillar)	334	W67930	A	1	3.00	18.50	73.80	4.70	.68	......	......	......	......	......	8,147	14,665
Same (in Klondike section, 16 room)	334	W67932	A	1	2.70	17.70	75.40	4.20	.54	......	......	......	......	......	8,178	14,720
Same (composite of samples W67895, W67930, and W67932)	234	29910	A	1	2.63	19.13	73.92	4.32	.59	4.63	84.24	1.08	5.14	......	8,113	14,603
				2	......	19.65	75.91	4.44	.61	4.46	86.52	1.11	2.86	......	8,332	14,998
				3	......	20.56	79.44	......	.64	4.67	90.54	1.16	2.99	......	8,719	15,694
Same (car samples from 10 loaded cars)	334	W69018, W69019	C	1	3.25	17.90	70.92	7.93	.53	......	......	......	......	......	7,700	13,859
				2	......	18.50	73.30	8.20	.55	......	......	......	......	......	7,958	14,325
				3	......	20.15	79.85	......	.60	......	......	......	......	......	8,670	15,605
2 miles northwest of; Buckeye No. 1 mine, Pocahontas No. 3 bed (pillar of 3 room, to right of north entry).	334	26712	A	1	3.07	19.04	74.33	3.56	.55	......	......	......	......	2.3	8,212	14,782
Same (pillar of 9 room, to left of Price's entry)	334	26713	A	1	2.16	19.15	74.75	3.94	.53	......	......	......	......	1.5	8,252	14,854
Same (face of 4 room, 200 feet from 3 right entry)	334	26714	A	1	3.05	19.48	73.96	3.51	.70	......	......	......	......	2.4	8,198	14,756
Same (pillar of 6 room, 100 feet from Bennett's air course)	334	26715	A	1	2.90	18.66	75.36	3.08	.82	......	......	......	......	2.1	8,252	14,854
Same (on left inby rib of 4 room, 160 feet from 5 cross entry)	334	26716	A	1	3.26	18.78	74.55	3.41	.91	......	......	......	......	2.4	8,217	14,791
Same (face of 8 room, 100 feet from Sinai air course)	334	25717	A	1	3.83	19.95	72.92	3.80	.86	......	......	......	......	2.5	8,169	14,704
Same (composite of samples 26712 to 26717)	334	26718	A	1	2.88	18.82	74.72	3.57	.73	4.60	83.94	1.19	5.97	2.2	8,228	14,810
				2	......	19.39	76.93	3.68	.75	4.41	86.43	1.23	3.50	......	8,472	15,250
				3	......	20.13	79.87	......	.78	4.58	89.73	1.28	3.63	......	8,796	15,833
Same (on chain pillar, face of Simmons entry)	334	W67893	A	1	2.40	18.30	76.00	3.20	.54	......	......	......	......	......	8,295	14,931
Same (face of 6 room, 7 cross entry)	334	W67931	A	1	2.80	18.70	75.60	2.90	.63	......	......	......	......	......	8,266	14,879
Same (on 7 pillar, 1 parting, north entry)	334	W67961	A	1	2.10	18.40	75.70	3.80	.59	......	......	......	......	......	8,253	14,855
Same (composite of samples W67893, W67931, and W67961)	334	29921	A	1	2.43	19.55	74.61	3.41	.67	4.77	85.19	1.20	4.76	......	8,250	14,850
				2	......	20.04	76.47	3.49	.69	4.61	87.31	1.23	2.67	......	8,455	15,219
				3	......	20.77	79.23	......	.71	4.78	90.47	1.27	2.77	......	8,761	15,770

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[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).
[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.
[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
MERCER COUNTY—continued.																
Simmons; Buckeye No. 2 mine, Pocahontas No. 6 bed (face of 12 room, 120 feet from main entry).	334	26707	A	1	3.32	20.22	73.33	3.13	0.84					2.5	8,243	14,837
Same (face of air course)	334	26708	A	1	3.77	19.75	74.30	2.18	.73					3.0	8,308	14,954
Same (on pillar of 7 room, 150 feet from entry)	334	26709	A	1	3.51	20.19	74.30	2.00	.65					2.4	8,371	15,014
Same (on 3 pillar stump, next to 2 room neck)	334	26710	A	1	3.43	19.82	74.89	1.86	.67					2.4	8,355	15,039
Same (composite of samples 26707, 26708, 26709, and 26710)	334	26711	A	1	3.49	20.30	73.82	2.39	.66	4.99	85.19	1.27	5.50	2.6	8,334	15,001
				2		21.03	76.49	2.48	.68	4.77	88.27	1.32	2.48		8,636	15,545
				3		21.56	78.44		.70	4.89	90.51	1.35	2.55		8,855	15,939
Same (face of 1 left main heading, 300 feet from main entry)	334	W67981	A	1	2.60	19.50	74.80	3.10	.78						8,313	14,963
Same (in heading on main entry)	334	W67982	A	1	2.10	19.20	73.80	4.90	.59						8,158	14,684
Same (face of main heading, on cross entry, 500 feet from entry)	334	W67983	A	1	5.20	19.10	73.00	2.70	.66						8,099	14,578
Same (composite of samples W67981 to W67983)	334	29922	A	1	3.30	19.48	73.72	3.50	.72	4.81	84.50	1.24	5.23		8,166	14,699
				2		20.14	76.24	3.62	.74	4.59	87.38	1.28	2.39		8,445	15,201
				3		20.90	79.10		.77	4.76	90.67	1.33	2.47		8,763	15,773
Same (car samples from 6 loaded cars)	334	W69494, W69495	C	1	3.45	18.73	72.85	4.97	.61						7,971	14,347
				2		19.40	75.45	5.15	.63						8,256	14,860
				3		20.45	79.55		.66						8,704	15,667
Springton, 1½ miles northwest of; Modoc No. 1 mine, Pocahontas No. 3 bed (face of 1 right entry, main entry)	337	26702	A	1	3.57	16.92	76.28	3.23	.55					2.2	8,188	14,738
Same (face of 1 main entry)	337	26703	A	1	3.11	17.51	75.62	3.76	.61					2.3	8,211	14,780
Same (face of 5 room, A entry, left entry)	337	26704	A	1	3.60	16.93	75.82	3.65	.54					2.7	8,156	14,681
Same (composite of samples 26702 to 26704)	337	26705	A	1	3.44	17.61	75.34	3.61	.55	4.59	83.86	1.06	6.33	2.4	8,186	14,735
				2		18.24	78.02	3.74	.57	4.36	86.85	1.10	3.38		8,477	15,259
				3		18.95	81.05		.59	4.53	90.23	1.14	3.51		8,807	15,853
Same (on pillar of 3 room, B entry, 200 feet from entry)	337	26706	A	1	3.04	18.06	75.39	3.51	.58					2.4	8,224	14,803
				2		18.63	77.75	3.62	.60						8,482	15,268
				3		19.33	80.67		.62						8,801	15,842
Modoc No. 2 mine, Pocahontas No. 3 bed (face of main entry, 200 feet from north entry).	337	26697	A	1	3.20	17.58	74.97	4.25	.54					2.3	8,128	14,630

Same (face of 8 left entry, 400 feet from main entry)	337	26699	A	1	3.81	17.43	75.85	2.91	.56					2.9	8,225	14,805
Same (face of 5 room, Q entry, 600 feet from entry)	337	26700	A	1	2.87	16.70	76.95	3.48	.57					2.0	8,244	14,839
Same (composite of samples 26697 to 26700)	337	26701	A	1	3.44	16.63	76.37	3.56	.51	4.49	83.82	1.10	6.52	2.6	8,192	14,746
				2		17.22	79.09	3.69	.53	4.26	86.80	1.14	3.58		8,484	15,271
				3		17.88	82.12		.55	4.42	90.12	1.18	3.73		8,809	15,856
Weyanoke; Weyanoke No. 1 mine, Pocahontas No. 3 bed (face of 15 right entry).	338	W67936	A	1	2.60	17.00	76.50	3.90	.54						8,192	14,746
Same (face of 2 room, 18 right cross entry)	338	W67965	A	1	2.00	17.20	76.60	4.20	.59						8,175	14,715
Same (face of 13 left entry)	338	W67966	A	1	2.60	18.40	74.80	4.20	.49						8,146	14,663
Same (composite of samples W67936, W67965, and W67966)	338	29984	A	1	2.40	17.91	75.55	4.14	.61	4.54	84.91	1.16	4.64		8,163	14,693
				2		18.35	77.41	4.24	.62	4.37	87.00	1.19	2.58		8,364	15,055
				3		19.16	80.84		.65	4.56	90.85	1.24	2.70		8,735	15,723
Same (car sample from 9 loaded cars)	338	30233	C	1	3.05	16.65	72.22	8.08	.56	4.44	80.53	1.04	5.35		7,744	13,939
				2		17.17	74.50	8.33	.58	4.23	83.06	1.07	2.73		7,988	14,378
				3		18.73	81.27		.63	4.61	90.61	1.17	2.98		8,714	15,685
MINERAL COUNTY.																
Emoryville, ¾ mile southeast of; Low Volatile mine, Thomas bed (face of main entry).	339	W69072	B	1	2.40	16.10	65.88	15.62	2.54						7,000	12,600
				2		16.50	67.50	16.00	2.60						7,172	12,910
				3		19.64	80.36		3.10						8,539	15,370
Harrison, 2 miles from; Oakmont mine, Thomas bed (face of 11 room, 13 right entry).	339	W69071	B	1	2.40	15.42	71.83	10.35	2.93						7,456	13,420
				2		15.80	73.60	10.60	3.00						7,633	13,740
				3		17.67	82.33		3.36						8,539	15,370
MINGO COUNTY.																
Thacker, 2 miles east of; Thacker No. 3 mine, Thacker bed (face of 3 room, 4 left entry, main entry).	340	17484	B	1	2.19	35.60	55.21	7.00	1.15					.7	7,682	13,828
				2		36.40	56.44	7.16	1.18						7,854	14,137
				3		39.21	60.79		1.27						8,460	15,228
2¼ miles east of; Thacker No. 5 mine, Thacker bed (face of 14 room, 6 right entry, main entry).	340	17485	B	1	2.44	34.94	56.53	6.09	1.01					1.0	7,762	13,972
				2		35.81	57.95	6.24	1.04						7,956	14,321
				3		38.19	61.81		1.11						8,486	15,275
3½ miles east of; Thacker No. 9 mine, Thacker bed (face of main entry).	340	17486	B	1	2.58	34.58	56.51	6.33	.75					1.1	7,683	13,829
				2		35.50	58.00	6.50	.77						7,887	14,197
				3		37.97	62.03		.82						8,435	15,183
Same (face of 7 right entry, main entry)	340	17487	B	1	2.69	33.85	57.43	6.03	.66					1.2	7,733	13,919
				2		34.78	59.02	6.20	.68						7,946	14,303
				3		37.08	62.92		.72						8,471	15,248
Same (composite of samples 17484 to 17487)	340	17488	B	1	2.44	34.37	56.85	6.34	.95	5.23	77.90	1.54	8.04	1.0	7,721	13,898
				2		35.23	58.27	6.50	.97	5.08	79.85	1.58	6.02		7,914	14,245
				3		37.68	62.32		1.04	5.43	85.40	1.69	6.44		8,464	15,235
4 miles southeast of; Thacker No. 11 mine, Thacker bed (face of 1 room, 5 left entry, south entry)	339	17482	B	1	2.74	34.14	58.25	4.87	1.45					1.2	7,805	14,049
				2		35.10	59.89	5.01	1.49						8,025	14,445
				3		36.95	63.05		1.57						8,448	15,206

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[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes [a] (page).	Sample.			Proximate.				Ultimate.					Air-drying loss.	Calorific value.	
		Laboratory No.[b]	Kind.[c]	Condition.[d]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.		Calories.	British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
OHIO COUNTY.																
Elm Grove; Elm Grove No. 1 mine, Pittsburgh bed (at left rib, 50 feet from face of 27 left butt entry).	340	31621	A	1	3.35	41.40	47.42	7.83	3.19	......	......	......	......	1.7	7,330	13,194
Same (on right rib, at face of 21 right butt entry)	340	31622	A	1	2.84	41.67	47.73	7.76	3.68	......	......	......	......	1.3	7,355	13,239
Same (on left rib, at face of main north entry)	340	31623	A	1	3.20	41.45	46.82	8.53	3.92	......	......	......	......	1.6	7,286	13,115
Same (on right rib, 35 feet from face, 27 right butt entry)	340	31624	A	1	2.77	41.00	48.43	7.80	3.55	......	......	......	......	1.3	7,374	13,273
Same (composite of samples 31621 to 31624)	340	31625	A	1	2.99	41.35	47.57	8.09	3.60	5.30	72.83	1.38	8.80	1.5	7,334	13,201
				2	......	42.62	49.04	8.34	3.71	5.12	75.07	1.42	6.34	......	7,560	13,608
				3	......	46.50	53.50	......	4.05	5.59	81.90	1.55	6.91	......	8,248	14,846
PRESTON COUNTY.																
Corinth, ½ mile southwest of; Wills No. 3 mine, Lower Kittanning bed (face of 1 room, 1 right heading).	341	26516	B	1	3.36	23.93	63.48	9.23	3.04	4.87	76.23	1.34	5.29	2.4	7,527	13,549
				2	......	24.76	65.69	9.55	3.15	4.66	78.88	1.39	2.37	......	7,789	14,020
				3	......	27.37	72.63	......	3.48	5.15	87.21	1.54	2.62	......	8,612	15,502
Kempton; Kempton or No. 42 mine; Middle Kittanning bed (face of main heading).	342	26578	B	1	4.09	20.80	69.79	5.32	.79	4.86	80.45	1.32	7.26	3.3	7,915	14,247
				2	......	21.69	72.76	5.55	.82	4.60	83.88	1.38	3.77	......	8,252	14,854
				3	......	22.97	77.03	......	.87	4.87	88.81	1.46	3.99	......	8,737	15,727
RALEIGH COUNTY.																
Affinity; Affinity mine, Beckley bed (face of air course, 1 right entry, 2 north entry).	342	26691	A	1	2.05	18.49	75.42	4.04	.53	......	......	......	......	1.4	8,238	14,828
Same (face of 2 west entry)	342	26692	A	1	2.77	17.14	75.78	4.36	.50	......	......	......	......	2.0	8,125	14,626
Same (face of fan entry)	342	26693	A	1	2.78	16.96	75.76	4.50	.50	......	......	......	......	2.2	8,089	14,560
Same (composite of samples 26691 to 26693)	342	26694	A	1	2.51	17.53	75.71	4.25	.52	4.62	84.85	1.29	4.47	1.9	8,159	14,686
				2	......	17.98	77.66	4.36	.53	4.45	87.03	1.32	2.31	......	8,369	15,064
				3	......	18.80	81.20	......	.55	4.65	91.00	1.38	2.42	......	8,751	15,752
Same (on right inby rib, 2 south entry, about 50 feet outby 3 right entry).	342	26695	A	1	2.71	18.15	75.91	3.23	.57	......	......	......	......	1.6	8,221	14,798
				2	......	18.66	78.02	3.32	.59	......	......	......	......	......	8,450	15,210
				3	......	19.30	80.70	......	.61	......	......	......	......	......	8,740	15,732

Same (face of dip heading, 1 west entry)	342	W68115	A	1	2.70	17.20	76.50	3.60	.49	......	......	......	......	......	8,178	14,720
Same (face of 1 left entry, 1 north entry)	342	W68122	A	1	2.90	16.80	76.50	3.80	.44	......	......	......	......	......	8,119	14,614
Same (pillar in 3 left crosscut, 1 south entry)	342	W68123	A	1	2.10	18.30	74.50	5.10	.78	......	......	......	......	......	8,100	14,580
Same (composite of samples W68115, W68122, and W68123)	342	30169	A	1	2.57	17.15	75.93	4.35	.68	4.57	84.12	1.45	4.83	......	8,101	14,582
				2	......	17.60	77.94	4.46	.70	4.39	86.34	1.49	2.62	......	8,315	14,967
				3	......	18.42	81.58	......	.73	4.60	90.37	1.56	2.74	......	8,703	15,665
Same (car samples of run-of-mine coal from 8 loaded cars)	342	W69148, W69149	C	1	2.90	16.51	72.72	7.87	.71	......	......	......	......	......	7,720	13,895
				2	......	17.00	74.90	8.10	.73	......	......	......	......	......	7,950	14,310
				3	......	18.50	81.50	......	.79	......	......	......	......	......	8,651	15,571
Big Stick; Big Stick mine, Beckley bed (on rib of 10 room, 4 left entry, 200 feet from entry).	344	26683	A	1	2.42	16.94	76.12	4.52	.75	......	......	......	......	1.8	8,126	14,627
Same (face of 16 room, 2 right entry, 300 feet from entry)	344	26684	A	1	2.39	17.45	75.98	4.18	.53	......	......	......	......	1.7	8,190	14,742
Same (face of 3 right entry, 3 main entry)	344	26685	A	1	2.62	16.73	76.82	3.83	.52	......	......	......	......	1.9	8,185	14,733
Same (300 feet from face of 1 main entry)	344	26686	A	1	3.23	17.72	75.73	3.32	.51	......	......	......	......	2.3	8,166	14,699
Same (composite of samples 26683 to 26686)	344	26687	A	1	2.68	17.17	76.18	3.97	.59	4.61	84.65	1.51	4.67	1.9	8,181	14,726
				2	......	17.64	78.28	4.08	.61	4.43	86.98	1.55	2.35	......	8,406	15,131
				3	......	18.39	81.61	......	.64	4.62	90.68	1.62	2.44	......	8,763	15,773
Same (pillar of slant entry, 9 room, 4 right entry)	344	26688	A	1	2.45	17.46	76.11	3.98	.52	......	......	......	......	1.6	8,207	14,773
Same (pillar of straight entry, opposite 7 room)	344	26689	A	1	2.73	17.77	75.47	4.03	.63	......	......	......	......	1.8	8,160	14,688
Same (composite of samples 26688 and 26689)	344	26690	A	1	2.45	17.54	76.03	3.98	.57	4.67	85.20	1.50	4.08	1.7	8,196	14,753
				2	......	17.98	77.94	4.08	.58	4.51	87.34	1.54	1.95	......	8,402	15,124
				3	......	18.74	81.26	......	.60	4.70	91.05	1.61	2.04	......	8,759	15,766
Same (face of 2 right entry, 3 left entry, 3 main entry)	344	W68118	A	1	1.80	16.80	76.00	5.40	.49	......	......	......	......	......	8,079	14,542
Same (face of 3 right entry, 1 right air course, 3 main entry)	344	W68134	A	1	2.20	16.00	78.10	3.70	.49	......	......	......	......	......	8,206	14,771
Same (face of 8 right entry, 1 crosscut, 1 main entry)	344	W68135	A	1	1.80	17.40	76.50	4.30	.59	......	......	......	......	......	8,162	14,692
Same (composite of samples W68118, W68134, and W68135)	344	30167	A	1	1.93	17.05	76.16	4.86	.61	4.45	84.29	1.60	4.19	......	8,119	14,614
				2	......	17.39	77.65	4.96	.62	4.32	85.95	1.63	2.52	......	8,279	14,902
				3	......	18.30	81.70	......	.65	4.55	90.44	1.72	2.64	......	8,711	15,680
Same (car samples of run-of-mine coal from 8 loaded cars)	344	W68806, W68807	C	1	2.40	15.66	74.77	7.17	.52	......	......	......	......	......	7,890	14,201
				2	......	16.05	76.60	7.35	.53	......	......	......	......	......	8,083	14,550
				3	......	17.32	82.68	......	.57	......	......	......	......	......	8,725	15,704
Mistletoe; Lynwin mine, Beckley bed (face of 6 room, 2 left entry)	345	W68136	A	1	2.40	17.00	75.20	5.40	.49	......	......	......	......	......	8,055	14,499
Same (face of main heading, 7 right entry)	345	W68137	A	1	3.70	17.90	75.70	2.70	.53	......	......	......	......	......	8,029	14,452
Same (composite of samples W68136 and W68137)	345	30148	A	1	3.10	16.88	75.92	4.10	.59	4.56	83.46	1.42	5.87	......	8,013	14,423
				2	......	17.42	78.35	4.23	.61	4.36	86.13	1.47	3.20	......	8,269	14,884
				3	......	18.19	81.81	......	.64	4.55	89.94	1.53	3.34	......	8,634	15,541
Same (tipple samples of run-of-mine coal being loaded)	345	W70283, W70284, W70285, W70286	C	1	1.78	16.99	70.13	11.10	.63	......	......	......	......	......	7,547	13,584
				2	......	17.30	71.40	11.30	.64	......	......	......	......	......	7,683	13,830
				3	......	19.50	80.50	......	.72	......	......	......	......	......	8,662	15,592

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes a (page).	Sample. Laboratory No.b	Sample. Kind.c	Sample. Condition.d	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
RALEIGH COUNTY—continued.																
Oswald; Oswald No. 3 mine, Sewell bed (face of 5 room, 2 south entry, 1 right entry).	346	W68165	A	1	2.70	21.20	72.20	3.90	0.63	......	......	......	......	......	8,122	14,620
Same (21 pillar, straight entry, 7 entry)	346	W68169	A	1	2.50	21.90	70.60	5.00	.93	......	......	......	......	......	8,024	14,443
Same (face of 2 right entry, 4 south entry)	346	W68170	A	1	2.90	21.10	74.00	3.00	.78	......	......	......	......	......	8,275	14,895
Same (composite of samples W68165, W68169, and W68170)	346	30156	A	1	2.70	21.39	72.01	3.90	.93	4.80	83.34	1.63	5.40	......	8,125	14,625
				2	......	21.98	74.01	4.01	.96	4.62	85.65	1.68	3.08	......	8,350	15,030
				3	......	22.90	77.10	......	1.00	4.81	89.23	1.75	3.21	......	8,699	15,658
Same (car samples of run-of-mine coal from 8 loaded cars)	346	{W69099 W69100}	C	1	2.80	21.87	70.18	5.15	.56	......	......	......	......	......	7,946	14,303
				2	......	22.50	72.20	5.30	.58	......	......	......	......	......	8,175	14,715
				3	......	23.76	76.24	......	.61	......	......	......	......	......	8,633	15,539
Slab Fork; Slab Fork No. 2 mine, Beckley bed (face of 22 right entry, 150 feet from main entry).	346	W68154	A	1	2.40	17.30	76.70	3.60	.44	......	......	......	......	......	8,214	14,785
Same (face of 9 room, 21 left entry)	346	W68156	A	1	2.70	18.40	74.80	4.10	.44	......	......	......	......	......	8,202	14,764
Same (face of 11 room, 19 left entry)	346	W68161	A	1	1.80	18.60	76.00	3.60	.49	......	......	......	......	......	8,233	14,819
Same (composite of samples W68154, W68156, and W68161)	346	30175	A	1	2.30	18.57	75.03	4.10	.54	4.64	84.48	1.53	4.71	......	8,152	14,674
				2	......	19.01	76.79	4.20	.55	4.48	86.47	1.57	2.73	......	8,344	15,019
				3	......	19.84	80.16	......	.57	4.68	90.26	1.64	2.85	......	8,709	15,676
Slab Fork No. 3 mine, Beckley bed (face of main air course, 10 right entry).	346	W68155	A	1	2.80	17.70	77.20	2.30	.44	......	......	......	......	......	8,321	14,978
Same (face of 3 room, 5 right entry, left panel)	346	W68157	A	1	2.50	16.70	73.20	7.60	.49	......	......	......	......	......	7,856	14,141
Same (face of 19 room, A entry)	346	W68160	A	1	2.80	17.40	76.70	3.10	.49	......	......	......	......	......	8,159	14,686
Same (face of 13 room, D entry)	346	W68184	A	1	2.40	20.70	73.30	3.60	.68	......	......	......	......	......	8,240	14,832
Same (composite of samples W68155, W68157, W68160, and W68184).	346	30176	A	1	2.83	17.75	75.00	4.42	.55	4.62	83.60	1.54	5.27	......	8,083	14,549
				2	......	18.27	77.18	4.55	.57	4.44	86.03	1.58	2.83	......	8,318	14,972
				3	......	19.14	80.86	......	.60	4.65	90.13	1.66	2.96	......	8,715	15,687
Same (face of main air course, 10 right entry; bony coal)	346	W68158	A	1	1.70	15.10	60.50	22.70	.34	......	......	......	......	......	6,422	11,560
Same (face of 19 room, A entry; bony coal)	346	W68159	A	1	1.10	14.40	61.80	22.70	.35	......	......	......	......	......	6,524	11,743

Same (composite of samples W68158 and W68159)	346	30177	A	1	1.40	14.49	61.48	22.63	.36	3.63	67.72	1.03	[illegible]	......	[illegible]	[illegible]
				2	......	14.70	62.35	22.95	.37	3.52	68.68	1.04	3.44	......	6,556	11,801
				3	......	19.08	80.92	......	.48	4.57	89.14	1.35	4.46	......	8,509	15,316
Slab Fork No. 5 mine, Beckley bed (extension of 22 left entry, 1 right entry, 21 left entry).	346	W68150	A	1	2.40	17.80	76.30	3.50	.59	......	......	......	......	......	8,233	14,819
Same (face of 6 room, 19 left entry)	346	W68151	A	1	2.90	17.70	76.00	3.40	.44	......	......	......	......	......	8,188	14,738
Same (9 room, dip workings, 19 right entry, dip entry)	346	W68152	A	1	2.60	17.20	76.10	4.10	.44	......	......	......	......	......	8,170	14,706
Same (composite of samples W68150 to W68152)	346	30178	A	1	2.60	17.40	76.32	3.68	.53	4.64	84.51	1.51	5.13	......	8,154	14,677
				2	......	17.86	78.36	3.78	.54	4.47	86.77	1.55	2.89	......	8,372	15,070
				3	......	18.56	81.44	......	.56	4.65	90.18	1.61	3.00	......	8,701	15,662
Same (car samples of run-of-mine coal from 8 loaded cars)	346	W68808 W68809	C	1	3.15	16.90	73.90	6.05	.46	......	......	......	......	......	7,856	14,140
				2	......	17.45	76.30	6.25	.48	......	......	......	......	......	8,111	14,600
				3	......	18.61	81.39	......	.51	......	......	......	......	......	8,652	15,573
Tams, ½ mile east of; Tams Nos. 1, 3, and 4 mines, Beckley bed (face of 6 right entry, 1,500 feet south of entry mouth, No. 1 mine).	348	W68086	A	1	2.00	16.90	75.00	6.10	.49	......	......	......	......	......	7,977	14,359
Same (face of air course, No. 3 mine)	348	W68084	A	1	2.60	17.20	76.80	3.40	.44	......	......	......	......	......	8,204	14,767
Same (face of main entry, No. 4 mine)	348	W68080	A	1	3.40	17.00	75.40	4.20	.68	......	......	......	......	......	8,069	14,524
Same (composite of samples W68086, W68084, and W68080)	348	29973	A	1	2.67	17.00	75.65	4.68	.55	4.55	84.11	1.50	4.61	......	8,091	14,564
				2	......	17.47	77.72	4.81	.57	4.37	86.42	1.54	2.29	......	8,313	14,963
				3	......	18.35	81.65	......	.60	4.59	90.78	1.62	2.41	......	8,733	15,719
Same (car samples of run-of-mine coal from 8 loaded cars)	348	W68804 W68805	C	1	2.85	16.71	73.88	6.56	.66	......	......	......	......	......	7,880	14,184
				2	......	17.20	76.05	6.75	.68	......	......	......	......	......	8,111	14,600
				3	......	18.45	81.55	......	.73	......	......	......	......	......	8,698	15,657
Tamroy; Tamroy mine, Sewell bed (face of 5 west entry)	349	W68166	A	1	4.00	21.30	73.00	1.70	.48	......	......	......	......	......	8,218	14,792
Same (face of 3 heading)	349	W68167	A	1	3.60	20.10	74.50	1.80	.48	......	......	......	......	......	8,243	14,837
Same (face of 3 room, 4 south entry)	349	W68168	A	1	2.80	21.80	73.30	2.10	.49	......	......	......	......	......	8,328	14,990
Same (composite of samples W68166 to W68168)	349	30159	A	1	3.47	21.43	73.05	2.05	.55	4.94	84.75	1.60	6.11	......	8,225	14,805
				2	......	22.20	75.68	2.12	.57	4.71	87.80	1.67	3.13	......	8,521	15,338
				3	......	22.68	77.32	......	.58	4.81	89.71	1.71	3.19	......	8,707	15,671
Same (car samples of run-of-mine coal from 8 loaded cars)	349	W68843 W68844	C	1	3.05	20.60	71.02	5.33	.58	......	......	......	......	......	7,958	14,324
				2	......	21.25	73.25	5.50	.60	......	......	......	......	......	8,208	14,775
				3	......	22.49	77.51	......	.63	......	......	......	......	......	8,686	15,635
Wood Bay, ½ mile south of; MacAlpin 1 and 3 mines, Beckley bed (face of 7 room, 8 panel, 3 right entry).	350	W68259	A	1	2.10	17.70	78.00	2.20	.49	......	......	......	......	......	8,335	15,003
Same (face of 16 room, 5 panel, 3 right entry)	350	W68260	A	1	2.20	17.20	77.60	3.00	.78	......	......	......	......	......	8,282	14,908
Same (composite of samples W68259 and W68260)	350	30154	A	1	2.15	17.50	77.72	2.63	.51	4.59	86.58	1.53	4.16	......	8,356	15,041
				2	......	17.88	79.43	2.69	.52	4.45	88.48	1.56	2.30	......	8,540	15,372
				3	......	18.37	81.63	......	.53	4.57	90.92	1.60	2.38	......	8,776	15,797
Same (car samples of run-of-mine coal from 8 loaded cars)	350	W68810 W68811	C	1	3.50	16.79	73.53	6.18	.53	......	......	......	......	......	7,811	14,060
				2	......	17.40	76.20	6.40	.55	......	......	......	......	......	8,095	14,570
				3	......	18.59	81.41	......	.59	......	......	......	......	......	8,648	15,566

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

Table of chemical analyses—Continued.

Locality, bed, etc.	Mine notes[a] (page).	Sample. Laboratory No.[b]	Sample. Kind.[c]	Sample. Condition.[d]	Proximate. Moisture.	Proximate. Volatile matter.	Proximate. Fixed carbon.	Proximate. Ash.	Ultimate. Sulphur.	Ultimate. Hydrogen.	Ultimate. Carbon.	Ultimate. Nitrogen.	Ultimate. Oxygen.	Air-drying loss.	Calorific value. Calories.	Calorific value. British thermal units.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WEST VIRGINIA—Continued.																
RANDOLPH COUNTY.																
Lanesville; outcrop mine, Red Creek bed (face of outcrop faced back 3 or 4 feet).	351	W69067	B	1	6.50	17.20	64.61	11.69	2.76	......	......	......	......	......	7,006	12,610
				2	......	18.40	69.10	12.50	2.95	......	......	......	......	......	7,489	13,480
				3	......	21.03	78.97	......	3.37	......	......	......	......	......	8,561	15,410
WYOMING COUNTY.																
Alpoca, 1½ miles from; Alpha mine, Beckley bed (face of 22 room, main entry, 40 feet from face).	351	W68147	A	1	2.20	18.70	74.70	4.40	.98	......	......	......	......	......	8,172	14,710
Same (50 feet from face of cross-entry heading)	351	W68149	A	1	2.40	17.80	75.20	4.60	1.02	......	......	......	......	......	8,169	14,704
Same (face of 36 room, main entry, 10 feet from face)	351	W68162	A	1	2.30	18.20	75.40	4.10	1.27	......	......	......	......	......	8,179	14,722
Same (pillar in 5 room, 3 air course)	351	W68163	A	1	2.00	18.50	75.20	4.30	.83	......	......	......	......	......	8,182	14,728
Same (composite of samples W68147, W68149, W68162, and W68163).	351	30166	A	1	2.23	18.66	74.76	4.35	1.25	4.58	83.93	1.38	4.51	......	8,146	14,663
				2	......	19.09	76.46	4.45	1.28	4.43	85.84	1.41	2.59	......	8,332	14,998
				3	......	19.98	80.02	......	1.34	4.64	89.84	1.48	2.70	......	8,720	15,696
Same (car samples of run-of mine coal from 8 loaded cars)	351	W68841, W68842	C	1	3.25	18.00	73.24	5.51	1.02	......	......	......	......	......	7,961	14,329
				2	......	18.60	75.70	5.70	1.05	......	......	......	......	......	8,228	14,810
				3	......	19.72	80.28	......	1.11	......	......	......	......	......	8,725	15,705
WYOMING.																
LINCOLN COUNTY.																
Elkol, 6 miles southwest of Kemmerer; Elkol mine, Elkol bed (face of 6 room, 1 south entry).	352	*30735	A	1	20.98	35.09	40.75	3.18	.59	6.22	57.09	.90	32.02	7.3	5,498	9,896
				2	......	44.41	51.57	4.02	.75	4.92	72.25	1.14	16.92	......	6,958	12,524
				3	......	46.27	53.73	......	.78	5.13	75.28	1.19	17.62	......	7,250	13,050
Same (face of 21 room, 3 north entry)	352	*30762	A	1	20.78	35.36	40.62	3.24	.69	6.27	57.83	.90	31.07	6.1	5,602	10,084
				2	......	44.63	51.28	4.09	.87	5.00	73.00	1.14	15.90	......	7,071	12,728
				3	......	46.53	53.47	......	.91	5.21	76.11	1.19	16.58	......	7,372	13,270

Sublet; No. 5 mine, No. 5 or Willow Creek bed (20 feet south of neck of 46 room, 7 north entry).	352	30793	A	1	3.73	38.08	52.53	5.66	1.32	......	......	......	......	1.3	7,338	13,208
Same (15 feet south of neck of 70 room, 6 south entry)	352	30794	A	1	3.43	38.08	52.83	5.66	.78	......	......	......	......	1.1	7,409	13,336
Same (45 feet from main slope, 9 south back entry)	352	30795	A	1	3.80	37.87	52.83	5.50	.79	......	......	......	......	1.5	7,345	13,221
Same (face of 8 south entry, at 11 room)	352	30796	A	1	3.44	40.21	51.13	5.22	1.03	......	......	......	......	1.2	7,428	13,370
Same (composite of samples 30793 to 30796)	352	30797	A	1	3.58	38.43	52.51	5.48	.97	5.28	74.45	1.30	12.52	1.3	7,396	13,313
				2	......	39.86	54.46	5.68	1.01	5.06	77.21	1.35	9.09	......	7,670	13,806
				3	......	42.26	57.74	......	1.07	5.36	81.86	1.43	10.28	......	8,132	14,638

[a] Figures in column 2 refer to page of this bulletin where may be found the description of the section in the mine where the sample was taken.

[b] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all others were analyzed at the Pittsburgh laboratory. An asterisk preceding the laboratory number indicates that the volatile matter was determined by the modified method (see p. 6).

[c] The kind of sample is denoted by letter, as follows: A=mine sample collected by an inspector of the Bureau of Mines; B=mine sample collected by a geologist of the United States Geological Survey, or of a State geological survey; C=car sample taken at the fuel-testing plant or in the field.

[d] The form of analysis is denoted by number, as follows: 1=sample as received; 2=dried at a temperature of 105° C.; 3=moisture and ash free.

DESCRIPTION OF SAMPLES.

ALABAMA.

BIBB COUNTY.

Belle Ellen. Belle Ellen Mine.

Analyses 26276 to 26281 (p. 17). Bituminous coal, Cahaba field, from Belle Ell mine, a slope mine in Belle Ellen, on the Louisville & Nashville and the Southe R. R. Coal bed, Youngblood; Carboniferous age, Pottsville group. Bed is 32 inch thick and is 400 feet below the Woodstock seam, 36 inches thick, which is not work there; dips 0° to 23° west; cleat not well defined; bed disturbed by two faults a frequent rolls or horsebacks; roof, tender shale, varying in thickness from a knife ed to 12 inches; floor, fairly smooth, soft fire clay; cover at points of sampling, 1,000 fe The bed was sampled by E. B. Sutton on October 10, 1916, as described below:

Sections of coal bed in Belle Ellen mine.

Section	A.		B.		C.		D.		E.	
Laboratory No	26276		26277		26278		26279		26280	
Roof, shale and sandstone.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*i*
"Rash"		a 3		a 3		a 4		a 2		a
Coal	3	4	2	9	2	0	2	8		1
"Mother coal"	....		....		....		....			
Coal	....		....		....		....			1
Floor, fire clay.										
Thickness of bed	3	7	3	0	2	4	2	10	2	
Thickness of coal sampled	3	4	2	9	2	0	2	8	1	1

a Not included in sample.

Section A (sample 26276) was cut at face of 19 south heading. Section B (sampl 26277) was cut at face of 22 north heading. Section C (sample 26278) was cut at fac of 2 cross entry, 23 north heading. Section D (sample 26279) was cut at face of 7 room, 18 north heading. Section E (sample 26280) was cut at face of 19 north headin

The ultimate analysis of a composite sample, made by combining face sampl 26276, 26277, 26278, 26279, and 26280, is given under laboratory No. 26281.

System of mining, room and pillar. In 1916 the coal was shot off the solid wit permissible explosives, and only light shots were required. About 500 acres remaine to be mined. The estimated lifetime of the mine was 15 years. The average dail output was 650 tons.

For description and analyses of other samples of this coal, see Bureau of Mine Bull. 22, pp. 33, 331.

JEFFERSON COUNTY.

Bessemer. Virginia Mine.

Analyses 26217 to 26222 (p. 17). Bituminous coal, Warrior field, from Virgini mine, a slope mine 7 miles southwest of Bessemer, on the Louisville & Nashvill R. R. Coal bed, Nickel Plate; Carboniferous age, Pottsville group. Bed is 5 fee thick and is flat; roof, fairly hard shale, 6 to 7 feet thick, capped with sandstone floor, fairly hard, smooth fire clay; no cleat; one fault; rolls and horsebacks commor thickness of cover at points of sampling, 600 feet. The bed was sampled by E. F Sutton on September 25, 1916, as described below:

Sections of coal bed in Virginia mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	26217	26218	26219	26220	26222
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, shale and sandstone.					
Coal	5¼	6	4½	5½	4½
Shale	a 3½	a 2½	a 5	a 2½	a 4½
Coal	2 0	2 1	2 1½	1 8½	2 0½
"Rash"	a 5	a 3¾	a 3¼	a 3	a 2
Shale	a 6½	a 7	a 6	a 7	a 6½
Coal	1 7½	1 8	1 7½	1 7½	1 9½
Floor, fire clay.					
Thickness of bed	5 3¾	5 4¼	5 3¾	4 10	5 0½
Thickness of coal sampled	4 0¾	4 3	4 1½	3 9½	3 11¾

a Not included in sample.

Section A (sample 26217) was cut at face of 1 north heading, about 6,300 feet northwest of pit mouth. Section B (sample 26218) was cut at face of 19 right heading, about 7,400 feet northwest of pit mouth. Section C (sample 26219) was cut at face of 20 right heading, about 6,000 feet northwest of pit mouth. Section D (sample 26220) was cut at face of 17 right heading, about 6,600 feet northwest of pit mouth. Section E (sample 26222) was cut at face of main right heading, about 6,600 feet northwest of pit mouth.

The ultimate analysis of a composite sample made by combining face samples 26217 to 26220 is given under laboratory No. 26221.

System of mining, room and pillar. In 1916 the coal was undercut by hand and shot down with permissible explosives by shot firers, after the miners had left the mine, from 6 to 10 p. m. The charge was fired by battery. All the output was being taken from advance workings, the daily average output being about 1,000 tons. Haulage was by mules and by gasoline motor to the slope-engine rope. All of the coal went to coke ovens.

MAJESTIC. MAJESTIC MINE.

Analyses 32070 to 32074 (p. 18). Bituminous coal, Warrior field, from Majestic mine, a shaft mine at Majestic, on the Louisville & Nashville R. R. Coal bed, Black Creek; Carboniferous age, Pottsville group. Bed is 1 foot 10 inches to 2 feet 10 inches thick; rolls are common; bed contains some irregular, thin streaks of "mother coal"; roof, hard, sandy shale; floor, smooth, mostly soft fine clay; elevation of entrance above sea, 400 feet; cover at points of sampling, 300 feet. The bed was sampled by W. B. Plank on June 4, 1919, as follows:

Sections of coal bed in Majestic mine.

Section	A.	B.	C.	D.
Laboratory No.	32070	32071	32072	32073
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, sandy shale and coal:				
Coal	2 10	2 2	6½	2 2
"Mother coal"	....	....	½	....
Coal	....	....	6	....
"Mother coal"	....	....	½	....
Coal	....	....	9¼	....
Floor, fire clay.				
Thickness of bed	2 10	2 2	1 10¾	2 2
Thickness of coal sampled	2 10	2 2	1 10¾	2 2

Section A (sample 32070) was cut at face of 4 room, 1 cross entry left, 4 right north entry, at a point N. 47° E., 1,850 feet from the hoisting shaft. Section B (sample 32071) was cut at face of main north entry, 5 left, at a point N. 30° E., 2,100 feet from the hoisting shaft. Section C (sample 32072) was cut at face of 4 right south air course, at a point S. 70° W., 1,400 feet from the hoisting shaft. Section D (sample 32073) was cut at room neck, 30 feet outby face of 4 left south entry, at a point S. 25° W., 1,500 feet from the hoisting shaft.

The ultimate analysis of a composite sample made by combining face samples 32070 to 32073 is given under laboratory No. 32074.

System of mining, room and pillar. In 1919 the coal was sheared by hand along rib and shot down with a permissible explosive by the miners at 4 p. m. Men employed numbered 106 underground and 16 above ground. Haulage was by mule and storage-battery locomotive. The tipple was of wood, equipped with bar screens; 80 per cent of the coal passed through screens; the washery had one revolving screen with ½-inch round holes; maximum size washed, under 3 inches; sizes produced by washing, nut and pea, blacksmith ½ inch and less. Average daily tonnage, 200 tons washed. There were two loading tracks, with capacity for 20 empty and 20 loaded railroad cars. The daily capacity of the mine at time of sampling was 1,000 tons, the actual average 275 tons, and the maximum day's run 325 tons. All the coal was taken out in the advance work, and 75 per cent recovery was claimed.

PALOS. BESSIE MINE.

Analyses 26900 to 26903 and 26914 to 26917 (p. 18). Bituminous coal, Warrior field, from Bessie mine, a slope mine 2 miles east of Palos, Ala., on the San Francisco & Southern R. R. Coal bed, Mary Lee; Carboniferous age, Pottsville group. Bed is 8 to 9 feet thick; dips 3° S. E., with cleat in same direction; one fault; no rolls or horsebacks; shale partings; roof, good coal and shale; floor, smooth, hard shale. The bed was sampled by E. B. Sutton on December 4, 1916, as described below.

Sections of coal bed in Bessie mine.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	26902		26901		26900		26916		26915		26914	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, coal:												
Coal	1	7½	1	9	1	9	1	8	1	7	1	9
Shale		[a] 2½		[a] 1		[a] 2		[a] 1		[a] 1½		[a] ¾
Coal		4½		5		4		5½		4		5
Shale	[a] 1	10										
Shale			[a] 1	2	[a] 1	9	[a] 1	6	[a] 1	4	[a] 1	8
Coal	2	6½	2	9½	2	9	2	6½	2	7	2	6
Shale		[a] 1½		[a] 2		[a] 2½		[a] 1½		[a] 1		[a] 1½
Coal		7		9		8		8		7¼		7
Shale		[a] 3		[a] 2		[a] 3		[a] 2		[a] 1¾		[a] 2½
Coal		8		11½		11		10		9½		9½
Floor, shale:												
Thickness of bed	8	2½	8	3	8	9½	8	½	7	7	8	1¼
Thickness of coal sampled	5	9½	6	8	6	5	6	2	5	10¾	6	½

[a] Not included in sample.

Section A (sample 26902) was cut at face of 11–12 room, 18 left entry, 5,800 feet northeast of mine opening; section B (sample 26901) was cut at face of 27–28 room, 14 right entry, 5,000 feet southwest of mine opening, section C (sample 26900) was cut at face of 25–26 room, 15 right entry, 5,700 feet southwest of mine opening; section D (sample 26916) was cut at face of 10 right entry; section E (sample 26915) was cut at face of 28 room, 9 left entry; section F (sample 26914) was cut at face of 2 room, 10 left entry.

The ultimate analyses of composite samples made by combining face samples 26914 to 26916 and samples 26900 to 26902 are given under laboratory Nos. 26917 and 26903, respectively.

System of mining, room and pillar. In 1916, in the advance work, 45 per cent of the coal was taken out. Haulage was by mules and hoisting engine. The coal was cut by machine and shot down by the miners with permissible explosive at any time during the shift. Men employed numbered 250 underground and 30 above ground. The coal was dumped over a wooden tipple; all was crushed, washed, and shipped to coke ovens. In 1916 the mine had a capacity of 2,500 tons a day; the daily average output was 1,800 tons, but was expected to reach 2,500 tons.

SHELBY COUNTY.

ALDRICH. ALDRICH MINE.

Analyses 26730 to 26734 (p. 19). Bituminous coal, Cahaba field, from Aldrich mine, opened by a slope, at Aldrich, on the Southern R. R. Coal bed, Montevallo; Carboniferous age, Pottsville group. Bed is 3 feet 6 inches to 4 feet 6 inches thick; contains rock and "rash" partings. Dip is variable. One fault and a few rolls or horsebacks are encountered. Roof, fairly good sandstone; floor, smooth fire clay. The bed was sampled by E. B. Sutton on October 18 and 19, 1916, as described below:

Sections of coal bed in Aldrich mine.

Section	A.	B.	C.	D.
Laboratory No.	26732	26731	26730	26733
Roof (main), sandstone and shale.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Shale	[a] 1			
"Rash"	[a] 7½	[a] 5	[a] 9½	[a] 8½
Coal	1 7½	2 0	2 5½	2 3
"Rash"	[a] 2	[a] 5½		[a] 1½
"Rash" and shale			[a] 8	
Shale	[a] 2	[a] 3½		[a] 1½
Coal	[a] 5½		2	[a] 1
Shale	[a] 4½			[a] 4
"Rash"		[a] 3		
Coal	4½	4		7½
Floor, fire clay.				
Thickness of bed	3 9½	3 9	4 1	4 3
Thickness of coal sampled	2 0	2 4	2 7½	2 10½

[a] Not included in sample.

Section A (sample 26732) was cut from 1 panel. Section B (sample 26731) was cut from 6 panel. Section C (sample 26730) was cut from 9 panel. Section D (sample 26733) was cut from 2 panel.

The ultimate analysis of a composite sample made by combining samples 26730 to 26733 is shown under laboratory No. 26734.

System of mining, longwall. In 1916, 100 per cent of the coal was mined in the advance work. . Haulage was by three electric locomotives. There was one loading track, with capacity for 15 empty and 30 loaded railroad cars. The coal was cut by machine and shot down with permissible explosive by the miners at any time during the shift; dynamite was used for brushing roof or floor. Men employed numbered 219 underground and 59 aboveground. The coal was dumped over a wooden tipple and screened over shaking screens 5 by 30 feet and 3 by 10 feet, having 2½-inch, 1¼-inch, and ⅝-inch holes, respectively; coal was cleaned by two pickers on the screens and then washed; appearance of lump coal and screenings on cars, very good. The capacity and daily average output of the mine in 1916 was 600 tons. The lifetime of the mine was estimated at 50 years.

For description and other analyses of this coal see Bureau of Mines Bull. 22, pp. 38, 348.

HELENA. EUREKA NO. 2 MINE.

Analyses 25543 to 25546 (p. 19). Bituminous coal, Cahaba field, from Eureka No mine, a slope mine 2½ miles southwest of Helena, on the Atlanta, Birmingham Atlantic R. R. and the Louisville & Nashville R. R. Coal bed, Helena; Carbonifer age, Pottsville group. Bed is about 3½ feet thick; dips 0° to 90°; direction of dip, 57° E. Roof, fairly good shale; floor, shale and sandstone, hard, with smooth surfa The bed was sampled by E. B. Sutton on June 24, 1916, as described below:

Sections of coal bed in Eurkea mine.

Section	A.		B.		C.	
Laboratory No.	25545		25543		25544	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	[illegible]
Coal	2	1	2	2½	3	[illegible]
Shale		a 1¾		a 1	......	
Coal	1	5	1	3	......	
Floor, shale.						
Thickness of bed	3	7¾	3	6½	3	[illegible]
Thickness of coal sampled	3	6	3	5½	3	[illegible]

a Not included in sample.

Section A (sample 25545) was taken from face, 30 room, opposite 8 right cros heading. Section B (sample 25543) was taken from 7 right air course, between room 19 and 20. Section C (sample 25544) was taken from face, 22 room, off 6 left, 3,30 feet northeast of pit mouth.

The ultimate analysis of a composite sample made by combining face sample 25543 to 25545 is given under laboratory No. 25546.

System of mining, room and pillar. In 1916 the coal was shot off the solid. Th vertical depth to landings below entrance is about 1,500 feet. Output was 550 tons day. Forty to 60 per cent of the coal was taken in advance work. The probabl lifetime of the mine was 5 years. In May, 1919, the output of the mine was 250 tons day, all robbing work, retreating. The probable life was estimated to be 3 years.

MAYLENE. MAYLENE MINE.

Analyses 26301 to 26305 (p. 19). Bituminous coal, Cahaba field, from Maylen mine, a slope mine 1½ miles south of Maylene station, on the Southern R. R. Coa bed, Maylene; Carboniferous age, Pottsville group. Bed is 1 foot 6 inches to 2 feet inches thick; dips 18° to basin; roof, shale, from a few inches to 10 feet thick, ove which is sandstone; the shale is easily held up; floor, shale, 3 to 8 inches thick smooth surface; no cleat; one bounding fault and frequent rolls or horsebacks ar encountered. The Upper Maylene bed is only 15 inches thick and is not workable Interval between the Upper Maylene and the Maylene seam is 8 to 16 feet. The bed was sampled by E. B. Sutton on October 11, 1916, as described below:

Sections of coal bed in Maylene mine.

Section	A.		B.		C.		D.	
Laboratory No.	26301		26302		26303		26304	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
"Rash"		a 6½		a 5		a 8½		a 7
Coal	1	11	2	8	2	3	2	4
Shale		a 4½		a 4		a 3		a 3
Coal		a 5	a(?)	5	a(?)	5		a 5
Floor shale.								
Thickness of bed	3	3	3	10	3	7½	3	7
Thickness of coal sampled	1	11	2	8	2	3	2	4

a Not included in sample.

Section A (sample 26301) was cut at face of G heading. Section B (sample 26302) was cut at face of 19 west entry. Section C (sample 26303) was cut at face of 11 room, 15 east heading. Section D (sample 26304) was cut at face of 21 room, 12 west heading.

The ultimate analysis of a composite sample made by combining face samples 26301 to 26304 is given under laboratory No. 26305.

System of mining, longwall; mining is done in the bottom of the seam. In 1916 the coal was undercut by machines in parts of the mine, in the shale band beneath the coal seam and in the band of coal beneath the shale band. All of the coal was taken in advance work; little timbering was required. The coal was shot down with FF black powder. The daily average output at time of sampling was 125 tons. About 1,200 acres remained to be mined from this opening.

For description and other analyses of this coal, see Bureau of Mines Bull. 22, pp. 39, 351.

ALASKA.

ARCTIC COAST.

Analysis 26371 (p. 19). Subbituminous coal from Arctic coast, near Wainright Inlet. Outcrop of a bed, not named; Upper Jurassic (?) age. Data on sampling are not available.

INNOKO DISTRICT.

Analysis 26370 (p. 19). Anthracite, from Tramway, Innoko district. Outcrop of a bed, not named; Upper Cretaceous age, unnamed formation. Data on sampling are not available.

MATANUSKA FIELD.

CHICKALOON RIVER DISTRICT.

CHICKALOON.

Analysis 30265 (p. 19). Washed Chickaloon coal, Matanuska field. The sample was collected by G. W Evans from 120 sacks of washed Chickaloon coal, coked at Wilkenson, Wash., on February 6 to 8, 1918.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 22, pp. 45, 372; Bull. 85, pp. 22, 157; Bull. 123, pp. 24, 149.

EMERY. KELLY MINE.

Analyses 28731 and 28732 (p. 19). Bituminous coal, Matanuska field, from Kelly mine, at Emery, in sec. 16, T. 19 N., R. 3 E. Coal bed, Kelly; Eocene age, Chickaloon formation. Average thickness of bed, 3 feet 1 inch; dips 27° north; roof, shale and bone; floor, shale and carbonaceous shale; cover at points of sampling, 65 to 75 feet. The bed was sampled by G. W. Evans on May 10, 1917, as described below:

Sections of coal bed in Kelly mine.

Section	A.		B.	
Laboratory No.	28731		28732	
	Ft.	*in.*	*Ft.*	*in.*
Roof, shale and bone.				
Coal	2	10	1	0
Shale				½
Coal			2	5
Floor, shale and carbonaceous shale.				
Total thickness of bed	2	10	3	5½
Thickness of coal sampled	2	10	3	5½

Section A (sample 28731) was taken in 1 chute in a drift driven at a point about 85 feet west of the entrance, at an elevation of 955 feet above sea level. This coal bed is the upper bench of Kelly bed. Section B (sample 28732) was taken from 1 chute in a drift driven in lower bench of Kelly bed at a point about 75 feet west of entrance.

Because of faults encountered the mine was practically closed, the pillars being withdrawn. The coal was partly used for steaming purposes on the Government railroad and partly for domestic use at Anchorage. The daily output at time of sampling was 10 tons.

ESKA CREEK DISTRICT.

ESKA. DAVID MINE.

Analyses 28733 (p. 20). Bituminous coal, Matanuska field, from David mine, at Eska, in sec. 16, T. 19 N., R. 3 E., on the Alaskan R. R. Coal bed, David; Eocene age. Chickaloon formation. Bed is 2 feet 7 inches thick; dips 30° north; roof, shale and bone; floor, bone and carbonaceous shale; cover at point of sampling, about 60 feet; elevation above sea level, 955 feet. The bed was sampled by G. W. Evans on May 11, 1917, as described below:

Section of coal bed in David mine.

	Ft.	in.
Roof, shale and bone.		
Bone [a]		2
Coal	1	6
Shale [a]		1
Coal		10
Floor, shale and bone.		
Thickness of bed	2	7
Thickness of coal sampled	2	4

Sample taken from 2 chute, 75 feet from entrance.

System of mining, breast and pillar; coal shot off the solid. The output was used as fuel on the Government railroad and for domestic use at Anchorage. At the time the sample was taken pillars were being withdrawn and the mine was practically abandoned.

ESKA. EMERY MINE.

Analysis 28735 (p. 20). Bituminous coal, Matanuska field, from Emery mine, in sec. 16, T. 19 N., R. 3 E., on the Alaskan R. R. Coal bed, Emory; Eocene age, Chickaloon formation. Bed is 3 feet 10 inches thick; dips 28°; roof, coal and bone; floor, gray shale; cover at point of sampling, 60 feet. The bed was sampled by G. W. Evans on May 11, 1917, as described below:

Section of coal bed in Emory mine.

	Ft.	in.
Roof, coal and bone.		
Coal, with a few nodules	2	0
Coal, with some bone		8
Shale, brown [a]		2
Bone [a]	1	0
Floor, gray shale.		
Thickness of bed	3	10
Thickness of coal sampled	2	8

This sample was taken from 1 chute, 60 feet from entrance.

The bed had been virtually exhausted in the area lying between mine entrance and faults encountered about 300 feet in. The coal was used mainly for steam fuel on the Government railroad and for domestic use at Anchorage.

[a] Not included in sample.

ESKA. ESKA MINE.

Analysis 28734 (p. 20). Bituminous coal, Matanuska field, from Eska mine, located at Eska, in sec. 16, T. 19 N., R. 3 E., on the Alaskan R. R. Coal bed, Eska; Eocene age, Chickaloon formation. Bed is 2 feet 10 inches thick; dips 25°; roof, shale; floor, shale and bone; cover at point of sampling, 20 feet; elevation above sea level, 990 feet. The bed was sampled at 1 chute by G. W. Evans on May 11, 1917, the sample representing 2 feet 10 inches of coal.

At the time of sampling a gangway was driven in 25 feet and one chute turned off. Daily output, 15 tons.

ESKA. MCCAULEY PROSPECT.

Analysis 28836 (p. 20). Bituminous coal, Matanuska field, from McCauley prospect, in sec. 10, T. 19 N., R. 3 E., an outcrop on the hillside about 1¼ miles northeast of present operations at Eska Creek, in the Matanuska coal field, on the Alaskan R. R. Coal bed, McCauley; Eocene age, Chickaloon formation. Bed is 6 feet 8 inches thick; dips 14° southwest; roof and floor concealed; elevation above sea level, about 1,600 feet. The bed was sampled at one point in face of prospect by G. W. Evans on May 16, 1917, the sample representing 9 feet 8 inches.

At the time of sampling no work other than surface prospecting had been done.

ESKA. MAITLAND MINE.

Analyses 28736 and 28737 (p. 20). Bituminous coal, Matanuska field, from Maitland mine, at Eska, in sec. 16, T. 19 N., R. 3 E., on the Alaskan R. R. Coal bed, Maitland; Eocene age, Chickaloon formation. Bed is 2 feet 10 inches thick; dips 4° to 30°; roof, bone and shale; floor, shale; cover at point of sampling, about 50 feet; elevation above sea level, 979 feet. The bed was sampled at one point at the second plane or chute by G. W. Evans on May 10, 1917, the sample representing 2 feet 10 inches of coal. Sample 28737 represents a grab sample taken from the surface of a loaded railroad car.

System of mining, room and plane, but at time of sampling no systematic method had been developed. The coal was shot off the solid. Bed has many rolls, horsebacks, and other disturbances. Men employed numbered 15 underground and 5 above ground. The tipple is of wood. At time of sampling the output was 25 tons a day, 30 per cent of which was from advance workings. Haulage was by man power. There was one loading track, with capacity for four empty and three loaded railroad cars. Appearance of coal on cars was very good. The daily capacity of the mine was 30 tons; entire output was shipped as run of mine for locomotive use on the railway and for domestic use at Anchorage.

UPPER ESKA CREEK. OUTCROP.

Analysis 29362 (p. 20), sample of bituminous coal, Matanuska field. The sample was taken by S. S. Smith on September 6, 1917, from an outcrop on the west bank of the west fork of the middle fork near the north boundary of sec. 9, T. 19 N., R. 3 E.

There were no mine workings or any prospective workings.

MOOSE CREEK DISTRICT.

MOOSE CREEK. DOHERTY MINE.

Analyses 28729 and 28730 (p. 20). Bituminous coal, Matanuska field, from Doherty mine, a slope mine at Moose Creek, on a branch connecting with the Matanuska division of the Government railroad in Alaska. Coal bed, Doherty; Eocene age, Chickaloon formation; bed dips 46°; roof, sandstone; floor, shale. Two samples of this coal were obtained by G. W. Evans on May 12, 1917. Sample 28729 is of screenings through a ½-inch screen, mostly of the friable shale near the floor of this bed. It was collected on the surface at the small cleaning plant. Sample 28730 was taken at interv along the surface of a pile of coal in the bunkers at the end of the tramroad connecti with the Government railroad.

The daily output at time of sampling was 110 tons.

MOOSE CREEK. OUTCROP.

Analysis 28837 (p. 20), sample of bituminous coal, Matanuska field. This samp was taken by S. S. Smith on September 6, 1917, from a bed on east bank of Moo Creek, opposite property of Doherty Coal Co., which is about 3,000 feet up Moose Cre from railroad right of way.

The bed dips 45° south, and ranges between 4 and 5 feet in thickness. The samp represents only 18 to 24 inches of the bed, as the rest was full of bone and dirt. N further information available.

NENANA FIELD.

CALIFORNIA CREEK. OUTCROP.

Analysis 26359 (p. 21). Lignite, Nenana field, from surface outcrop in a bluff o the east bank of California Creek, cut and quartered from partly cleaned weathere face. Coal bed, not named; Tertiary (Eocene) age. The bed was sampled by G. C Martin on July 3, 1916, as described below:

Section near SE. corner of SW. ¼ SW. ¼ sec. 15, T. 9 S., R. 6 W.

	Ft.	in
Roof, not exposed.		
Concealed.[a]		
Coal	6	
Coal[a]	4	
Concealed.[a]		
Floor, not exposed.		
Thickness of bed	10	
Thickness of coal sampled	6	

Much baked clay, probably from burning of large beds, was seen at altitudes o 1,400 to 1,650 feet in the NE. ¼ NW. ¼ and NE. ¼, on both sides of the stream tha enters California Creek from the southeast in the SE. ¼, and at 1,900 feet near th northwest corner of the section.

CALIFORNIA CREEK. OUTCROP.

Analyses 26360 and 26361 (p. 21). Lignite, Nenana field, from cliff on east bank o California Creek, cut and quartered from partly cleaned weathered face. Coal bed, not named; Tertiary age. Bed dips 10° to 15° southeast; strikes north 60° to 70 east. The bed was sampled by G. C. Martin on July 16, 1916, as described below:

Section of cliff on E. side of California Creek in SW. ¼ NE. ¼ sec. 27, T. 10 S., R. 6 W.

Laboratory No. Section.	26360 A.		26361 B.	
Roof, not stated.	Ft.	in.	Ft.	in.
Gravel[a]				
Coal	[a]12	0	12	0
Clay		[a]8		[a]8
Coal	6	6	[a]6	6
Clay	[a]1	6	[a]1	6
Floor, not stated.				
Thickness of bed	20	8	20	8
Thickness of coal sampled	6	6	12	0

[a] Not included in sample.

HEALY CREEK. OUTCROP.

Analysis 26368 (p. 21). Lignite, Nenana field, from outcrop on north bank of Healy Creek, about 1 mile above mouth. Coal bed, not named; Tertiary (Eocene) age. The bed was sampled by G. C. Martin on August 19, 1916, as described below:

Section on N. bank of Healy Creek, 1 mile above mouth.

	Feet.
Roof, not stated.	
Coal	6
Coal [a]	6±
Floor, not stated.	
Thickness of bed	12±
Thickness of coal sampled	6

LIGNITE CREEK. OUTCROP.

Analysis 26362 (p. 21). Lignite, Nenana field, from cliff on north bank of Lignite Creek; represents selection of less weathered pieces throughout the bed. Coal bed, B; Tertiary (Eocene) age. The bed was sampled by G. C. Martin on August 11, 1916, as described below:

Section of N. bank of Lignite Creek in SW. ¼ SE. ¼ sec. 30, T. 11 S., R. 6 W., altitude 1,650 feet.

	Ft.	in.
Roof, not stated.		
Coal	7	0
Clay [a]		6
Coal	12	0
Clay [a]	1	0
Coal	7	0
Floor, not stated.		
Thickness of bed	27	6
Thickness of coal sampled	26	0

LIGNITE CREEK. OUTCROP.

Analysis 26363 (p. 21). Lignite, Nenana field, from west side of Fault Gulch, Lignite Creek (upper thick bed), in the NW. ¼ SE. ¼ sec. 26, T. 11 S., R. 6 W.; selection of least-weathered parts of outcrop. Coal bed, not named; Tertiary (Eocene) age; dips 26° north; strikes, north 80° west. The bed was sampled by G. C. Martin on August 11, 1916. The sample represented 16 feet of coal, the exposed thickness of the bed. Roof and floor not recorded.

LIGNITE CREEK. OUTCROP.

Analysis 26364 (p. 21). Lignite, Nenana field, from gulch tributary to Lignite Creek, from the north ¼ mile northeast of the southwest corner of sec. 26, T. 11 S., R. 6 W., cut from partly cleaned outcrop. Coal bed, not named; Tertiary (Eocene) age. The bed was sampled by G. C. Martin on August 12, 1916. The sample represented 12 feet of coal, the exposed thickness of the bed. Roof and floor not recorded.

LIGNITE CREEK. CLIFF FACE.

Analysis 26365 (p. 21). Lignite, Nenana field, from bank of Lignite Creek 15/100 mile north of southeast corner of section 26, cut from fresh cliff face. Coal bed, not named; Tertiary (Eocene) age. The bed was sampled by G. C. Martin on August 12, 1916. The sample represented 10 feet of coal, which was the exposed thickness of the bed. Roof and floor not recorded.

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[a] Not included in sample.

LIGNITE CREEK. OUTCROP.

Analysis 26366 (p. 21). Lignite, Nenana field, from tributary of Lignite C draining section 27 about 500 feet, in NE. ¼ NW. ¼ sec. 27, T. 11 S., R. 6 W., cut natural exposure. Coal bed, not named; Tertiary (Eocene) age. Dips 15° north strikes north 70° east. The bed was sampled by G. C. Martin on August 8, 1916. sample represented 25 feet of coal, which was the exposed thickness of the bed. and floor not recorded.

LIGNITE CREEK. OUTCROP.

Analysis 26367 (p. 22). Lignite, Nenana field, from bluff on north bank of Lig Creek about 1 mile above mouth, in NE. ¼ NW. ¼ sec. 5, T. 12 S., R. 7 W., cut f least-weathered parts of natural exposure. Coal bed, not named; Tertiary (Eoce age; dips 12° south; strikes north 105° east. The bed was sampled by G. C. Ma on August 18, 1916, as described below:

Section of coal bed in Lignite Creek outcrop.

	F
Roof, not stated.	
Coal [a]	
Coal	
Floor, not stated.	
Thickness of bed	1
Thickness of coal sampled	

LIGNITE CREEK. OUTCROP.

Analysis 26369 (p. 23). Lignite, Nenana field, from outcrop on first large gu from northwest to large stream entering Lignite Creek, in NW. ¼ NW. ¼ sec. 35, T. 11 R. 7 W. Coal bed, not named; Tertiary (Eocene) age. The bed was sampled G. C. Martin on August 20, 1916, as described below:

Section of coal bed in Lignite Creek outcrop.

	Ft.
Roof, not stated.	
Coal	12
Clay [a]	
Coal	6
Clay [a]	
Coal	11
Floor, not stated.	
Thickness of bed	30
Thickness of coal sampled	29

LIGNITE CREEK. PROSPECT.

Analyses 26588 and 26589 (p. 24). Lignite, Nenana field. The samples we taken by G. W. Evans on September 15, 1916, at outcrop of Nos. 5 and 1 coal be on the north side of Lignite Creek, about 6 miles from the point at which this cre empties into Nenana River. Coal beds 5 and 1; Eocene age. Sample 26588 repr sents an 8-foot section cut from No. 5 bed, which is uniform and is 30 feet thic Sample 26589 represents an 8-foot section from No. 1 bed, which is 45 to 50 fe thick. Bed dips 6°; roof, sandstone; floor, clay; height above sea level, about 2,0 feet. No work has been done on these outcrops; they are the result of natural erosio

[a] Not included in sample.

ARKANSAS.

FRANKLIN COUNTY.

ALIX. NO. 2 MINE.

Analyses 69641, 69643, 69644, average of mine-face samples; analysis 69642, average of tipple samples; analysis 69645, of slack through 1½-inch bar screen, and analyses 69640 and 69646, of lump over 1½-inch bar screen (p. 22). Bituminous coal taken from face and from tipple, Arkansas field, of No. 2 mine, a shaft mine 1 mile east of Alix, on the Missouri Pacific R. R. Coal bed, locally known as Denning; Carboniferous (Allegheny) age; Spadra shale. Bed is 4 feet ½ inch to 4 feet 9½ inches thick at sections where face samples were taken; these measurements include middle band; dip, 5 per cent northwest; roof, shale; floor, shale. The bed was sampled by J. F. Davies on June 28, 1918, as described below:

Sections of coal bed in No. 2 mine.

Section	A.		B.		C.	
Laboratory No.	69641		69643		69644	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, shale:						
Coal	1	8¾	1	7½	1	8¼
Muck		a 6¾		4½		
Shale						a 10
Coal	1	5	2	½	2	3¼
"Sulphur"		a ½				
Coal		5¾				
Floor, shale:						
Thickness of bed	4	2¾	4	½	4	9½
Thickness of coal sampled	3	7½	3	8	3	11½

a Not included in sample.

Section A (sample 69641) was cut at 9 room in 3 west plane. Section B (sample 69643) was cut at 3 room in 1 east plane. Section C (sample 69644) was cut at face of 1 east slope.

System of mining, room and pillar. At time of sampling coal was shot down with black blasting powder and no mining machines were used. Men employed numbered 23 underground and 4 on the surface. Coal was dumped from self-dumping cages over wooden tipple and screened over 1½-inch openings in bar screens, producing slack and lump sizes. One picker on railroad cars; miners were said to pick the coal when loading it at the face. Fifty per cent of the coal was mined in advance work, and a total recovery of 60 per cent was claimed. Haulage was by mules. Two loading tracks, with capacity for 20 empty and 16 loaded railroad cars. At time of sampling the coal was shipped principally to Little Rock and Kansas City, Mo., for steaming purposes. Forty to 45 per cent of the coal was shipped as slack through 1½-inch bar screens. The capacity of the mine was 475 tons a day, and average daily output at time of sampling was 80 to 100 tons. The mine was about worked out.

SEBASTIAN COUNTY.

BONANZA. WOODSON BARR OR NO. 135 MINE.

Analyses 69378, 69379, 69397, average of mine-face samples, and analyses 69374 to 69377, average of tipple samples (p. 22). Semianthracite (?) coal taken from face and tipple, Arkansas field, from Woodson Bar or No. 135 mine, a slope mine 3 miles east of Bonanza, on a spur of the St. Louis & San Francisco R. R. Coal bed, Upper Hartshorne; Carboniferous (Allegheny) age, Spadra shale. Bed is 4 feet to 6 feet 6 inches thick; dip, 8 per cent north; roof, shale; floor, hard rock. The bed was sampled by N. H. Snyder and J. F. Davies on June 8, 1918, as described below:

Sections of coal bed in Woodson Barr or No. 135 mine.

Section	A.		B.		C.	
Laboratory No.	69378		69379		6939	
Roof, shale:	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*i*
Coal	1	7½	2	½	2	
"Sulphur"		*a* 1¼				
Coal		7¾				
Shale		*a* 1½		*a* 2		*a*
Coal	1	6¼	1	2¼	1	
Thickness of bed	4	¼	3	4¾	3	1
Thickness of coal sampled	3	9½	3	2¾	3	

a Not included in sample.

Section A (sample 69378) was cut in 51 room, 7 west main entry, 4,000 feet fro slope opening. Section B (sample 69379) was cut in 1 room, at face of 19 east entr Section C (sample 69397) was cut in room neck of last room, at face of 9 west entr

System of mining, room and pillar. In 1918 the coal was shot down with blac blasting powder and the mining was done by hand. Men employed numbered underground and 10 on the surface. The coal was dumped on a crossover dump an passed over bar screens; two sizes were produced, as follows: Slack, through 1½-inc bar screen, 40 to 47 per cent of entire tonnage; lump, over 1½-inch bar screen, 53 to per cent of entire tonnage. At times one picker was employed on the railroad car miners pick out some slate when loading coal at face. About 50 per cent of the co was taken out in advance work, and a total recovery of 60 per cent was claime Haulage was by mules. The two loading tracks had capacity for 20 empty and loaded railroad cars. The coal was shipped to Kansas City, Omaha, and to the S Louis & San Francisco R. R. for domestic and railroad use. The capacity and avera daily output of the mine in June, 1918, was 375 tons.

HARTFORD. CENTRAL No. 10 MINE.

Analysis 29838, average of tipple samples; analyses 69619 to 69624 and 69628 a 69631 (p. 23). Semibituminous, Arkansas field, from Central No. 10 mine, a slope mi at Hartford, on the Chicago, Rock Island & Pacific R. R. Coal bed, Hartshorne; C boniferous age, Spadra shale. Bed is 3 to 4 feet thick and dips 4°. Frequent fau and occasional rolls or horsebacks are encountered. Bed contains thin "sulphu bands, usually near the middle. Roof, mostly hard gray sandstone; floor, hard rou gray shale. The bed was sampled by W. H. McCoubrey on January 12, 1918, as scribed below. Commercial samples were taken at the tipple by J. F. Davies and H. Snyder on June 26, 1918.

Sections of coal bed in Central No. 10 mine.

Section	A.		B.		C.
Laboratory No.	29835		29836		2983
Roof, main, hard gray sandstone; immediate, soft gray shale:	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*
Top coal	3	9	4	1	3
Middle band of soft shale		*a* 8			
Middle band of soft fire clay				*a* 7	
Bottom coal (poor grade)		7		8	
Thickness of bed	5	0	5	4	5
Thickness of coal sampled	4	4	4	9	4

a Not included in sample.

Section A (sample 29835) was taken from face of 4 south entry. Section B (samp 29836) was taken from face of 2 south entry. Section C (sample 29837) was taken fro face of 3 north entry.

The ultimate analysis of a composite sample made by combining face sampl 29835 to 29837 is given under laboratory No. 29838.

System of mining, double room and pillar. In 1918 coal was cut by machine in the fire clay and shot down with permissible explosives. Men employed numbered 107 underground and 23 above ground. The tipple was of wood. The total output was shipped as run of mine. Haulage was by mules. The coal was picked on the cars by two pickers. There were three loading tracks, with capacity for 30 empty and 30 loaded railroad cars. The appearance of the lump coal on the cars was good. The capacity of the mine in January, 1918, was 625 tons, the actual daily average 575 tons.

Hartford. Central No. 11 Mine.

Analyses 69615 and 69620, 69632 and 69633, average of mine-face samples, and analyses 69617 and 69621, 69623 and 69635, average of tipple samples, (p. 23). Bituminous coal taken from face and tipple, Hartford field, from No. 11 mine, a shaft mine 2½ miles northeast of Hartford, on the Midland Valley R. R. Coal bed, Lower Hartshorne, Carboniferous (Allegheny) age, Spadra shale. Bed is 7 feet 4 inches to 8 feet 6 inches thick at sections sampled; dip, 18 per cent; roof, fairly strong and dark shale with "sulphur" bands; floor, soft, smooth shale. The bed was sampled by W. H. McCoubrey on June 25, 1918, as described below. Commercial samples were taken at the tipple on June 25, 1918, by J. F. Davies and N. H. Snyder.

Sections of coal bed in No. 11 mine.

Section	A.		B.		C.		D.	
Laboratory No.	69615		69620		69632		69633	
Roof, not noted:	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Bony coal	1	2		6½	....		....	
Coal		2½	1	7	1	9	1	7½
Shale band		1/16		1/16		¼		1/16
Coal		1		3		4		1½
Shale band		1/32		1/16		1/16		2
Coal		7		5½		11		11
Shale band		1/16	....		....			1
Bony coal	....			¼		⅛	....	
Coal	1			5½		11½		10½
"Sulphur" band		1/16		1/16	....		....	
Bony coal	....		....			9		4
Coal		9½		4		6	....	
Bony coal		6½	....			2½		8½
Shale and "sulphur" band		8		¼	....		....	
Coal	....		1	1½	2	½		7½
Bony coal		3		8	....		....	
Coal		4½		3	....		....	
Shale band		⅛		½	....			2½
Coal		7		4	....		2	4
"Sulphur" band		⅛		1	....		....	
Coal	1	8½	2	3	....		....	
Floor, smooth, soft shale.								
Thickness of bed	8	0	8	6	7	4	7	10
Thickness of coal sampled	8	0	8	6	7	4	7	10

Section A (sample 69615) was taken at face of 1 east entry, west plane. Section B (sample 69620) was taken at face of 3 east entry, west slope. Section C (sample 69632) was taken at face of 4 east entry, east plane. Section D (sample 69633) was taken at face of 20 room, 2 east entry, east plane.

In 1918, 75 per cent of the coal was mined in the advance work and a total recovery of 90 per cent was claimed. Haulage was by mules, by storage-battery locomotive, and by tail rope. The four loading tracks had capacity for 40 empty and 40 loaded railroad cars.

System of mining, room and pillar, entry and air course. The coal was cut by hand and shot down with black blasting powder. Pieces of bone, "muck," roof, and floor appeared in the coal, but the miners endeavored to pick the coal at the face. Men employed numbered 102 in the mine and 17 men on the surface. Two pickers were employed on the railroad cars, and there was an underground coal inspector. The

mine was equipped with a shaker screen and a loading boom; a picking table was bei
installed.

The coal was shipped by the Midland Valley R. R. to Omaha, Nebr., for steam p
poses. The capacity of the mine was 1,500 tons a day; the average daily output
July, 1918, was 400 tons. Additional labor would increase the tonnage.

HUNTINGTON. CENTRAL NO. 6 MINE.

Analyses 27612 to 27617 (p. 23). Semibituminous coal, Arkansas field, from Cent
No. 6 mine, a shaft mine, Greenwood-Huntington district, on a spur off the Mansfie
branch of the St. Louis & San Francisco R. R., in sec. 33, T. 5 N., R. 30 W., Diamo
Township, about 3 miles west of Huntington. Coal beds, Upper and Lower Hartshor
Carboniferous (Allegheny) age, Spadra shale. The beds are separated by a layer
hard shale averaging about 8 inches in thickness and locally called "muck;" the upp
seam averages about 4 feet 2 inches in thickness; the lower, 2 feet 2 inches. R
varies; on the north section a very hard sandstone and on the south a shale that thicke
toward the south; floor, soft gray shale. The beds were sampled at five points
J. F. Davies and W. W. Fleming on February 16 and 17, 1917, as described below:

Sections of coal beds in Central No. 6 mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	27612	27614	27616	27613	2761
Roof, sandstone.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft.*
Coal, clean	1 0		2 6		
Bone (hard)		a 10			
"Mother coal"	¼				
Bone and "rash"				a 7½	
Coal, clean	1 1				
Black "sulphur"	a 2½		½		
Coal (with knife edges of "sulphur")		1 8	8	3 11	3
Coal, clean	1 5½	a 2			
Coal (with knife edges of "sulphur")		1 7½			
Bone	1	a 4½	a 7		
"Muck"	a 9½	a 11	a 1 10	a 1 0	a
Bone	a 2½				
Bone and "muck"			a 5½		
"Muck"			a 2½		
Coal, clean	4½	6	2 0	6	
"Muck"	a 3½	a 3		a 3	
"Muck" and bone					
Coal, clean	5½				1
"Sulphur" band	a 2				
Coal (with knife edges of "sulphur")		2 3		2 4½	
Coal	1 4				
Floor, soft gray shale.					
Thickness of bed	7 5¾	8 7	8 3½	8 8	7
Thickness of coal sampled	5 9¾	6 ½	5 2½	6 9½	5

a Not included in sample.

Section A (sample 27612) was taken from neck room 8, 5 north off 2 east entry. S
tion B (sample 27614) was taken from 21 room neck, 1 west south. Section C (sam
27616) was taken from 1 room, off back 4 east on main north. Section D (sample 276
was taken at junction 6 east and back entry of south-east. Section E (sample 276
was taken at 19 room 2 east off main south.

The ultimate analysis of a composite sample made by combining samples 27612
27616 is shown under laboratory No. 27617.

System of mining, double entry, entry and air course, room and pillar. In 1917 t
coal was shot from the solid with FF black blasting powder. The tipple was of wo
with shaker screens measuring 20 by 8 feet, making three sizes of coal; the diamet
of the holes were ½ inch, 1½ inch, and 2 inch. About 20 per cent of the output w
shipped as run of mine. Haulage was by mules, electric locomotives, and elect
hoists. The average daily output was 1,200 tons.

HUNTINGTON. CENTRAL NO. 6 MINE.

Analyses 69329 to 69334, average of mine-face samples, and analyses 69339, 69357, 69358, 69359, and 69360 to 69363, average of tipple samples (p. 23). Tipple samples of semibituminous coal, Huntington field, from No. 6 mine, a shaft mine 3 miles west of Huntington, on Frisco R. R. Coal beds, Upper and Lower Hartshorne; Carboniferous (Allegheny) age, Spadra shale; roof, slate; floor, black shale. The beds were sampled by N. H. Snyder and J. F. Davies on June 5 and 6, 1918, as described below. Commercial samples were taken at the tipple by G. S. Pope and N. H. Snyder on June 7, 1918.

Sections of coal beds in No. 6 mine.

Section	A.		B.		C.	
Laboratory No.	69331 and 69332		69329 and 69330		69333 and 69334	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal	1	5	2	1½	3	10½
Coal, bony		2¼				
Coal		5½				
"Sulphur"		[a] 1		[a] 1¼		
Coal		5	1	4¾		
"Sulphur"		[a] ½				
Coal	1	2				
"Muck"		[a] 11½		[a] 10½	[a] 1	1
Coal		8½		6¾		5¾
"Muck"		[a] 2¼		[a] 4¼		[a] 4¼
Coal	2	3½	2	1½	2	1½
Floor, black shale.						
Thickness of beds	7	11	7	6½	7	11
Thickness of coal sampled	6	7¾	6	2½	6	5¾

[a] Not included in sample.

Section A (samples 69331 and 69332) was cut at 28 room, 1 west, main south. Section B (samples 69329 and 69330) was cut at 5 east, main southeast. Section C (samples 69333 and 69334) was cut at heading, main southeast back entry. Samples 69360 and 69363 represented tipple samples of run-of-mine coal; samples 69357 and 69358 represented tipple samples of slack coal over ¾-inch screen, and samples 69339 and 69359 represented tipple samples of slack through ¾-inch screen.

In 1918, 71 per cent of the coal was taken out in the advance work and a total recovery of 80 per cent was claimed.

System of mining, room and pillar, entry and air course. In 1918 machine mining was not practiced; the coal was shot down with black blasting powder; mining machines (electric) were formerly used. Haulage was by mules, motor, and electric rope. The three loading tracks had capacity for 40 empty and 40 loaded railroad cars. Men employed numbered 325 underground and 25 above ground. The coal was dumped over a tipple equipped with modern screens and a loading conveyer boom. Sizes produced were as follows: Slack, dust to 1 inch, 40.55 per cent; nut, 1 inch to 2½ inches, 9.47 per cent; lump, 2½ inches and over, 50.04 per cent. All screened coal passed over 1½-inch perforated screen, area 80 square feet, and 2-inch perforated screen, area 40 square feet. The screened coal was not reassembled. The coal was cleaned by four pickers on the loading boom and three pickers on railroad cars. No coal inspector was employed at the tipple, but two were employed underground. The miner rejected some "muck" and shale in loading coal at the face. The coal was being shipped to Kansas City, Omaha, and to the St. Louis & San Francisco R. R. The capacity of the mine was 1,700 tons a day, and the average daily output at the time the samples were taken was 1,450 tons; the output for the year 1917 was 156,653 tons, the mine being shut down from February 2 to 23, 1917, on account of explosions.

WASHINGTON COUNTY.

FAYETTEVILLE. STANBERY WAGON MINE.

Analysis 26260 (p. 24). Bituminous coal, from Stanbery wagon mine, 5 miles east Fayetteville. Coal bed, Morrow; Carboniferous age, Morrow formation. Roof, shal under limestone; floor, clay. The bed was sampled October 9, 1916, by D. Whit The samples represented 11¾ inches of coal, which was the entire thickness of bed.

The section was measured off second left, about 600 feet from opening of mine.

FAYETTEVILLE. WAGNON & REED WAGON MINE.

Analysis 26259 (p. 24). Bituminous coal, Washington County field, from Wagn & Reed wagon mine, 5½ miles east of Fayetteville. Coal bed, Morrow; Carbonifero age, Morrow formation. Roof, shale; floor, fire clay. The bed was sampled October 1916, by D. White; the sample represented 11½ inches of coal, which was the enti thickness of the bed.

The section was measured in main entry 400 feet from entrance of mine.

CALIFORNIA.

AMADOR COUNTY.

LIGNITE. IONE MINE.

Analyses 31141 and 31168 (p. 24). Lignite coal, Ione field, from Ione mine, a sha mine at Lignite, 4 miles northwest of Ione, on the Southern Pacific R. R. Coal be not named; Tertiary (Eocene) age, Ione formation. Bed is a few inches to 22 fe thick and lies in a basin generally flat; cleat, not observed; general characteristics of the bed shown in sections sampled; roof, sandy clay; floor, not noted; cover at poi sampling, about 80 feet. The bed was sampled by H. M. Wolflin and M. R. Camp bell on October 17, 1918, as shown below:

Section of coal bed in Ione mine.

Section	A.		B.	
Laboratory No.	31141		31168	
	Ft.	*in.*	*Ft.*	*in.*
Lignite	6	9	a 6	9
Clay		a ½		
Lignite	a 1	5¾	1	5
Clay		a ¼		
Lignite	a 1	7½	1	7
Clay		a ¾		
Lignite		a 2½		2
Clay		a 2		2
Lignite	a 1	7½	1	7
Thickness of bed	11	11¾	11	11
Thickness of lignite sampled	6	9	5	2

a Not included in sample.

Section A (sample 31141) was measured 1,300 feet S. 50° east of shaft. Section (sample 31168) was measured about 50 feet inby place where sample A was cut.

System of mining, room and pillar. In 1918 probably not more than a dozen me were employed, and the output was probably about 40 tons daily. Haulage was b mules. Coal was lowered from the shaft to the wooden tipple by gravity tram, an there hoisted again to screen and load.

MENDOCINO COUNTY.

Dos Rios. Natural Outcrop.

ıalysis 31139 (p. 25). Subbituminous coal, Dos Rios field, from 4 miles east of Dos ı, in NE. ¼ sec. 11, T. 21 N., R. 13 W., on the Northwestern Pacific R. R. Coal bed named; Tertiary (Miocene?) age. Bed is 15 feet 6 inches thick; dip, 15°; no ır at point of sampling; sample was cut from outcrop where it crosses Middle Fork el River. The bed was sampled by M. R. Campbell on October 9, 1919, as ribed below:

Section of coal bed in outcrop 4 miles east of Dos Rios.

	Ft.	In.
l	[a]1	6
l, sampled	3	0
l	[a]10	0
ckness of bed	14	6
ckness of coal sampled	3	0

MONTEREY COUNTY.

Stone Canon. Stone Canon Mine.

ınalyses 31100 and 31101 (p. 25). Bituminous coal, Stone Canon field, from a slope ıe, at Stone Canon in NW. ¼ sec. 14, T. 22 S., R. 13 E., 24 miles from McKay, the Southern Pacific R. R. Coal bed, not named; Tertiary (Miocene) age; Vaqueros dstone; dip, 30°; cleat, not observed. In the open part of the mine the bed is ly regular in thickness and generally without partings, but is said to pinch out in h directions from the slope. Roof, massive sandstone; floor, green clay that has en some trouble where all the coal has been removed; cover at point of sampling, out 500 feet. The bed was sampled by M. R. Campbell on September 30, 1918, as cribed below:

Section of coal bed in Stone Canon mine.

tion oratory No.	A. 31100		B. 31101	
	Ft.	*in.*	*Ft.*	*in*
l	[a]5	7		[a]4
l	5	10	7	6
l				[a]6
ting		[a]1		
ne				[a]2
l	1	1		
l			2	7½
l, bony		[a]6		
ne				[a]1½
l			1	10
ickness of bed	13	1	13	1
ickness of coal sampled	6	11	11	11½

[a] Not included in sample.

Section A (sample 31100) was measured at face of 1 east entry below the 300-foot vel, 300 feet from inside slope and 4,800 feet east of main slope. Section B (sample 101) was measured at face of 1 west entry below the 300-foot level, 200 feet west of side slope and 4,300 feet east of main slope.

Mine not worked in a commercial way; only enough coal extracted to keep the mine en and supply the few miners with light.

[a] Not included in sample.

COLORADO.

BOULDER COUNTY.

BROOMFIELD. MONARCH NO. 2 MINE.

Analyses 31314, 31315, and 31316 (p. 25). Subbituminous coal, Denver r
locally called Northern Lignite field, from Monarch No. 2 mine, a shaft mine 3
northwest of Broomfield, in sec. 28, T. 1 S., R. 69 W., on the Colorado & Sou
R. R. Coal bed, unnamed, Cretaceous age, Laramie formation. Bed is level
feet thick; roof, shale; floor, shale; cover at points of sampling, 285 feet. Th
was sampled by J. J. Forbes on December 3, 1918, as described below:

Sections of coal bed in Monarch No. 2 mine.

Section	A.	
Laboratory No.	31314	3
Roof, shale.	*Ft. in.*	F
Coal	5 6	
Shale	[a]1 0	
Coal	2 4	
Floor, shale.		
Thickness of bed	8 10	
Thickness of coal sampled	7 10	

[a] Not included in sample.

Section A (sample 31314) was cut at face of 7 southwest entry. Section B (s
31315) was cut at face of main south entry.

The ultimate analysis of a composite sample made by combining face sa
31314 and 31315 is given under laboratory No. 31316.

System of mining, room and pillar. In 1918 the coal was cut by puncher
shot down with black powder. Men employed numbered 137 underground a
men aboveground.

At the time of sampling the output was 600 tons a day, 60 per cent of whic
derived from advance workings. Haulage was by mules and by motors. No
the coal was shipped as run of mine. All the coal was screened in a wooden t
with Marcus screens having 2½-inch spaces. Sizes of coal: Over 2½ inches, l
under 2½ inches, slack. The coal was picked on tables. The three loading t
had a capacity for 30 empty and 30 loaded railroad cars. The coal on the cars app
bright and clean. The estimated lifetime of the mine at time of sampling was 30 y
The capacity of the mine was 650 tons a day; the maximum day's run was 769 to

LAFAYETTE. SIMPSON MINE.

Analysis 31391 (p. 25). Subbituminous coal, Denver region, from Simpson
a shaft mine at Lafayette, in sec. 2, T. 1 S., R. 69 W., on the Colorado & Sou
R. R., and on the Chicago, Burlington & Quincy R. R. Coal bed, Lower Sim
Cretaceous age, Laramie formation. Bed is level and 6 to 12 feet thick; roof, i
diate, coal; floor, soft shale; cover at point of sampling, 225 feet. The bed was sam
by J. J. Forbes on January 20, 1919, as described below:

Section of coal bed in Simpson mine.

Roof 3 feet of coal.
Coal....................
Floor, soft shale.
Thickness of bed....................
Thickness of coal sampled....................

Sample 31391 was cut at face of 13 southwest entry main south entry.

System of mining, room and pillar, retreating. At the time of sampling the coal as undercut by air mining machines and shot down with FF black powder. Men aployed numbered 67 aboveground. The tipple was of wood. At the time of mpling 95 per cent of the coal was shipped as run of mine; 5 per cent was screened rough 2½-inch spaces. Sizes of coal: Over 2½ inches, lump; through 2½ inches, ıck. Haulage was by electric motors and animals. There were two loading tracks, ith capacity for 100 empty and 100 loaded railroad cars. The coal on the cars was ight and lustrous. The lifetime of the mine was estimated in 1919 to be 5 years. he capacity of the mine was 1,000 tons a day, the daily output 500 tons.

LOUISVILLE. ACME MINE.

Analysis 31384 (p. 25). Subbituminous coal, Denver region, from Acme mine, a ıaft mine at Louisville, in sec. 8, T. 1 S., R. 69 W., on the Colorado & Southern ·. R. Coal bed, "Lower Acme"; Cretaceous age, Laramie formation. Bed is 6 to 8 ·et thick and lies flat; cleat runs N. 15° east. Faults and several rolls are encoun- ·ered. The bed contains bone and a little shale about 3 feet from bottom. Roof, ·andy shale, 18 inches roof coal left in some places; floor, soft sandy shale, smooth ·here it does not heave; cover at point of sampling, 185 feet. The bed was ·ampled at one point by J. J. Forbes on January 15, 1919, as described below:

Section of coal bed in Acme mine.

	Feet.
·oof, sandy shale.	
Coal	6
Floor, sand shale.	
Thickness of bed	6
Thickness of coal sampled	6

Sample 31384 was cut in 5 room, 6 northeast entry.

System of mining, room and pillar. In 1919 the coal was undercut by machine and shot down by miners with FF black powder and squibs. Very little powder was used for brushing roof or floor. Haulage was by mules and by rope hoist. Men employed numbered 95 underground and 15 above ground. The tipple was of wood covered with corrugated iron; it had shaking screens 6 by 24 feet, with holes usually 2½ inches in diameter. Of the coal 60 per cent was lump, and 40 per cent passed through shaking screens. About 20 per cent of the output was shipped as run of mine. The coal was picked in the mine and in the shaking screens. There were three loading tracks, with capacity for 24 empty and 30 loaded railroad cars. The lump coal on cars was in large lumps and presented a good appearance; screenings on cars were bright. Coal from narrow work and room necks was taken out in advance work; a recovery of 95 per cent was claimed. In 1919 the unmined area was 200 acres. The estimated lifetime of the mine was 15 to 20 years. Capacity of mine, 600 to 700 tons a day; average daily output, 600 tons; maximum day's run, 1,258 tons.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 22, pp. 55, 399.

DELTA COUNTY.

BOWIE. KING MINE.

Analysis 28920 (p. 25). Bituminous coal, Grand Mesa field, from King mine, a drift mine, Somerset district, ¾ mile northeast of Bowie, Colo., in sec. 10, T. 13 N., R. 91 W., on the Denver & Rio Grande R. R. Coal bed, King, known locally as the Juanita; Cretaceous age, Mesaverde formation. Bed is 9 to 14 feet thick, with practically no impurities; dips 3–33°, N. 29–33° E.; cleat runs N. 79–30° E.; roof, bone

and shale; floor, hard smooth bone and sandstone. Coal is cut out by "sp
sandstone averaging about 1 foot thick and having the appearance of dyke
bed was sampled by C. A. Herbert on July 21, 1917, as described below:

Section of coal bed in King mine.

Section Laboratory No.	
Roof, main, sandstone	2,
Roof, immediate, bone	
Coal	
Shale	
Coal	
Floor, bone.	
Thickness of bed	
Thickness of coal sampled	

The section (sample No. 28290) was cut from the last crosscut between th
left entries.

System of mining, room and pillar, with butt entries. In 1917 about 25 per
the coal was taken out in advance work, and a total recovery of 90 per ce
claimed. Haulage was by rope. There were three loading tracks, with capa
50 empty and 50 loaded railroad cars. The coal was cut partly by machine
hand in the floor and shot down with FFF black powder at 5.30 p. m. by sho
40 per cent dynamite was used for brushing roof or floor. Men employed nu
60 underground and 15 above ground. The coal was dumped over a
tipple; very little of it was shipped as run of mine. Fifty-nine per cent
coal passed through shaking screens; 31 per cent passed through 1-inch
and 28 per cent through 4-inch holes. No pickers were employed on the cars
coal consisted of large lumps and had a very good appearance on the cars. Th
had a capacity of 1,000 tons a day; the daily average output was about 450 to
maximum day's run 750 tons. The output for the year 1916 was 60,618 tons
unmined area was 950 acres, and the probable lifetime of the mine was 75 yea

For results of other analyses of coal from this mine see Bureau of Mines Bu
pp. 55, 400; Bull. 85, pp. 24, 164.

EL PASO COUNTY.

Colorado Springs. El Paso Mine.

Analyses 28907 to 28910 (p. 25). Subbituminous coal, Colorado Springs field
El Paso mine, a slope mine 3½ miles northeast of Colorado Springs, in sec. 33, T.
R. 66 W., on the Chicago, Rock Island & Pacific R. R. Coal bed, A; Cretaceou
Laramie formation. Bed is 6½ to 11 feet thick. The east side of the mine has
parting about 3 feet from floor; dip, about 5° N. 35–55° E.; a face cleat runs
35° W. No faults or rolls are encountered. Roof, sandstone, overlying 6
to 2½ feet of roof coal; floor, soft smooth shale. The bed was sampled at three
by C. A. Herbert on May 26, 1917, as described below:

Sections of coal bed in El Paso mine.

Section Laboratory No.	A. 28907		B. 28909	
	Ft.	in.	Ft.	in.
Roof, main, sandstone	40	0	40(?)	
Roof, immediate, coal		6	2	0
Coal	2	4	6	0
Dark shale		a5	......	
Coal	3	1	......	
Bone		a2		a2
Floor, fire clay or shale.				
Thickness of bed	6	0	6	2
Thickness of coal sampled	5	5	6	0

a Not included in sample.

Section A (sample 28907) was cut 10 feet outby face 5 east entry on left rib. Section B (sample 28909) was cut from face 20 room off 5 east entry. Section C (sample 28908) was cut from face 18 room off 6 west entry.

The ultimate analysis of a composite sample made by combining samples 28907 to 28909 is given under laboratory No. 28910.

System of mining, room and pillar, butt entries. In 1917 about 50 per cent of the coal was taken out in the advance work, and the total recovery claimed was 65 per cent. Haulage was by mules and rope. There were three loading tracks, with capacity for 14 empty and 14 loaded railroad cars. The coal was cut and sheared by hand in narrow work and in rooms, and shot down with FF black powder by miners at 4 p. m., the closing time. Men employed numbered 75 underground and 8 above ground. The coal was dumped over a wooden tipple, about 50 per cent being shipped as run of mine. The screened coal passed over shaking screens; 40 per cent passed through the 2¾-inch openings and 60 per cent through the 4½-inch openings. The screenings were crushed and at times the mine run was crushed to pass through 2½-inch openings. The appearance on the cars of the screenings and the lump coal, the latter in large lumps, was good. In 1917 the unmined area was 300 acres, and the estimated life of the mine was 20 years.

PIKE VIEW STATION. PIKE VIEW MINE.

Analyses 28911 to 28916 (p. 26). Subbituminous coal, Colorado Springs field, from Pike View mine, a shaft mine in sec. 18, T. 13 S., R. 66 W., 1 mile north of Pike View station, on the Denver & Rio Grande R. R. Coal bed, A; Cretaceous age; Laramie formation. Bed is 7 to 14 feet thick; average 12 feet; dip, about 13 feet in 2,000 north; a cleat making an angle of about 30° with the vertical runs approximately east. No faults, rolls, or horsebacks are encountered. The bed contains occasional small lenses of coal ¾ inch thick. Roof, soft white sandstone above coal (about 20 inches of top coal left for roof); floor, smooth bone, 2 inches, and fire clay, 2 feet. The bed was sampled by C. A. Herbert on June 7, 8, and 29, 1917, as described below:

Sections of coal bed in Pike View mine.

Section Laboratory No	A. 28915		B. 28912		C. 28911		D. 28914		E. 28913	
Roof, sandstone.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Top coal	3	0	3	0	3	0	3	0	3	0
Coal	7	5	8	2	7	8	8	6	7	9
Coal		a 8		a 4		a 4				
Bone		a 4		a 4				a 4		a 4
Floor, shale.										
Thickness of bed	11	5	11	10	11	0	11	10	11	1
Thickness of coal sampled	10	5	11	2	10	8	11	6	10	9

a Not included in sample.

Section A (sample 28915) was taken from right rib in 1 room off 106, 45 entry 15 feet outby face, 1 mile northwest of shaft. Section B (sample 28912) was taken from right rib in 10 entry opposite 31 room, 1 mile northwest of shaft. Section C (sample 28911) was taken from right rib in 8 room off main dip 10 feet outby face 1 mile from bottom of shaft northwest. Section D (sample 28914) was taken from face of 25 room off 106 entry, 1 mile northwest of shaft. Section E (sample 28913) was taken from right rib in 6 room outby face, 106, 45 entry, 1 mile northwest of shaft.

The ultimate analysis of a composite sample made by combining samples 28911 to 28915 is given under laboratory No. 28916.

System of mining, room and piller, butt entry. In 1917, 40 per cent of the coal was taken out in advance work, and a total recovery of 80 per cent was claimed. Haulage was by five electric motors and by mules. The coal was undercut by machine and

shot down with FF black powder by shot firers at 6 p. m. Men employed numbe
175 underground and 13 above ground. The coal was dumped over a wooden tip
from self-dumping steel cages. There were no pickers. The screened coal consis
of large lumps, and the appearance of the lump coal and the screenings on the cars
good.

The capacity of the mine in 1917 was 1,000 tons a day, the daily average output
tons, and the maximum day's run 1,011 tons. The unmined area was 600 acres
the probable lifetime of the mine was 20 years.

For description and analyses of other samples from this mine, see Bureau
Mines Bull. 85, pp. 24, 166.

GUNNISON COUNTY.

SOMERSET. SOMERSET MINE.

Analyses 31817, 31798, 31799, and 31800 (p. 26). Bituminous coal, Grand Me
field, from Somerset mine, a slope mine at Somerset, sec. 9, T. 13 S., R. 90 W., on t
Denver & Rio Grande R. R. Coal bed, not named; Cretaceous age, Mesaver
formation. Average thickness of bed is 24 feet; dip, 6 per cent; roof, sandstone; floo
sandstone; cover at point of sampling, 1,000 feet. The bed was sampled by J.
Forbes on April 15 and April 21, 1919, as described below:

Sections of coal bed in Somerset mine.

Section	A.		B.		C.		D.	
Laboratory No.	31817		31798		31799		31800	
Roof, sandstone:	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Bone		5						
Coal, bony		11		7		5		
Top coal	2	0					2	
Clay band		2						
Coal	7	4						
Clay	1	0						
Coal	3	0						
Shale		8						
Coal, dirty	3	0						
Floor, sandstone.								
Thickness of bed	18	6		7		5	3	
Thickness of coal sampled	18	6		7		5	3	

Section A (sample 31817) was cut from left rib, 15 room, 10 east entry. Section B
(sample 31798) was cut from left rib, 17 room, 10 east entry, between 2 and 3 crosscuts.
Section C (sample 31799) was cut from left rib, 17 room, 10 east entry, between 2 and 3
crosscuts. Section D (sample 31800) was cut from 10 east entry at mouth to 13 room.

System of mining, room and pillar. In 1919 the coal was cut by the miners and shot
down with permissible explosive. Men employed numbered 116 underground and
45 aboveground. The tipple was of wood. At the time of sampling, 66 per cent of
output was derived from advance workings; 95 per cent of output was shipped as run
of mine; 5 per cent was screened in shaking screens capable of making three sizes—
lump, nut, and slack. Haulage was by mules and engine plane. The four loading
tracks had capacity for 40 empty and 40 loaded railroad cars. The coal on the cars
presented a good appearance. In 1919 the probable lifetime of the mine was estimated
to be 25 years. The capacity of the mine was 2,000 tons a day, the average output
1,500 tons, and the maximum day's run 1,850 tons.

For descriptions and analyses of other samples of this coal, see Bureau of Mines Bull.
85, pp. 25, 169.

HUERFANO COUNTY.

RAVENWOOD. RAVENWOOD MINE.

Analyses 31406, 31407, and 31408 (p. 26). Bituminous coal, Trinidad field, from Ravenwood mine, a slope mine, at Ravenwood, on a spur of the Colorado & Southern R. R. Coal bed, Cameron; Cretaceous age, Vermejo formation. Thickness of bed is 2 feet 6 inches to 2 feet 8 inches; dip, 4 per cent southwest; cleat, indistinct. Frequent faults and occasional rolls are encountered. The bed is uniform, the coal being of "nigger-head" variety. Roof, main, sandstone; immediate, "draw slate," averaging 14 inches thick; floor, hard, smooth fire clay; cover at points of sampling, 250 feet. The bed was sampled by J. J. Forbes on January 28 and 29, 1919, as described below:

Sections of coal bed in Ravenwood mine.

Section	A.	B.
Laboratory No.	31406	31407
Roof, section A, sandstone overlaid with 17 inches of "draw slate"; section B, sandstone overlaid with 22 inches of "draw slate."	*Ft. in.*	*Ft. in.*
Coal	2 8	2 3
Floor, hard fire clay.		
Thickness of bed	2 8	2 3
Thickness of coal sampled	2 8	2 3

Section A (sample 31406) was cut at face of 11 north main entry. Section B (sample 31407) was cut at face of 1 dip, 5 south entry.

The ultimate analysis of a composite sample made by combining face samples 31406 and 31407 is given under laboratory No. 31408.

System of mining, room and pillar. In 1919 the coal was cut by machine and shot down by one shot firer, after the miners had left, with permissible explosive fired by fuse (double tape). Permissible explosive was also used for brushing roof or floor. Men employed numbered 75 underground and 15 aboveground. None of the output was shipped as run of mine. In the wooden tipple the coal was screened through shaking screens, one 6 by 18 feet, with 1½-inch perforations, the other 6 by 16 feet, with 2½-inch perforations. Haulage was by mule, and by tail rope on slope. Five pickers were employed on car. There were three loading tracks, with capacity for 14 empty and for many loaded railroad cars. The lump coal on cars consisted of large bright lumps, and the screenings on the cars were bright. The approximate total recovery was given as 75 to 80 per cent. In 1919 the daily capacity of the mine was 225 tons, which was equal to the average output; the maximum day's run was 260 tons. It was expected that by June, 1919, the daily output would be increased to 400 tons.

LAS ANIMAS COUNTY.

COKEDALE. BON CARBO MINE.

Analysis 31451 (p. 27). Coking bituminous coal, Trinidad field, from Bon Carbo mine, a drift mine 7 miles northwest of Cokedale, in secs. 31 and 32, Tps. 32 and 33 E., R. 65 W., on the Denver & Rio Grande R. R. Coal bed, Primero; Cretaceous age, Vermejo formation. Bed is 4 to 8 feet thick and dips 1½ per cent northwest, with cleat running east. Faults are encountered, but are not frequent; no rolls or horsebacks. A band of bone and shale from 1 to 6 inches thick extends through parts of mine. Roof, shale; floor, rough, soft shale; cover at point of sampling, 220 feet. The bed was sampled by J. J. Forbes on February 13, 1919, as described on the next page.

Section of coal bed in Bon Carbo mine.

	Ft.
Roof, main, shale; immediate, "draw slate."	
Coal	3
Shale	
Coal	
Bone	
Coal	1
Floor, shale.	
Thickness of bed	4
Thickness of coal sampled	4

Sample 31451 was cut at 1 south air course.

System of mining, room and pillar, butt entries. In 1919 the coal was cut machine and shot down with permissible explosive after the miners had left mine; "Giant" was used for brushing roof or floor. All the coal was shipped as of mine to coke ovens at Cokedale. Haulage was by seven electric locomotiv The wooden tipple had a revolving dump. There were two loading tracks, w capacity for 35 empty and 40 loaded railroad cars. The appearance of the coal the cars was good. Forty-five per cent of coal was taken out in advance work. the time of sampling the unmined area was 700 acres, and the mine was largely in development stage. The capacity of the mine was 700 tons a day, the actual da average 700 tons, and the maximum day's run 750 tons. The average daily tonn of coal coked was 700 to 1,500 tons.

Delagua. Cass Mine.

Analysis 31432 (p. 27). Bituminous coal, Trinidad field, from Cass mine, a d mine at Delagua, sec. 15, T. 31 S., R. 65 W., on the Colorado & Southeastern R. Coal bed, Delagua; Cretaceous or Tertiary age, Raton formation. Bed is 3 fee inches to 4 feet thick and lies flat. The vein is regular and clean. The immedi roof is 13 inches of "draw slate"; main roof, sandstone; floor, hard, rough fire cl cover at point of sampling, 300 feet. The bed was sampled by J. J. Forbes on F ruary 3, 1919, as described below:

Section of coal bed in Cass mine.

	Ft.
Roof, main, sandstone; immediate, "draw slate."	
Coal	
Shale	
Coal	3
Floor, hard fire clay.	
Thickness of bed	3
Thickness of coal sampled	3

Sample 31432 was cut at face of 3 east entry.

System of mining, room and pillar. In 1919 the coal was cut by machine and s down with a permissible explosive by shot firers after miners had left mine. same explosive was used for brushing roof or floor. Haulage was by mules and one electric locomotive. Men employed numbered 68 underground and 7 abo ground. The tipple was of wood. A small amount of the coal was mined in adva work; the mine was being opened and no pillars were withdrawn. It was expec the recovery would be 90 per cent. The probable lifetime of the mine was 15 to years. The daily capacity at time of sampling was 250 tons, the daily average out 230 tons, and the maximum day's run 270 tons. It was expected the daily out would be increased to 500 tons.

DELAGUA. DELAGUA MINE.

Analysis 29351 (p. 27). Bituminous coal, Trinidad field, from Delagua mine, a drift mine in sec. 15, T. 31 S., R. 65 W., at Delagua, about 4 miles west of Ludlow station on the Colorado & Southeastern R. R. Coal bed, Delagua; Cretaceous or Tertiary age, Raton formation. The bed is 5 to 8 feet thick. Well-defined face cleats run approximately east and west, or parallel to the dip. The bed is comparatively free of persistent partings of foreign matter. Immediately overlying the coal in the roof are 3 to 4 inches of friable bony coal, above which is mud-clay shale with partings (slickensides), necessitating heavy timbering. Floor is of shale; cover at point of sampling, about 500 feet. The bed was sampled by C. A. Herbert on October 1, 1917, as described below:

Section of coal bed in Delagua mine.

	Ft.	in.
Roof, shale.		
Coal	1	4
Shale [a]		5
Coal		11
Bone		1
Coal		10
Bone		½
Coal		9½
Shale [a]		7
Coal	2	10
Floor, shale.		
Thickness of bed	7	10
Thickness of coal sampled	6	10

Sample 29351 was cut at face of 7 room, 11 west entry.

In 1917 the coal was cut by pick, and the use of explosives had been reduced to a minimum; permissible explosives were used and were fired by shot firers after other employees had left the mine. Electric locomotives and mules were used for haulage. Very little lump coal was produced. The daily output of the mine in 1917 was 2,200 tons.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 28, 177.

DELAGUA. DELAGUA FIRST NORTH DISTRICT.

Analyses 31423 to 31426 (p. 27). Bituminous coal, Trinidad field, from Delagua First North District, a drift mine at Delagua, 5 miles from Ludlow, on the Colorado & Southeastern R. R. Coal bed, No. 1 or Delagua; Cretaceous or Tertiary age, Raton formation. Bed is 5 to 6 feet thick and lies flat. A few faults, one dike, and occasional rolls are encountered. The bed contains impure layers in certain sections of the mine. Roof, "draw slate" 8 to 16 inches, then sandstone; floor, soft rough fire clay; cover at points of sampling, 300 to 500 feet. The bed was sampled by J. J. Forbes on February 4, 1919, as described below:

Sections of coal bed in Delagua First North District.

Section Laboratory No.	A. 31423	B. 31424	C. 31425
Roof, sandstone, "draw slate" about 3 to 15 inches.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	5 3	5 3	5 5
Floor, hard fire clay.			
Thickness of bed	5 3	5 3	5 5
Thickness of coal sampled	5 3	5 3	5 5

[a] Not included in sample.

Section A (sample 31423) was cut in 10 room, 8 east, 14 east entry. Section B (sample 31424) was cut in 9 room, 7 east, 6 north entry. Section C (sample 31425) was cut at face of 18 east parting.

The ultimate analysis of a composite sample made by combining face samples 31423 to 31425 is given under laboratory No. 31426.

System of mining, block. In 1919 the coal was cut by miners by pick. No explosives were used. Haulage was by four electric locomotives and by mules. The tipple was of wood. Five to 10 per cent of the coal was taken out in advance work, and a total recovery of 96 per cent was claimed. The capacity of the mine at time of sampling was 1,000 tons, the actual daily average was 900 tons, and the maximum day's run 1,100 tons.

DELAGUA. DELAGUA THIRD NORTH DISTRICT.

Analysis 31427 (p. 27). Bituminous coal, Trinidad field, from Delagua Third North District, a slope mine at Delagua, 5 miles from Ludlow, on the Colorado & Southern and the Denver & Rio Grande R. R. Coal bed, Delagua; Cretaceous or Tertiary age, Raton formation. Bed is 6 to 7 feet thick and dips 2° northwest, with cleat running northeast and southwest; roof, 3 to 24 inches of "draw slate," with hard sandstone above it; floor, hard, medium, rough fire clay; cover at point of sampling, 700 feet. The bed was sampled at one point by J. J. Forbes on February 5, 1919, as described below:

Section of coal bed in Delagua Third North District.

	Ft.	in.
Roof, main, sandstone; immediate, "draw slate."		
Coal	1	9
"Sulphur" band		½
Coal	1	8½
Dirty streak [a]		3
Coal	2	7
Floor, hard fire clay.		
Thickness of bed	6	4
Thickness of coal sampled	6	1

Sample 31427 was cut at face of 17 west, 5 north.

Systems of mining, room and pillar and block. In 1919, 50 per cent of the coal was cut by machine and shot down with a permissible explosive by shot firers after miners had left the mine; the same explosive was used for brushing roof or floor. Men employed numbered 175 underground and 60 above ground. The tipple was of wood. The coal was screened through bar screens 18 feet long, having 1½-inch spaces. Haulage was by five electric locomotives and by mule. Four pickers were employed on car and conveyor and there were four loading tracks. The lump coal, medium lumps, on the cars had a bright luster, as had the screenings. Five per cent of the coal was taken out in the advance work, and a total recovery of 95 per cent was claimed. The daily capacity of the mine was 1,000 tons, the actual daily average 1,000 tons, and the maximum day's run 1,200 tons.

HASTINGS. HASTINGS MINE.

Analyses 29277, 29278, and 29465 (p. 27). Bituminous coal, Raton Mesa field, from Hastings mine, a slope mine at Hastings, in sec. 25, T. 32 S., R. 64 W., on the Colorado & Southeastern R. R., with connections to the Colorado & Southern R. R. and the Denver & Rio Grande R. R. Coal bed, A and B beds, Cretaceous age, Vermejo (?) formation. Bed varies from 4½ feet to over 7 feet in thickness and dips about 10 per cent west at outcrop, decreasing to less than 4 per cent west at face of slope.

[a] Not included in sample.

Well defined slips or "faces" are encountered. Roof and floor are of shale. The bed was sampled by C. A. Herbert on September 21 and 22, 1917, and on November 5, 1917, as described below:

Sections of coal bed in Hastings mine.

Section	A.	B.	C.
Laboratory No.	29277	29278	29465
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, shale.			
Coal			7
"Sulphur"			a ½
Coal			2½
Bone			1
Coal	2 0	3 6	5
Bone	a 1	a 5½	1
Coal	5	3½	10
Bone	a 4		1
Coal	2 6		1 8
Floor, shale.			
Thickness of bed	5 4	4 3	4 0
Thickness of coal sampled	4 11	3 9½	3 11½

a Not included in sample.

Section A (sample 29277) was cut in B bed from right rib in crosscut off main opposite 3 north entry, about 1 mile from mine opening. Section B (sample 29278) was cut in A bed at face of last room off 7½ N., about 1 mile from mine opening. Section C (sample 29465) was cut at face of crosscut, 60 feet north of air shaft between A and B beds.

System of mining, double entry, room and pillar. In 1917 the coal was undercut by hand to a depth of 3½ to 5 feet; owing to the coal being friable and to the occurrence of slips or "faces" undercutting was not difficult; the face of the main and back slope was cut by chain breast mining machines. Pillars were pulled after rooms were finished. The coal was shot with a permissible explosive by shot firers after all the men were out of the mine. Haulage was by mules attached to cars by shafts or "guns." There were two loading tracks, with capacity for 150 empty and 150 loaded cars.

For descriptions and analyses of other samples of this coal see Bureau of Mines Bull 22, pp. 69, 449, and Bull. 85, pp. 29, 178.

MORLEY. MORLEY MINE.

Analyses 32046, 32047, and 32048 (p. 27). Bituminous (coking) coal, Trinidad field, from Morley mine, a slope and a drift mine at Morley, on the Atchison, Topeka & Santa Fe R. R. Coal bed, Engle-Starkville; Cretaceous age, Trinidad (?) formation. Bed is 4½ to 10 feet thick; dip (approximately 18 per cent), almost due south. A cleat runs east and west. Roof, 2½ feet of roof coal, above which is sandstone; floor, fairly smooth, soft shale; cover at points of sampling, 900 feet. The bed was sampled by J. J. Forbes on May 29, 1919, as described below:

Sections of coal bed in Morley mine.

Section	A.	B.
Laboratory No.	32046	32047
Roof, sandstone, 3 feet of coal left for protection.	*Ft. in.*	*Ft. in.*
Coal	4 4	3 8
Shale and bone	2	5
Coal	2 0	1 11
Floor, shale.		
Thickness of bed	6 6	6 0
Thickness of coal sampled	6 6	6 0

Section A (sample 32046) was cut at face of main slope. Section B (sample 32047) was cut at face of 7 left entry, main slope.

The ultimate analysis of a composite sample made by combining face samples 32046 and 32047 is given under laboratory No. 32048.

System of mining, room and pillar, in panels. The mine is opened on the east side by a drift and on the west side by a slope. The east side is on the retreating system and was to be worked out soon. At the time of sampling, no explosives were used, pick methods being employed exclusively. Men employed numbered 215 underground and 57 above ground. Ten per cent of the output was shipped as run of mine. The wooden tipple had bar screens 20 feet long, with 2¾-inch spaces, shaking screens 20 feet long by 6 feet wide, with 2¾-inch holes, and small-coal screens with bars 20 feet long, spaced 1½ inches apart. Of the coal going to screens 75 per cent passed through. Motors and mules were used for haulage in the east side opening, and rope and mules were employed on the west side. The coal was picked within the mine. There were three loading tracks, with capacity for 40 empty railroad cars and 1½ miles of track for loaded railroad cars. The screenings on the cars were fairly bright. The lumps were large and bright. Of the mine output 50 per cent was shipped to Pueblo, where it was washed and finally coked at a by-product plant. Forty per cent of the coal was taken out in the advance work, and a recovery of 85 per cent was claimed. The probable lifetime of the mine was 40 years. The capacity of the mine at time of sampling was 1,100 tons, which equaled the actual average output.

For descriptions and analyses of other samples of coal from this mine see Bureau of Mines Bull. 22, pp. 69, 450, and Bull. 85, pp. 29, 179.

SOPRIS. SOPRIS NO. 2 MINE.

Analysis 31949 (p. 27). Bituminous coal, Trinidad field, from Sopris No. 2 mine, a slope mine at Sopris, in NW. ¼ SE. ¼ sec. 33, T. 33 S., R. 64 W., on the Colorado & Southern R. R. Coal bed, Cameron (locally known as Sopris); Cretaceous age, Vermejo formation. Bed is 4 feet thick and dips 1½°. Occasional faults and rolls are encountered. Roof, "draw slate;" floor, rough, very hard sandstone. The bed was sampled by J. J. Forbes on May 14, 1919, as described below:

Section of coal bed in Sopris No. 2 mine.

Roof, main, sandstone; immediate, shale.

	Ft.	in.
Bone and coal mixed		6
Coal	1	2
Bone		2
Coal		5
Bone		1
Coal		5
Bone		1
Coal	1	3
Bony shale [a]		7
Coal	3	0
Floor, hard sandstone.		
Thickness of bed	7	8
Thickness of coal sampled	7	1

Sample 31949 was cut at face of 3 east entry.

System of mining, room and pillar, in panels. In 1919 the coal was cut and sheared by machine and by hand and shot down with a permissible explosive by shot firers after the miners had left the mine. Haulage was by mule, by three electric loco-

[a] Not included in sample.

otives, and by rope. Men employed numbered 350 underground and 55 above-ound. The tipple was of wood. None of the coal was shipped as run of mine, entire ıtput going to Pueblo, Colo., to be crushed, washed, and coked in a by-product plant. he size produced by crushing was about ¾ inch. Two pickers were on the belt. here was one loading track, ¾ mile long. The coal on the cars presented a bright ppearance. Seventy per cent of the coal was mined in advance work, and the covery was claimed to be 95 per cent. The probable lifetime of the mine was) years. The daily average output of the mine was 800 tons.

STARKVILLE. STARKVILLE MINE.

Analysis 32030 (p. 27). Bituminous coal, T inidad field, from Starkville mine, a rift mine ½ mile from Starkville, on the Santa Fe R. R. Coal bed, known as Engle-tarkville; Cretaceous age, Vermejo formation. Bed is 4 to 6 feet thick and lies flat. requent rolls are encountered. Roof, in some sections 2 feet of "draw slate," in others andstone; floor, medium hard, fairly smooth shale; cover at point of sampling was ver 1,000 feet; elevation of entrance, 6,100 feet above sea. The bed was sampled by . J. Forbes on May 20, 1919, as described below:

Section of coal bed in Starkville mine.

Roof, main, sandstone; immediate, black shale.

	Ft.	in.
Coal	1	10
Bone		1
Coal		2
Bone		1
Coal		4
Bone		4
Coal		4
Shale [a]		6
Coal	1	2
Floor, shale.		
Thickness of bed	4	10
Thickness of coal sampled	4	4

Sample 32030 was cut at face of 8 south entry, J–6.

System of mining, room and pillar. In 1919 very little development work was being done, the mine being worked retreating. The coal was broken down by squeezes. No explosives were used for the coal; permissible explosives fired by fire boss, were used only in rock or bottom shale. Men employed numbered 220 underground and 40 aboveground. The tipple was of wood. None of the coal was shipped as run of mine. Bar screens 18 feet in length, with 4-inch and ¾-inch spaces, were used. Screenings up to ¾ inch were washed and coked; 75 per cent of the coal was lump. Haulage was by mules and by five electric locomotives. One picker was employed on the car. There were two loading tracks with large capacity for railroad cars. The lump coal, large and small lumps, on the cars was bright; the screenings on the cars were dull. From 15 to 20 per cent of the coal was taken out in the advance work and about 85 per cent from pillars; the recovery claimed was 95 per cent. The estimated lifetime of the mine was 25 years. The capacity and average daily output of the mine was 900 tons. The daily output, however, was to be increased after new development. Of the coal from this property 75 per cent was shipped to the operator's by-product coking plant at Pueblo, Colo., for coking, and 25 per cent was sold to the Atchison, Topeka & Santa Fe R. R.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 22, p. 71, and Bull. 85, pp. 32,182.

[a] Not included in sample.

MESA COUNTY.

Cameo. Cameo Mine.

Analyses 28917 to 28919 (p. 28). Bituminous coal, Book Cliffs field, from Ca
mine, a slope mine in NW. ¼ NW. ¼ sec. 34, T. 10 S., R. 98 W., at Cameo, 4 r
northeast of Palisades, on the Denver & Rio Grande R. R. Coal bed, Cameo;
taceous age, Mesaverde formation. Bed is 9 to 10 feet thick and dips 2 to 4° north
with well-defined cleat. There is a thin layer of bony coal about 8 inches
roof, 10 inches near the middle, and 3 feet at the bottom. Roof, good hard dark sl
floor, bone; cover at points of sampling, 2,000 feet (?). The bed was sampled
C. A. Herbert on July 13, 1917, as described below:

Sections of coal bed in Cameo mine.

Section	A.		B
Laboratory No.	28917		28
	Ft.	*in.*	*Ft.*
Roof, main, sandstone and shale; immediate, shale	2	0	.....
Coal		7	
Bone		2	
Coal	1	10	3
"Sulphur"		1	.....
Coal	1	8	.....
Bone		[a] 10	[a]
Coal		10	1
Bone and coal	[a] 1	6	.....
Floor, bone	3	0?	3
Thickness of bed	7	6	5
Thickness of coal sampled	5	2	5

[a] Not included in sample.

Section A (sample 28917) was taken from 7 north off 6 west. Section B (sam
28918) was taken from face of 22 room off 8 west.

The ultimate analysis of a composite sample made by combining samples 28
and 28918 is given under laboratory No. 28919.

System of mining, room and pillar, butt entry. In 1917, 50 per cent of the
was taken out in advance work, and the total recovery claimed was 90 per c
Haulage was by two electric locomotives and mules. There were three load
tracks, with capacity for 35 empty and 35 loaded railroad cars. The coal was under
by machine in the bone and shot down by the shot firers at 6 p. m., permissible ex
sives and 40 per cent dynamite being used to brush the roof or the floor.
employed numbered 55 underground and 15 aboveground. The coal was dum
over a wooden tipple, about 80 per cent being shipped as run of mine. There w
no pickers. The coal was screened through shaking screens 6 by 10 feet, with 3-i
openings, and 6 by 16 feet, with 1½-inch openings, respectively. The appeara
of the screenings was good. The capacity of the mine in 1917 was 700 tons a d
and the average daily output was 600 tons.

For other analyses of coal from this mine see Bull. 22, pp. 72, 458.

OURAY COUNTY.

Ridgway. Kennedy Mine.

Analysis 31044 (p. 28). Subbituminous coal, Tongue Mesa field, from B. Kenne
mine, a drift mine 12 miles northeast of Ridgway, in NW. ¼ sec. 23, T. 46 N., R. 7
Ridgway is on a narrow-gage line of the Denver & Rio Grande R. R. Coal bed,
named; Upper Cretaceous age, Mesaverde formation. Bed is reported to be 40 f
thick and dips 15°; cover at point of sampling, 100 feet. The bed was sampled
M. R. Campbell on September 18, 1919, as described:

Section of coal bed in Lou Creek mine.

	Feet.
Roof, not noted.	
Coal (reported)	a 29
Coal (sampled)	7
Coal	a 4
Floor, not noted.	
Thickness of bed	40
Thickness of coal sampled	7

Sample 31044 was measured in main entry 300 feet from mine mouth. Wagon mine coal was hauled to Ridgway.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 85, pp. 35, 192.

PITKIN COUNTY.

Placita. Placita Mine.

Analysis 25826 (p. 28). Bituminous coal from Placita mine at Placita, in sec. 6, T. 11 S., R. 88 W., on the Crystal River R. R.

Coal bed, not named; Upper Cretaceous age, Mesaverde formation. The coal bed was sampled on August 14, 1916, by E. Russell Lloyd. The sample represented 3 feet 5 inches of coal, the entire thickness of bed except 2 inches of bone at the top, which was not sampled. Sample 25826 was measured 1,200 feet southwest of mine mouth.

ROUTT COUNTY.

Milner. Chergo (Old Hutchinson) Mine.

Analysis 31038 (p. 28). Bituminous coal, Yampa field, from Chergo mine, a slope mine in NW. ¼ sec. 13, T. 5 N., R. 86 W., 7 miles south of Milner, on the Denver Northwestern & Pacific R. R. Coal bed known as Wadge; Upper Cretaceous age, middle group of coal beds in the Mesaverde formation. Bed is 9 feet 6 inches thick and dips 10° or 12° west; it consists of clear coal, without partings, and is regular in thickness. Roof, shale; floor, not noted; cover at point of sampling, 50 feet. The bed was sampled by M. R. Campbell on September 6, 1918, sample 31038, representing 9 feet 6 inches of coal. The thickness of the bed was measured at face of main slope, 300 feet from mine mouth.

The mine was operated by no particular system and was worked only for local supply. There was no regular output. The haulage was by horsepower.

Mount Harris. Mount Harris Mine.

Analyses 31199 to 31207 (p. 28). Bituminous coal, Yampa field, from Mount Harris mine, a slope mine 1,000 feet south of Mount Harris Station, in sec. 15, T. 6 N., R. 87 W. on the Denver & Salt Lake R. R. Coal bed, Wadge; Cretaceous age, Mesaverde formation. Bed is 8 feet to 9 feet 6 inches thick; dip, 16° north, 8° 26′ east. A well-defined cleat runs south 30° east. One fault (8-foot displacement) has been encountered, but no rolls or horsebacks. The bed is free from impurities. Roof, good, of sandy shale; floor, hard and fairly smooth, of sandy shale; cover at points of sampling, 100 to 800 feet. Elevation of entrance is 6,400 feet above sea level. The bed was sampled by J. J. Forbes October 29 to 31, 1918, as described below:

Sections of coal bed in Mount Harris mine.

Section	A.		B.		C.		D.		E.		F.		G.		H.	
Laboratory No.	31199		31200		31201		31202		31203		31204		31205		31206	
Roof, sandy shale:	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
"Top slate"																
Coal	8	1½	8	9	9	0	9	5	5	6	8	4	9	0	8	6
Shale		a 2½								a ½						
Coal	1	0							3	3½						
Floor, sandy shale:																
Thickness of bed	9	4	8	9	9	0	9	5	8	10	8	4	9	0	8	6
Thickness of coal sampled	9	1½	8	9	9	0	9	5	8	9½	8	4	9	0	8	6

a Not included in sample.

Section A (sample 31199) was cut from left rib, 20 feet from face of 10 south entr

Section B (sample 31200) was cut from face of 3 east, main south slope. Section (sample 31201) was cut 20 feet from face of G slope, left rib, main south entry. Section D (sample 31202) was cut from face of 7 east back entry, 2 south entry. Sectio E (sample 31203) was cut at face of 10 east entry, main south entry. Section F (sampl 31204) was cut from left rib in last crosscut in A slope and 40 feet from face of entr Section G (sample 31205) was cut 30 feet from face of main south entry on left ri Section H (sample 31206) was cut from rib of main dip and 5 feet from face.

The ultimate analysis of a composite sample made by combining face sampl 31199 to 31206, is given under laboratory No. 31207.

System of mining, panel. In 1918 the coal was cut by machine and shot dow with black powder by three shot firers after miners had left mine. Men employe numbered 175 underground and 50 aboveground. The tipple was of wood. Th openings of the screens were 8 inches, 3 inches, and 1½ inches; of the coal going t screens 70 per cent passed through them. The coal was picked on car by two picker The four loading tracks had capacity for 40 empty and 60 loaded railroad cars. Th lump coal on the cars was large and bright; the screenings on the cars were clean an bright. Fifty per cent of the coal was mined in advance work, and the recover claimed was 85 per cent. The unmined area was approximately 1,600 acres, an the estimated lifetime of the mine was 20 years. The daily capacity of mine wa 2,000 tons, the daily average 1,500 tons, and the maximum day's run 2,200 tons.

For descriptions and analyses of other samples of this coal see Bureau of Mine Bull. 123, pp. 32, 170.

MOUNT HARRIS. WADGE MINE.

Analyses 31233 to 31235 (p. 29). Bituminous coal, Yampa field, from Wadge mine a slope mine at Mount Harris, in sec. 15, T. 6 N., R. 87 W., on the Denver & Sal Lake R. R. Coal bed, Wadge; Cretaceous age, Mesaverde formation. Thickness o bed is 8 feet 7 inches, and dip 16 per cent, with rectangular cleat. Roof and floo sandy shale; cover at points of sampling, 400 to 500 feet. The bed was sampled a two points by J. J. Forbes on November 13, 1918, and represented 8 feet 6 inches an 8 feet 7 inches of coal.

Section A (sample 31233) was cut at face of 3 north, main entry. Section B (sampl 31234) was cut at face of 1 north, main entry.

The ultimate analyses of a composite sample made by combining face sample 31233 and 31234 is given under laboratory No. 31235.

System of mining, room and pillar, in panels. In 1918 the coal was cut by han and by mining machines and shot down with black powder. Men employed num bered 80 underground and 30 aboveground. The tipple was of wood. At the tim of sampling the output was 400 tons a day, 50 per cent of which was from advanc workings. None of the coal was shipped as run of mine, but all was screened i shaking screens with 2½ and 1¼ inch spaces. Sizes of coal, lump, nut, and slack The coal was picked on screens by one picker. Haulage was by rope with stea and electric haulage engines. The three loading tracks had capacity for 60 empt and 35 loaded railroad cars. The appearance of the coal on the cars was good. Th estimated lifetime of the mine in 1918 was 30 years. The capacity of the mine wa 1,000 tons a day, and the maximum day's run 698 tons.

For description and analysis of other samples from this mine see Bureau of Mine Bull. 22, pp. 80, 482.

DUNKLEY CANYON. WEBBER MINE.

Analysis 30862 (p. 29). Bituminous coal, Yampa field, from Webber mine, a drift mine at Dunkley Canyon, 10 miles south of Mount Harris, in NW. ¼ sec. 2, T. 4 N., R. 87 W., not on any railroad. Coal bed, Wadge; Upper Cretaceous age, middle coal group of the Mesaverde formation. Bed is 11 feet 9 inches thick and is regular; dip, 54°; cleat, not observed. Bed generally is clear coal, without partings. Roof and floor are of shale. The cover at point of sampling is 25 feet. The bed was sampled by M. R. Campbell September 3, 1919. Sample was a grab sample taken at face and represented most of the coal bed. The face was in too dangerous a condition for a sample to be cut across it. The drift had been driven in about 125 feet and was mined only to supply the needs of a few local ranchmen.

OAK CREEK. ARGO MINE.

Analyses 31130 to 31134 (p. 29). Bituminous coal, Yampa field, from Argo mine, a drift and slope mine 1 mile northwest of Oak Creek, in sec. 36, T. 4 N., R. 86 W., on the Denver & Salt Lake R. R. Coal bed, Argo or Pinnacle; Cretaceous age, Mesaverde formation. Bed is 9 feet 6 inches to 10 feet 10 inches thick; dip, 10° to 12° northwest; cleat on strikes southwest. No faults are encountered; rolls are small and infrequent. One inch of sandstone, and at intervals a little bone are present near the roof. The roof consists of 8 inches sandy shale; the floor is good, medium smooth, of sandy shale. Cover at points of sampling, 800 to 1,000 feet. Elevation of entrance is 7,400 feet above sea level. The bed was sampled by J. J. Forbes on October 6 and 7, 1918, as described below:

Sections of coal bed in Argo mine.

Section	A.		B.		C.		D.	
Laboratory No.	31130		31131		31132		31133	
Roof, sandy shale:	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		5	10	2		8		10
Sandstone		a ¾				a 1		
Coal	9	8¼			1	11		
Bone						2		3
Coal					1	0	8	8
Bone						5		
Coal					5	6		
Floor, sandy shale:								
Thickness of bed	10	2	10	2	9	9	9	9
Thickness of coal sampled	10	1¼	10	2	9	8	9	9

a Not included in sample.

Section A (sample 31130) was cut at face of south entry, 5,000 feet southwest of portal. Section B (sample 31131) was cut 15 feet from face of 9 slope, left rib, 120 feet below south entry. Section C (sample 31132) was cut at face of south slope, 375 feet below 4 level. Section D (sample 31133) was cut at face of 3 level, 2,100 feet from south slope.

The ultimate analysis of a composite sample made by combining face samples 31130 to 31133 is shown under laboratory No. 31134.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down with FF black powder by shot firers after the miners had left the mine. About 100 men were employed aboveground and 250 underground. The tipple was of wood. About 40 per cent of the output was shipped as run of mine. The coal was screened over a screen with 3-inch round perforations and over a shaking screen 12 by 6 feet, with 1¼-inch round perforations. Excluding run of mine, the proportions of sizes shipped were: Slack, 25 per cent; nut, 19 per cent; lump, 56 per cent. Haulage was by three electric motors, electric hoists, and by mules. Two pickers were employed.

The four loading tracks had capacity for 60 empty and 60 loaded railroad cars. T lump coal on the cars had a good appearance, the lumps being large; screenings the cars were bright. About 50 per cent of the coal was mined in advance wor and recovery was about 80 per cent. The unmined area consisted of 1,200 acr The daily capacity of the mine was 2,000 tons, the average output 1,500 tons, a the maximum day's run 2,400 tons. The output for 1917 was 330,000 tons.

WELD COUNTY.

ERIE. PURITAN MINE.

Analysis 31323 (p. 29). "Black lignite" or subbituminous coal, Denver region, calle locally Northern Lignite field, from Puritan mine, a shaft mine 6 miles northeast Erie, in sec. 34, T. 2 N., R. 68 W., on the Union Pacific R. R. The coal is of Cretaceou age, Laramie formation. The bed is 10 feet 6 inches thick and lies flat. Roo "soapy" shale over the 3 feet of top coal left; floor, sandstone; cover at point of sam pling, 110 feet. The bed was sampled by J. J. Forbes on December 12, 1918. Th sample represented the thickness mined, or 6 feet 9 inches of coal.

Sample 31323 was cut at face of 13 room, 4 northwest entry.

System of mining, room and pillar. In 1918 the coal was undercut by punche machines and shot down with FF black powder. Men employed numbered 139 under ground and 20 aboveground. At the time of sampling the output was 1,200 tons day, 60 per cent of which was derived from advance workings; 35 per cent was shippe as run of mine, and 65 per cent was screened in shaking screens with 2½-inch holes Sizes of coal: 2½-inch round-hole slack; 2½-inch lump. Haulage was by motor and b mules. The three loading tracks had capacity for 50 empty and 50 loaded railroa cars. The appearance of the coal on the cars was good. The estimated lifetime o the mine at time of sampling was 15 years. The capacity of the mine was 1,500 ton a day and the maximum day's run 1,626 tons.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 22, pp. 82, 489.

FREDERICK. BAUM MINE.

Analysis 31344 (p. 29). Subbituminous coal, Denver region, locally known as Northern Lignite field, from Baum mine, a shaft mine ½ mile from Frederick, in sec. 36, T. 2 N., R. 68 W., on the Union Pacific R. R. Coal bed, Cretaceous age, Laramie formation. Bed is 6 feet 10 inches thick and lies level; roof, "soapstone"; floor, sandy "soapstone"; cover at point of sampling, 200 feet. The bed was sampled by J. J. Forbes on December 16, 1918. One foot of top coal was left in roof, and the sample represented the remaining thickness of the bed, or 5 feet 6 inches of coal.

Section of coal bed in Baum mine.

Sample 31344 was cut at face of 13 room, 16 northeast entry.

System of mining, room and pillar. The coal is cut by electric chain cutting machines and shot down with black powder. Men employed numbered 50 underground and 30 aboveground. The tipple is of frame construction. At the time of sampling the output was 500 tons a day, 25 per cent of which was derived from advance workings. All the coal was screened in screens with 2½-inch spaces. Haulage was by mules to partings, thence by electric locomotive to bottom. There were three loading tracks, with capacity for 2,000 tons. The estimated lifetime of the mine at time of sampling was 20 years. The capacity of the mine was 1,000 tons a day and the maximum day's run 1,034 tons.

IDAHO.

FREMONT COUNTY.

MONIDA. SCOTT & BUEY MINE.

Analysis 29821 (p. 29). Subbituminous coal, from Scott & Buey mine, in sec. 11, T. 14 N., R. 38 E., 15 miles east of Monida, on the Oregon Short Line. Coal bed, not named; Upper Cretaceous age, Frontier (?) formation. Thickness at point of sampling, 3 feet 8 inches, the sample represented 2 feet 8 inches of coal, which was overlaid by 6 inches of clay and 6 inches of coal. The bed was sampled by G. R. Mansfield on September 15, 1917. The sample, which was cut at face of main entry 110 feet from mine mouth, was weathered.

TETON COUNTY.

DRIGGS. BELLENT MINE.

Analysis 29182 (p. 29). Bituminous coal from Bellent mine, 10 miles west of Driggs, in sec. 36, T. 5 N., R. 43 E., on the Oregon Short Line R. R. Mine has no railroad connection. Coal bed, not named; Upper Cretaceous age, Frontier (?) formation. The bed was sampled by G. R. Mansfield on August 21, 1917.

Section of the coal bed in Bellent mine.

	Ft.	in.
Roof, not noted.		
Coal	3	4
Bone [a]		[a] 2
Clay [a]		[a] 8
Coal [a]	1	0
Bone		[a] 2
Coal	3	0
Floor, not noted.		
Thickness of bed	8	4
Thickness of coal sampled	7	4

The sample was cut at face of main entry, 315 feet north 35° west of mine mouth.

VICTOR. PINE CREEK PASS MINE.

Analysis 29280 (p. 29). Subbituminous coal, from Pine Creek Pass mine, a slope mine 8 miles west of Victor, in sec. 25 (?), T. 3 N., R. 44 E., on the Oregon Short Line R. R. Mine has no railroad connection. Coal bed, not named; Upper Cretaceous age, Frontier (?) formation. The bed was sampled by G. R. Mansfield on September 9, 1917. The sample represented 1 foot 10 inches of coal. The section was measured on north wall of slope, 12 feet from mine mouth, under 12 feet of cover.

ILLINOIS.

CHRISTIAN COUNTY.

PANA. SPRINGSIDE MINE.

Analyses 25748 to 25752 and 26336, 26337, and 26338 (p. 30). Bituminous coal, Illinois field, from Springside mine, a shaft mine 1 mile northeast of Pana, on the Chicago & Eastern Illinois R. R. Coal bed, No. 6; Carboniferous age, Carbondale formation. Bed is 7 feet 6 inches thick and has a slight northeast dip, with frequent rolls or horsebacks; roof, black, slaty shale from a few inches to 14 feet thick, then strong lime-

[a] Not included in sample.

stone; floor, hard, smooth clay several feet thick; cover, about 710 feet. The bed w sampled by J. R. Fleming on August 2, 1916, and October 18, 1916, as describ below:

Sections of coal bed in Springside mine.

Section	A.	B.	C.	D.	E.	F.
Laboratory No.	25748	25749	25750	25751	26336	2633
Roof, black shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft.*
Coal bright, brittle	1 10	2 3½	2 3	8	3 1	2
Bone and "sulphur"	[a] 1	[a] 2		[a] 1	[a] ¾	
"Sulphur" band			[a] ½			
Coal, bright and brittle	6	1 4	5	2 4		
"Sulphur" band				[a] 1		
Bone and "sulphur"	[a] 1½		[a] 1			
"Mother coal" and "sulphur"						
"Mother coal" and bone		[a] ½				
Coal, bright, firm	4	6		1 3		
Coal, laminated dull			4		3 3	3
"Sulphur" band			[a] ½	[a] ¾		
Bone and "sulphur"	[a] 1	[a] 1½				
Coal, hard bright		4		6		
Coal laminated with dull bands	2 6		2 6			
"Blue band," bone and coal						[a]
"Sulphur" bands	[a] ½	[a] ½		[a] ½		
Shale, "blue band"					[a] 1½	
Coal, bright hard				10		1
Coal, hard dull	10	8			1	
"Sulphur" band		[a] ½				
Coal, laminated dull		11				
Shale bands and coal	[a] 5	[a] 5	[a] 2½	[a] 5		
Coal, hard dull	1 0	1 0	1 0	9		
Floor, clay.						
Thickness of bed	7 8¾	7 10	6 10½	7 4	7 4	7
Thickness of coal sampled	7 0	7 ½	6 6	6 9	7 2	6 1

[a] Not included in sample.

Section A (sample 25748) was cut in 20 main entry, main north, 5,400 feet fro shaft. Section B (sample 25749) was cut in room 13, 17 west, main north, 5,400 fe from shaft. Section C (sample 25750) was cut in room 10, 5 south, off 5 east, off ma north, 2,700 feet from shaft. Section D (sample 25751) was cut at face of 7 east, o main north, 4,500 feet from shaft. Section E (sample 26336) was cut in room 9, off north, off main east south, 4,800 feet southeast of shaft. Section F (sample 2633 was cut at face of main east south entry, 5,400 feet southeast from shaft.

The ultimate analysis of a composite sample made by combining samples 257 to 25751 is given under laboratory No. 25752. The ultimate analysis of a composi sample made by combining samples 26336 and 26337 is given under laborato No. 26338.

System of mining, room and pillar, in panels. In 1916 the mining was done by ha on bench above "blue band"; the top was shot down and the bottom shot up lat with FF black powder. The daily average output of the mine was 1,125 tons, most derived from advance workings. Forty per cent of the coal passed through a 1¼-inc screen. All coal going to washery was crushed to 3½-inch size. There was tra capacity for 60 empty and 60 loaded cars. The probable lifetime of the mine w about 25 years.

FRANKLIN COUNTY.

Buckner. United No. 14 Mine.

Analysis 26129 (p. 30). Bituminous coal, Illinois field, from United No. 14 mine, shaft mine ½ mile east of Buckner, on the El Dorado–St. Louis branch of the Illinois Ce tral R. R.; also served by the Chicago, Burlington & Quincy R. R. Coal bed: Herrin, No. 6, of the Illinois Geological Survey; Carboniferous age, Carbondale formatio Bed averages 9 feet 6 inches in thickness; roof, gray shale; floor, fire clay; cover sampling, 550 feet. The bed was sampled by J. R. Fleming on September 13, 1916, as described below:

Section of coal bed in No. 2 mine.

	Ft.	in.
Roof, shale.		
Top coal [a]	2	0
Coal, bright, brittle	1	0
Bone [a]		1
Coal, laminated with dull streaks	4	3
"Blue band," shale [a]		1
Coal, hard	1	4
Floor, fire clay.		
Thickness of bed	8	9
Thickness of coal sampled	6	7

Sample 26129 was cut at face of 8 panel, off 6 north, off main east, inby room neck No. 9.

The shaft is 555 feet deep. System of mining, room and pillar, in panels. In 1916 the coal was all undercut by chain breast machines and shot down with permissible explosive. Daily average output, over 4,000 tons; capacity, 5,000 tons.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 123, pp. 33, 171.

BUSH. BUSH NO. 2 MINE.

Analyses 30877 to 30881 (p. 30). Bituminous coal, Illinois field, from Bush No. 2 mine, a shaft mine 1½ miles northwest of Bush, in sec. 31, T. 7 S., R. 1 E., on the Missouri Pacific R. R. Coal bed, Herrin, or No. 6; Carboniferous age, Carbondale formation. Bed is 7½ to 12 feet thick, and averages 10 feet. There are top, middle, and bottom benches; top bench left as roof in mine. "Blue band" about 1½ inches, 18 to 30 inches above the coal. Lower coal is thickest where whole bed is thickest. Coal rather soft; "sulphur" streaks very common. Fault crosses main north entry just off bottom. About midway of bed is a persistent layer of "mother coal." Roof, gray shale 18 feet thick; floor, fire clay, which heaves a little. Cover at points of sampling, 160 feet. The bed was sampled by G. H. Cady and C. R. Schroyer on August 27, 1918, as described below:

Sections of coal bed in Bush No. 2 mine.

Section	A.		B.		C.		D.	
Laboratory No.	30877		30878		30879		30880	
Roof, gray shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	[a] 1	3	[a] 3?	0	[a] 1	6?	[a] (?)	
Coal	3	1½	3	2	3	4	3	2
"Soot band"		¼		2¼		½		⅛
Coal	1	8	2	0	1	9	1	10
"Blue band"		[a] 1½		[a] 1½		[a] 1½		[a] 2
Coal	1	5½	2	11	1	9	1	6
Floor, gray clay.								
Thickness of bed	7	7½	11	4¾	8	5¾	6	8⅛
Thickness of coal sampled	6	3	8	3¼	6	10½	6	6⅛

Section A (sample 30877) was cut at face of main northeast entry, 1,100 feet east and 400 feet north of shaft. Section B (sample 30878) was cut at end of northwest entry, 1,400 feet west and 300 feet north of shaft. Section C (sample 30879) was cut at face of 5 south entry, 2 west entry, south, 500 feet south, 1,000 feet west of shaft. Section D (sample 30880) was cut at end of main south entry, 1,200 feet south of shaft.

The ultimate analysis of a composite sample made by combining face samples 30877 to 30880 is given under laboratory No. 30881. At time of sampling the daily output was 2,000 tons.

[a] Not included in sample.

CHRISTOPHER. OLD BEN NO. 10 MINE.

Analyses 29741 to 29747, and 29754 (p. 31). Bituminous coal, Illinois field, from Old Ben No. 10 mine, a shaft mine 1 mile north of Christopher, on the Chicago, Burlington & Quincy R. R. Coal bed, Herrin, or No. 6, in the Illinois Geological Survey; Carboniferous age, Carbondale formation. The bed contains a "blue band" 2 to 10 inches thick, and is 7 to 10 feet thick. No faults, but a few rolls or horsebacks, are encountered. Roof, average, 18 inches of roof coal and main roof shale; floor, hard, smooth fire clay; vertical depth from surface at point of sampling, 600 feet. The bed was sampled by W. B. Plank on February 13 to 15, 1918, as described below:

Sections of coal bed in No. 10 mine.

Section	A.		B.		C.		D.		E.		F.		G.	
Laboratory No	29741		29742		29743		29744		29745		29746		29754	
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Roof, shale and coal.														
Top coal													2	1
Coal	5	4½	6	0	4	0	3	2		9	4	½	[a] 4	0
"Mother coal"						½				¼		½		[a] ¼
Coal						10				10	1	6½		[a] 10
"Mother coal"						¼				¼				[a] ¼
"Sulphur"								½						
Coal					1	1	1	10½		8½			[a] 1	1
"Blue band"		[a] 2½				[a] 3¼		[a] 2½						[a] 3½
"Mother coal"										1½				
Coal	1	5			2	0	2	3½	3	5			[a] 2	0
Bony coal		[a] 4½		6						9½		9½		
Coal		3												
Floor, fire clay.														
Thickness of bed	7	7½	6	6	8	3	7	7	6	8	6	5	10	4
Thickness of coal sampled	7	½	6	6	7	11¾	7	4½	6	8	6	5	2	1

[a] Not included in sample.

Section A (sample 29741) was cut from last crosscut, 12 northeast entry, at mouth of 1 east. Section B (sample 29742) was cut at 12 room neck, 5 west, 6 southwest. Section C (sample 29743) was cut at face of 19 room, 10 northwest, 100 feet from 10 northwest. Section D (sample 29744) was cut from last crosscut, 3 northeast at mouth of 4 west. Section E (sample 29745) was cut at face of 14 southwest entry at 22 room. Section F (sample 29746) was cut at last crosscut, 11 west, 3 southeast, at 8 room. Section G (sample 29754) was cut at 18 room, 10 northwest, 60 feet from entry, top coal.

The ultimate analysis of a composite sample made by combining face samples 29741 to 29746 is given under laboratory No. 29747.

System of mining, panel. In 1918 the coal was cut by machine and shot down with permissible explosives by four shot firers. Men employed numbered 430 underground and 75 above ground. The tipple was of steel, having a rescreener and self-dumping cage. None of the output was shipped as run of mine. Sizes of coal: 6-inch lump and 3 by 6 inch egg, prepared in tipple; Nos. 1, 2, and 3 nut, prepared in rescreeners. Haulage was by 17 electric locomotives. The coal was picked on picking tables by 10 to 12 pickers. There was track capacity for 50 empty and 50 loaded railroad cars. Fifty per cent of the coal was taken out in advance work, and total recovery was about 55 per cent. The unmined area comprised 600 acres, and the estimated lifetime of the mine was 12 years. The capacity of the mine in 1918 was 4,000 tons a day; the actual average 3,000 tons, and the maximum day's run 3,450 tons.

CHRISTOPHER. OLD BEN NO. 11 MINE.

Analyses 30892 to 30896 (p. 31). Bituminous coal, Illinois field, from Old Ben No. 11 mine, a shaft mine 1¾ miles north of Christopher, in sec. 14, T. 6 S., R. 1 E., on the Chicago, Burlington & Quincy R. R. Coal bed, Herrin, or No. 6; Carboniferous ge, Carbondale formation. The thickness of the bed averages 10 feet 2 inches. There are three distinct benches—lower one (below "blue band"), middle, and upper; lower part of lower bench is very hard and thin-bedded. Cover at points of sampling, 90 feet. The bed was sampled by C. R. Schroyer on September 5, 1918, as described below:

Sections of coal bed in Old Ben No. 11 mine.

Section	A.	B.	C.	D.
Laboratory No.	30892	30893	30894	30895
Roof, gray clay shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal			4 6?	2½–3
Coal	3 8½	1 7	2 11	3 3½
Coal, dull and bright		1 0		2 8
Coal, bright		1 11		
"Mother coal"	½	1		
Coal	1 10	6½	2 0	
"Blue band"		[a] 5½		[a] 1½
Clay, coaly	[a] 1½			
"Mother coal"			1½	
Coal	2½		2½	
Gray rock	[a] 3		[a] 2½	
Coal	1 10	1 3½	2 4	2 0
Coal, hard thin		7		3
Floor, gray clay.				
Thickness of bed	8 0	7 5	12 3½	8 4
Thickness of coal sampled	7 7½	6 11¾	12 0¾	8 2½

[a] Not included in sample.

Section A (sample 30892) was cut at face of 2 north entry, 12 west entry, 1 northwest entry, 1,000 feet west, 3,500 feet north of main shaft. Section B (sample 30893) was cut at face of main west entry, 4,500 feet west of main shaft. Section C (sample 30894) was cut at face of 1 northeast entry, 2,700 feet east and 300 feet north of main shaft. Section D (sample 30895) was cut at face of 1 southeast entry, 4 east panel, 29 room, 2,000 feet east of main shaft.

The ultimate analysis of a composite sample made by combining face sample 30892 to 30895 is given under laboratory No. 30896. At time of sampling the daily output was 4,500 tons.

HERRIN. No. 5 (FRANKLIN EMERY) MINE.

Analyses 30867 to 30871 (p. 31). Bituminous coal, Illinois field, from No. 5 (Franklin Emery) mine, a shaft mine 4 miles north and 1 mile east of Herrin, in sec. 33, T. 7 S., R. 2 E., on the Chicago, Burlington & Quincy R. R. Coal bed, Herrin, or No. 6; Carboniferous age, Carbondale formation. Thickness of bed, maximum, 12 feet; minimum, 9 feet; average, 10 feet. The bed contains three well-defined benches; "blue band," the only common impurity, varies from 18 to 36 inches above bottom of bed. Coal rather uniform, bright, and lustrous. Roof, gray, sandy shale, or coal, fairly constant, in places rolling; floor, fire or floor clay; cover at points of sampling, 340 feet. The bed was sampled by G. H. Cady and C. R. Schroyer on August 28, 1918, as described below:

Sections of coal bed in No. 5 (Franklin Energy) mine.

Section	A.	B.	C.	D.
Laboratory No.	30867	30868	30869	30870
Roof, gray sandy shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	4 1	1 9½	4 4	7 9
"Mother coal"	¼	¼		
Coal	7½	1 10½	2 9	
"Mother coal"	1¼	¼		
Coal	2 8½	2 6½		
"Blue band"	[a] 1½		[a] 1½	
Coal	2 6	1 6	2 4	
Floor, gray clay.				
Thickness of bed	10 2	7 8¾	9 6½	7 9
Thickness of coal sampled	10 ½	7 8¾	9 5	7 9

[a] Not included in sample.

Section A (sample 30867) was cut at face of 14 room, 7 northwest entry, 2,300 west and 740 feet north of shaft. Section B (sample 30868) was cut in crosscut betw 1 and 2 northeast entries, 1,115 feet north and 515 feet east of shaft. Section C (sam 30869) was cut at face of 3 room, 7 southeast entry, 1,400 feet east, and 515 feet so of shaft. Section D (sample 30870) was cut in stub of 7 west entry, 4 south, off w 2,140 feet south and 1,540 feet west of shaft.

The ultimate analysis of a composite sample made by combining face sam 30867, 30868, 30869, and 30870 is given under laboratory No. 30871. At time sampling daily output was 1,500 tons.

Orient. Orient Mine.

Analyses 30266, 30267, 30844, and 31050 (p. 31). Car samples of bituminous c Illinois field, from Orient mine, a shaft mine, 520 feet deep, at Orient, on a spur conn ing with the Chicago, Burlington & Quincy, the Chicago & Eastern Illinois, and Illi Central Railroads. Coal bed, Herrin, or No. 6, of the Illinois Geological Surv Carboniferous age, Carbondale formation. Two samples of coal, one (30266) repres ing 15 cars and one (30267) 17 cars, were collected by W. B. Plank on April 3 an 1918. One sample (30844) of coal, representing 32 cars, was collected by T. Frase July 22 to 24, 1918; one sample (31050) of coal, representing 159 cars, was collecte T. Fraser on September 13 to 23, 1918. At the time of sampling the average d capacity was 5,000 tons and the maximum day's run 6,777 tons. Loaded tr capacity, 250 cars.

For description and analyses of other samples of coal from this mine see Bu of Mines Bull. 123, pp. 33, 173.

Royalton. North or No. 1 Mine.

Analyses 30205 and 30207 (p. 32). Bituminous coal, Illinois field, from North or 1 mine, opened by two shafts 317 feet deep at Royalton, on the Missouri Pacific R Coal bed, Herrin, or No. 6, of the Illinois Geological Survey; Carboniferous Carbondale formation. Thickness of the bed averages from 7 to 11 feet; from 1½ feet of roof coal is left in mining. Roof, gray shale; floor, fire clay; a "blue ba consisting of bony coal or shale and averaging from ½ inch to several inches t lies about 18 inches above the floor and is rejected by miners. Two car samp one (30205) representing 13 cars and one (30207) representing 22 cars of coal, collected by W. B. Plank on March 26 and 27, 1918.

System of mining, double-entry room and pillar. Prior to October 1, 1918, black powder was used for blasting down the coal in the rooms, but permissible ex sives with No. 6 detonators were used in the entries only; since that time permis explosives have been installed and used entirely. Machines were used for un cutting the coal. About 500 men were employed underground. Haulage was electric locomotives and by mules. The daily average output of mine was 3,800 and the maximum day's run 4,154 tons. In 1917, 555,565 tons of coal were mined; output for 1918 was 644,323 tons.

For description and analyses of other samples from this mine see Bureau of Mi Bull. 123, pp. 33, 174.

Sesser. Sesser Coal Co. No. 1 Mine.

Analyses 26492 to 26497 and car samples 30206, 30208, 30485, and 30486 (p. Bituminous coal, Illinois field, from No. 1 mine, a shaft mine 640 feet deep, 1½ m southeast of Sesser, on the Chicago, Burlington & Quincy R. R. Coal bed, Herrin No. 6, of the Illinois Geological Survey; Carboniferous age, Carbondale formati Bed is 7 to 8 feet thick, excluding top coal left on roof; roof, gray, dirty shale; fl clay; cover at points of sampling, 650 feet. Car samples representing 32 cars w taken by W. B. Plank on about March 25, 1919: sample 30206 represented 9 cars; sample 30208 represented 5 cars; sample 30485 represented 10 cars; sample 30486 represented 8 cars. The bed was sampled by J. R. Fleming on October 27 and 28, 1916, as described below:

Sections of coal bed in No. 1 mine.

Section	A.		B.		C.		D.		E.	
Laboratory No.	26492		26493		26494		26495		26496	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Top coal	a 2	6	a 2	6	a 2	4	a 2	0	a 2	0
Coal, bright	5	3	3	0	5	1	5	7	2	1
Bone and "mother coal"				½						
Bone and "sulphur"						a ½				
"Mother coal"										½
Coal, bright			1	8		8			3	2
Bone				a 1						
Coal, bright				7						
"Blue band"		a 1		a 1½		a 1½		a 1½		a 1½
Coal, bright, hard	1	8	1	10	3	1	1	6	1	7
Floor, clay.										
Thickness of bed	7	0	7	4	7	0	7	2½	7	0
Thickness of coal sampled	6	11	7	1½	6	10	7	1	6	10½

a Not included in sample.

Section A (sample 26492) was cut at face of main east entry, 4,400 feet east of shaft. Section B (sample 26493) was cut at face of 1 new south entry, off main east, 5,000 feet southeast of shaft. Section C (sample 26494) was cut in 2 room, 3,200 feet east 10° south of shaft. Section D (sample 26495) was cut at face of main north entry, 4,400 feet north of shaft. Section E (sample 26496) was cut at face of 8 east entry, main north entry, 3,000 feet northeast of shaft.

The ultimate analysis of a composite sample made by combining face samples 26492, 26493, 26494, 26495, and 26496 is given under laboratory No. 26497.

The mine is operated on the panel system. In 1916 the coal was undercut by chain machines and by puncher machines, which were to be changed to electric-chain machines. Permissible explosive was used in blasting. Four sizes of coal were loaded. The daily output of the mine in 1916 was 3,000 tons, which equals the capacity.

WEST FRANKFORT. OLD BEN NO. 8 MINE.

Analyses 30887 to 30890 (p. 33). Bituminous coal, Illinois field, from Old Ben No. 8 mine, a shaft mine ½ mile south of West Frankfort, in sec. 25, T. 7 S., R. 2 E., on the Illinois Central, Chicago & Eastern Illinois, and Chicago, Burlington & Quincy Railroads. Coal bed, Herrin, or No. 6; Carboniferous age, Carbondale formation. Maximum thickness of bed, 10 feet; minimum, 7 feet 6 inches; average, 9 feet; roof, poor, gray clay, top coal left; floor, gray clay shale; cover at points of sampling, 464 feet. The bed was sampled by C. R. Schroyer on September 3, 1918, as described below:

Sections of coal bed in Old Ben No. 8 mine.

Section	A.		B.		C.	
Laboratory No.	30887		30888		30889	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	a 1	3?				
Coal	2	6½	3	9¼	1	10
"Mother coal"		½				½
Coal	4	1½				8
Pyrite and "mother coal"				1		⅞
Coal			1	9	2	4½
"Blue band"		a 1½		a 1½		a 1
Coal	1	10	1	7½	1	9
Floor, clay-shale.						
Thickness of bed	9	10¾	7	4	6	8⅞
Thickness of coal sampled	8	6½	7	2¾	6	7⅞

a Not included in sample.

Section A (sample 30887) was cut in face of 4 east, north entry, 5,200 feet ea 4,700 feet north of shaft. Section B (sample 30888) was cut at face of 6 west main south entry, 3,200 feet south and 3,600 feet west of shaft. Section C (s 30889) was cut at face of main south entry, 6,100 feet south of shaft.

The ultimate analysis of a composite sample made by combining face samples 3 30888, and 30889 is given under laboratory No. 30890. At time of sampling the output of the mine was 4,500 tons of coal.

West Frankfort. Old Ben No. 9 Mine.

Analyses 30882 to 30886 (p. 33). Bituminous coal, Illinois field, from Old Ben mine, a shaft mine 1 mile east of West Frankfort, in sec. 20, T. 7 S., R. 3 E., o Chicago, Burlington & Quincy R. R. Coal bed, Herrin, or No. 6; Carboniferou Carbondale formation. Maximum thickness of bed is 9 feet 4 inches; minimu feet; average, 9 feet. The coal is rather hard and has a bright luster. Roof, clay shale, top coal left; floor, clay and shale. The bed was sampled by C. R. Sch on September 4, 1918, as described below:

Sections of coal bed in Old Ben No. 9 mine.

Section	A.		B.		C.		D
Laboratory No.	30882		30883		30884		30
Roof, clay shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft*
Coal	4	9¾	3	9¾	4	9¾	3
"Mother coal"				1			
Coal			1	5			
"Blue band"		[a]1¼		[a]1¼		[a]1¼	
Pyrite							
Coal	1	10	1	4	1	10	3
Coal				6			
Floor, clay and shale.							
Thickness of bed	6	9	7	3	6	9	6
Thickness of coal sampled	6	7¾	7	1¾	6	7¾	6

[a] Not included in sample.

Section A (sample 30882) was cut at face of 4 west entry, main south, 1,950 feet and 2,300 feet south of main shaft. Section B (sample 30883) was cut at face of 1 entry, northeast, 2,875 feet east and 700 feet north of main shaft. Section C (sam 30884) was cut at face of main south entry, 4,800 feet south and 300 feet east of m shaft. Section D (sample 30885) was cut in back north entry, 4,200 feet north and feet east of shaft.

The ultimate analysis of a composite sample made by combining face samples 30 30883, 30884, and 30885 is given under laboratory No. 30886. At time of sampling daily output was 4,500 tons.

PERRY COUNTY.

Duquoin. Paradise Mine.

Analyses 26462 to 26469 (p. 33). Bituminous coal, Illinois field, from Paradise mi a shaft mine 380 feet deep, 3 miles east of Duquoin, on the Illinois Central R. R. C bed, Herrin, or No. 6, of the Illinois Geological Survey; Carboniferous age, Carbond formation. Bed is 9 feet to 10 feet 6 inches thick; roof, gray, slaty shale, top coal be left up; floor, underclay, 4 feet thick; cover at points of sampling, 380 feet. The b was sampled by J. R. Fleming on October 21, 1916, as described below:

Sections of coal bed in Paradise mine.

ion	A. 26462	B. 26463	C. 26464	D. 26465	E. 26466	F. 26467
f, shale.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Top coal	[a]2 6	[a]2 0	[a]2 6	[a]3 0	[a]3 0	[a]2 6
Top parting	Streak.	Streak.				
Top coal			[a]9	[a]9		
Coal (bright)	2 5	1 11		5		
Bone	[a]½					
Coal, laminated	8					
Bone and shale		[a]1				
Coal, with dull laminations		3 8				
Bone and "sulphur"	[a]1			[a]1½		
Coal, from dull to bright			3 8			
Coal, dull and bituminous bands				3 4		
"Rashy" coal					[a]11	
Coal with "mother coal" partings					4 0	1 5
"Blue band"		[a]4	[a]2	[a]5	[a]1	
Coal, hard	2 4	1 7	1 11			
Coal, bright				1 8½	1 6	3 6
"Blue band"	[a]1½					[a]½
Coal, hard	1 6					1 10
Bottom coal		[a]7				
or, clay.						
Thickness of bed	9 8	10 2	9 0	9 9	9 6	9 3½
Thickness of coal sampled	6 11	7 2	5 7	5 5½	5 6	6 9

[a] Not included in sample.

Section A (sample 26462) was cut at room 26, 2 south, main east, 2,800 feet south of aft. Section B (sample 26463) was cut at face of 12 south entry, 2 plug east. Secon C (sample 26464) was cut at face of main east entry. Section D (sample 26465) as cut at face of main north entry. Section E (sample 26466) was cut at face of 7 est entry, main north entry, 4,400 feet north-northwest of shaft. Section F (sample 467) was cut at face of 9 south entry, 5 west, main north, 3,600 feet northwest of shaft.

The ultimate analysis of a composite sample made by combining face samples 462, 26463, 26464, 26465, 26466, and 26467 is shown under laboratory No. 26468. sample of top coal was also taken, for the proximate analysis of which see laboratory o. 26469. This sample was cut at room 6, 10 south, main east.

System of mining, room and pillar, in panels. In 1916 the coal was undercut by ain mining machines and shot with black blasting powder. The coal was hand icked on a shaker screen and on the car. There were four loading tracks under the pple. Egg and nut sizes of coal were rescreened. The daily capacity of the mine 1 1916 was 3,000 tons and the average daily output 2,500 tons.

DUQUOIN. SECURITY No. 1 MINE.

Analyses 31033 to 31037 (p. 33). Bituminous coal, Illinois field, from No. 1 mine, shaft mine 3 miles south of Duquoin, in sec. 29, T. 6 S., R. 1 W. Coal bed, Herrin, r No. 6; Carboniferous age, Carbondale formation. Thickness of bed varies from 7 eet to 9 feet; average, 7 feet 6 inches; roof, "soapstone"; floor, gray, clay shale; cover t points of sampling, 85 feet. The bed was sampled by C. R. Schroyer on September 0, 1918, as described below:

Sections of coal bed in No. 1 mine.

Section	A. 31033	B. 31034	C. 31035	D. 31036
Roof, "soapstone."	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Coal	[a]1 0	[a]Coal.	[a]2 0	[a]1 (?)
Coal	5 0	2 6	1 0	5 2
Clay and "mother coal"	½	½	½	1½
Coal	1½	2 9	7	1½
"Mother coal"			½	
Coal			2 8½	
"Blue band"	[a]2	[a]1½	[a]1½	[a]1½
Coal	1 0	1 1½	1 2½	8
Floor, gray clay shale.				
Thickness of bed	7 4½	6 6	7 8½	7 2½
Thickness of coal sampled	6 2½	6 4½	5 6½	6 1½

[a] Not included in sample.

Section A (sample 31033) was cut in 17 north entry, 4 west north, 2 room, 1 feet north and 5,000 feet west of shaft. Section B (sample 31034) was cut at face south entry, 8 west south, about 4,000 feet south and 1,000 feet west of shaft. Sec C (sample 31035) was cut at face of 8 room, south of 6 east south, 2,500 feet south 2,000 feet east of shaft. Section D (sample 31036) was cut at face of 18 south entr west south, 3,200 feet west and 1,200 feet south of shaft.

The ultimate analysis of a composite sample made by combining samples 31 31034, 31035, and 31036 is given under laboratory No. 31037. At time of sampling daily production was 2,700 tons.

SALINE COUNTY.

GRAYSON. SALINE NO. 6 MINE.

Analyses 28448, 28449, and 28450 (p. 33). Bituminous coal, Illinois field, f Saline No. 6, a shaft mine, 330 feet deep, at Grayson, 2½ miles east of Eldorado the Louisville & Nashville and the Big Four Railroads. Coal bed, Herrin, or No of the Illinois Geological Survey; Carboniferous age, Carbondale formation. The is rather firm and is 5 to 7 feet thick; roof, shale, characterized by numerous py concretions, called "nigger heads"; floor, clay; cover at points of sampling, 350 f The bed was sampled by J. R. Fleming on May 15 and 16, 1917, as described bel

Sections of coal bed in No. 6 mine.

Section	A.		B
Laboratory No.	28448		284
Roof, slaty shale.	*Ft.*	*in.*	*Ft.*
Coal, bright	3	4½	2
Bone and shale		a ½	.....
Bone and "sulphur"	....		
Coal, hard, lustrous	1	8	1
"Sulphur"	....		Str
Coal, bright, hard	....		1
Floor, clay.			
Thickness of bed	5	1	5
Thickness of coal sampled	5	½	4

a Not included in sample.

Section A (sample 28448) was cut in face of 7 room, 8 east, 3 southwest entry. S tion B (sample 28449) was cut in face of 5 west, 4 southwest entry.

The ultimate analysis of a composite sample made by combining face sam 28448 and 28449 is given under laboratory No. 28450.

System of mining, room and pillar. In 1917 the coal was undercut by ch machines, both shortwall and breast. FF black blasting powder was used, the sh being fired by shot firers after miners had left the mine. Men employed numbe 180 underground. Haulage was by loose-gate cars and by mules. The daily p duction at time of sampling averaged 1,150 tons.

WILLIAMSON COUNTY.

HERRIN. POND CREEK (BOBBY DIX) MINE.

Analyses 30872 to 30876 (p. 34). Bituminous coal, Illinois field, from Pond Cr (Bobby Dix) mine, a shaft mine 4 miles northeast of Herrin, in sec. 5, T. 8 S., R. 2 on the Chicago, Burlington & Quincy R. R. Coal bed, Herrin, or No. 6; Carbonifer age, Carbondale formation. Bed averages 8½ feet in thickness; the maximum va tion is about 10 to 15 feet. The coal is rather soft and brittle, and there is much f coal. There are three benches, the top one being left as roof; "blue band," maxim 1½ inches, 17 to 26 inches above bottom; thin seams of "mother coal" at seve horizons in middle bench. Roof, 18 to 20 inches of top coal, above which is gray shale ("soapstone"), 15 to 18 feet; floor, gray clay shale, generally level. The bed was sampled by C. R. Schroyer on August 29, 1918, as described below:

Sections of coal bed in Pond Creek (Bobby Dix) mine.

Section	A.		B.		C.		D.	
Laboratory No.	30872		30873		30874		30875	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, top coal and "soapstone."								
Coal		a (?)	a 2?	0	a 1?	8	a 1	6
Coal		2	3	8	5	4½	4	3½
Pyrite		¼						
Coal	2	6						
"Mother coal"		½		½				
Coal	1	10	1	4				
"Mother coal"		½						
Coal	1	6						
"Blue band"		a 1½		1½		½		½
Coal	1	2	1	8	1	5	2	2
Coal			a 1?					
Floor, gray clay shale.								
Thickness of bed	7	4¾	9	10	8	6	8	0
Thickness of coal sampled	7	3¼	6	10	6	10	6	6

a Not included in sample.

Section A (sample 30872) was cut at face at end of main south entry, about 1,500 feet south of shaft. Section B (sample 30873) was cut at face at end of main north entry, 1,500 feet north of shaft. Section C (sample 30874) was cut at face of 6 east entry, main south, 1,200 feet south and 1,800 feet east of shaft. Section D (sample 30875) was cut at face of 5 southwest entry, 1,500 feet south and 1,000 feet west of shaft.

The ultimate analysis of a composite sample made by combining face samples 30872, 30873, 30874, and 30875 is given under laboratory No. 30876. The daily output at time of sampling was 1,600 tons.

RENDVILLE. No. 2 (WEAVER) MINE.

Analyses 30863 to 30866 (p. 34). Bituminous coal, Illinois field, from No. 2 (Weaver) mine, a shaft mine 3¾ miles northwest of Herrin, in sec. 1, T. 8 S., R. 1 E., on the Illinois Central and Chicago, Burlington & Quincy Railroads. Coal bed, Herrin, or No. 6; Carboniferous age, Carbondale formation. Bed varies in thickness from 8 feet 7 inches to 10 feet 4 inches. There are three benches; the top bench, 1 foot 4 inches to 2 feet of hardest coal, was left for roof. Roof, gray clay shale; floor, clay shale; cover at point of sampling, 210 feet. The bed was sampled by C. R. Schroyer on August 31, 1918, as described below:

Sections of coal bed in No. 2 (Weaver) mine.

Section	A.		B.		C.	
Laboratory No	30863		30864		30865	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "soapstone."						
Coal	1	4	7	1	a 1	6
Coal	5	8		a 3	3	6½
"Mother coal"						½
Coal					1	6
"Blue band"		a 2		a 2½		a 1½
Coal	1	7	a 2	0?	1	11
Floor, gray clay shale.						
Thickness of bed	8	9	9	6½	8	7
Thickness of coal sampled	8	7	7	1	6	11½

a Not included in sample.

Section A (sample 30863) was cut in back south entry, main south, 3,200 feet sou of shaft. Section B (sample 30864) was cut at face of 3 west entry, main north ent 800 feet north and 3,600 feet west of shaft. Section C (sample 30865) was cut at fa of 7 west south entry, 2,500 feet south and 1,000 feet west of shaft.

The ultimate analysis of a composite sample made by combining face samp 30863, 30864, and 30865 is given under laboratory No. 30866. At time of sampli the daily output was 2,300 tons.

HERRIN. REND NO. 2 MINE.

Analyses 28810 to 28815 (p. 34). Bituminous coal, Illinois field, from Rend No mine, a shaft mine, 215 feet deep, 4½ miles northwest of Herrin, on the Illinois Ce tral and Chicago, Burlington & Quincy Railroads. Coal bed, Herrin, or No. 6, Illinois Geological Survey; Carboniferous age, Carbondale formation. Bed is 7 fee inches to 11 feet 6 inches thick, including about 2 feet of coal left up for roof. T bed was sampled by J. R. Fleming on June 7 to 8, 1917, as described below:

Sections of coal bed in No. 2 mine.

Section	A.		B.		C.		D.		E.	
Laboratory No	28810		28811		28812		28813		2881	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	
Roof, shale.										
Top coal, not sampled	a 2	0	a 1	10	a 2	1	a 2	3	a 1	
Coal, banded		8								
Coal				8		9				
Coal, hard, bright	4	4								
Bone				½		a ½		a 1		
Coal			4	3	1	2½				
Coal, with a few partings							4	11		
Coal, slightly laminated									5	
Bone						a ½				
Coal					3	½				
"Blue band"		a 1		a ½		a ½		a 1		
Coal	1	9	2	0	2	½	1	7	2	
Bottom coal, "sulphury"								a 2		
Floor, clay.										
Thickness of bed	8	10	8	10	9	4	9	1	9	
Thickness of coal sampled	6	9	6	11½	7	½	6	6	7	

a Not included in sample.

Section A (sample 28810) was cut at face of 10 east entry, main south. Section (sample 28811) was cut at face of 7 room, 1 south stub, 8 west, main south. Sectior (sample 28812) was cut at in 12 room, 3 west, main north. Section D (sample 2881 was cut at in 2 room, 2 north panel, 2 east, main north. Section E (sample 2881 was cut in 26 room, 1 east, main south.

The ultimate analysis of a composite sample made by combining face samples 2881 28811, 28812, 28812, and 28814, is given under laboratory No. 28815.

System of mining, room and pillar. In 1917 the coal was undercut by chain m chines and shot down with FF black powder. All of the coal was screened. T daily capacity of the mine at time of sampling was 3,500 tons.

INDIANA.

GREENE COUNTY.

JASONVILLE. GILMOUR NO. 7 MINE.

Analyses 31295 to 31299 (p. 34). Bituminous coal, bituminous coal field, from G mour No. 7 mine, a shaft mine 3 miles southwest of Jasonville, on the Southeaste R. R., with Chicago, Indianapolis, and Louisville connections. Coal bed, No. 4 of t Indiana Geological Survey; Carboniferous (Allegheny) age, Carbondale formatio Bed is 4½ to 5½ feet thick; dip, southwest; cleat, indistinct. Occasional rolls a encountered. There is a middle band of bony coal and carbonaceous shale. Ro shale; no roof coal; floor, hard, smooth clay; vertical depth to landing below entranc

145 feet. The bed was sampled by T. Fraser and J. J. Bourquin on November 18, 1918, as described below:

Sections of coal bed in Gilmour No. 7 mine.

Section	A.		B.		C.		D	
Laboratory No.	31298		31297		31295		31296	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.								
"Rash" coal		2½		a 1½		a 2		a 2
Coal	1	9	1	10½	1	8	1	9
Shale		¼		a 1	(b)		(b)	
Coal		2½		9		2½	....	
Bone		¼	(b)			a 2		a 1½
Coal	1	9	....		....		....	
"Mother coal"		½	....		....		....	
Coal		4½	1	5½	2	3	2	3½
Floor, hard clay.								
Thickness of bed	4	4½	4	3½	4	5½	4	4
Thickness of coal sampled	4	4½	4	¾	4	1½	4	½

a Not included in sample. b "Sulphur" streak.

Section A (sample 31298) was cut at face of 5 room, 2 south, 18 west, south. Section B (sample 31297) was cut at face of 17 east, south, opposite 4 south. Section C (sample 31295) was cut 10 feet from face of 15 east, south. Section D (sample 31296) was cut at face of 6 room, 6 south, 15 east, south.

The ultimate analysis of a composite sample made by combining face samples 31295, 31296, 31297, and 31298 is given under laboratory No. 31299.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down by the miners, at time of going off shift, with FFF black powder. Men employed numbered 80 underground and 10 above ground. The tipple was of steel. Self-dumping cages were used. The coal was screened through shaking screens with 1½-inch holes. The lump coal was coked at the average rate of 750 tons daily. The coal was picked on car and on shaker screens by four men. Haulage was by two electric locomotives and by mules. The three loading tracks had capacity for 30 empty and 30 loaded railroad cars. The lump coal on cars was of medium size and good appearance; the screenings on cars appeared good. The entire output was mined from advance work, and the total recovery claimed was 75 per cent. The unmined area in 1918 was approximately 1,000 acres. The probable lifetime of the mine was 5 years. The daily capacity was 1,000 tons, the daily average 750 tons, which was to be increased to 1,000 tons, and the maximum's day run 1,162 tons.

LINTON. VANDALIA NO. 24 MINE.

Analyses 31278 to 31281 (p. 35). Bituminous coal, block coal field, from Vandalia No. 24 mine, a shaft mine 2 miles northwest of Linton, on the Pennsylvania R. R. Coal bed, No. 4 of the Indiana Geological Survey; Carboniferous (Allegheny) age, Carbondale formation. Bed is 3½ to 5½ feet thick; dip, irregularly southwest; cleat, indistinct. Occasional rolls are encountered. Bony coal and irregular carbonaceous shale constitute the middle band. Roof, shale and sandstone; floor, hard, smooth clay. Vertical depth to landings below entrance, 120 feet. The bed was sampled by J. J. Bourquin and T. Fraser on November 21, 1918, as described below:

Sections of coal bed in Vandalia No. 24 mine.

Section	A.		B.		C.	
Laboratory No.	31279		31278		31280	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, immediate, sandstone	25	0	145	0	20	0
Coal	1	6	1	4	1	6½
Bone coal		a ½		a ½	....	
Coal		6	1	3	....	
Coal and middle band		a 1		a 1½		a ½
Coal	2	2	2	½	2	7½
Floor, hard clay.						
Thickness of bed	4	3½	4	9½	4	2
Thickness of coal sampled	4	2	4	7½	4	1½

a Not included in sample.

Section A (sample 31279) was cut at face of 4 north entry, 600 feet from main wes entry. Section B (sample 31278) was cut at face of 4 room, 5 east entry, 5 nort entry. Section C (sample 31280) was cut in 9 north west entry, opposite 15 room.

The ultimate analysis of a composite sample made by combining face sample 31278, 31279, and 31280 is given under laboratory No. 31281.

System of mining, room and pillar. In 1918 the coal was cut by machine an shot down by the miners with FF black powder, which was used also for brushing roof Men employed numbered 65 underground and 8 aboveground. The tipple was o wood and the coal was dumped with self-dumping cages. About 50 per cent of th production was shipped as run of mine. Bar screens 12 feet long, having 1½-inch spaces, and bar screens with 4-inch openings were used. Haulage was by two electri locomotives and by mules. Two pickers were employed on the car. The thre loading tracks had capacity for 30 empty and 30 loaded railroad cars. The lump coa on the cars was of medium size and had a good appearance; the appearance of screen-ings on the cars was good. Ninety-five per cent of the coal was mined in advanc work, and a recovery of 75 per cent was claimed. The probable area to be mine from this shaft was about 400 acres. The estimated lifetime of the mine was 3 to years. The capacity was 800 tons a day, the average daily output 450 tons, which wa to be increased, and the maximum day's run 820 tons.

KNOX COUNTY.

SOUTH BRUCEVILLE. OLIPHANT JOHNSON NO. 1 MINE.

Analyses 27660, 27661, and 27632 to 27636 (p. 35). Bituminous coal, Indiana field, from Oliphant Johnson No. 1 mine, a shaft mine 1½ miles south of Bruceville, in T. 4 N., R. 9 W., on the Vandalia R. R. Coal bed, No. 5 of the Indiana Geological Survey; Carboniferous (Allegheny) age, Carbondale formation. Bed is 5 feet 6 inche to 8 feet thick; roof, light-colored shale containing "niggerheads;" floor, carbona-ceous shale and fire clay; cover at points of sampling, 420 feet. The bed was sampled by H. I. Smith and J. R. Fleming on February 14 and 15, 1917, as described below:

Sections of coal bed in No. 1 mine.

Section	A.	B.	C.	D.	E.	F.
Laboratory No.	27632	27633	27634	27660	27661	[b] 27636
	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Roof, shale.						
Coal	8½	1 6½	1 2½	0 10½	1 3	2 11½
Coal				[a] 1½		
"Mother coal"	½			[a] ½		
Coal	8			[a] 5		
Bone	[a] 3	[a] 4	[a] 3		[a] 1	½
Coal	6½	1 6½	3½	2½	7	5½
Bone and coal	1½		[a] 2½		½	[a] 2½
"Sulphur"	[a] Streak.	[a] Streak.				
Coal	9½	7½	1 6½	1 5		
"Sulphur"	Streak.	[a] ½		Streak.		
Coal	1 4½	5½	2½	1 1½		
"Sulphur"	Streak.			Streak.		
"Mother coal"		½				
Coal	10½	8½	4½	1 5½		
"Sulphur"	[a] ½	Streak.	Streak.			
Coal	8½	6	2 4	[a] 2½	1 ½	
"Sulphur"	Streak.	Streak.			[a] ½	
Coal	1 ½	10½		1 3½	2 11	
Bone coal		½	½			
Coal		6½	7			
Floor, clay.						
Thickness of bed	7 2½	7 3	7 0	7 1½	5 11½	3 8
Thickness of coal sampled	6 10½	6 10½	6 6½	6 4	5 10	3 5½

[a] Not included in sample. [b] Special sample, lower half of seam.

Section A (sample 27632) was cut at face of 4 room, 4 southeast entry, 1,800 feet northeast of shaft. Section B (sample 27633) was cut at face of 14 room, 1 north entry, main east entry, 900 feet north of shaft. Section C (sample 27634) was cut in face of 2 west entry, straight south entry. Section D (sample 27660) was cut at face of 10 room, 1 southeast entry, 1,200 feet from east shaft. Section E (sample 27661) was cut ce of 8 room, 2 east entry, back north entry. Section F (sample 27636) was cut in 3 l-through from face, 2 west entry, straight south entry, 1,500 feet southeast of shaft.

The ultimate analysis of a composite sample made by combining face samples 27632, 27633, and 27634 is given under laboratory No. 27635.

The mine is operated on a modified panel, room and pillar system. In 1917 the coal was undercut by shortwall machines and shot down with permissible explosive, fired with fuse and No. 6 detonator. Shots were fired by miners just before they went off shift. Men employed numbered 270. Haulage was by electric locomotive. The daily average production was 2,000 tons.

PIKE COUNTY.

WINSLOW. AYRSHIRE NO. 7 MINE.

Analyses 30843 and 30228 to 30231 (p. 35). Car samples of bituminous coal, bituminous coal field, from Ayrshire No. 7 mine, a shaft mine at Winslow, on the Southern R. R. Coal bed No. 5 of the Indiana Geological Survey, Carboniferous (Allegheny) age, Carbondale formation. Car samples 30228, representing 10 cars; 30229, representing 10 cars; 30230, representing 10 cars; 30231, representing 5 cars, and 30843 were secured from the loading boom, while each car was being loaded, by T. Fraser on July 26, 1918.

This mine at time of sampling was hoisting 1,200 to 1,700 tons of coal a day in mine cars on self-dumping cages. The coal was sized by shaking screens making 4-inch lump, 4 by 2-inch lump, and 2-inch screenings. When the market demanded it, the 2-inch screenings were elevated to a jig washer for cleaning. At the time of sampling the cars were loaded with the 2-inch lump. The coal was loaded into the cars by a loading boom, with little breakage. Two slate pickers were employed on the loading boom. The impurities in the coal as loaded consisted of "sulphur" in the form of thin sheets or scales, occasional pieces of white roof shale, and some bony coal.

The sample was secured by taking about 70 pounds of coal from the loading boom while each car was being loaded. In sampling large lumps a hammer was used, so that fragments might be secured from a large number of lumps, and small amounts were taken at frequent intervals. The sample was crushed on a clean concrete floor, mixed, and reduced.

SULLIVAN COUNTY.

DUGGER. VANDALIA NO. 10 MINE.

Analyses 31262 to 31267 (p. 36). Bituminous coal, bituminous coal field, from Vandalia No. 10 mine, a shaft mine, 265 feet deep, 1½ miles southwest of Dugger, on the Pennsylvania R. R. Coal bed, No. 4, of the Indiana Geological Survey; Carboniferous (Allegheny) age, Carbondale formation. Bed is 4½ to 6 feet thick; dip, southwest, with cleat. Occasional rolls are encountered. The bed contains a carbonaceous shale middle band ranging from a streak to unminable thickness. Roof, sandstone or gray shale; floor, hard, gray clayey shale; vertical depth from surface to points of sampling, 200 to 280 feet. The bed was sampled by J. J. Bourquin and T. Fraser on November 21, 1918, as described below:

Sections of coal bed in Vandalia No. 10 mine.

Section	A.		B.		C.		D.		E.	
Laboratory No.	31262		31266		31264		31265		31263	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.										
"Rash"		a 2		a 2		2				a 1½
Coal, bright	1	3	a 1	3	1	6			2	10½
"Mother coal" and "sulphur"		a ¼		a ¼		½				
Coal		7¾		a 7¾		11	2	9½		
"Mother coal"		a 3¼		3¼						
Coal		3¼		a 3¼						
"Sulphur" or bony coal		⅛		a ⅛				2		
Coal		11		a 11			1	8½		
Middle band		1		a 1		1		½		a 1½
Coal	1	3½	a 1	3½	2	3½		11¾	2	4
Floor, hard clay.										
Thickness of bed	4	11	4	11	4	11½	5	2½	5	5½
Thickness of coal sampled	4	5½		3½	4	11½	5	2½	5	2½

a Not included in sample.

Section A (sample 31262) was cut at face of main north entry, opposite 15 east ent Section B (sample 31266) was cut at face of main north entry, opposite 15 east en Section C (sample 31264) was cut at face of 20 room, 14 north entry, 14 east, north ent Section D (sample 31265) was cut opposite 14 room, 2 south entry, 3 east entry, 3 so entry. Section E (sample 31263) was cut at face of 3 west entry, 2 south entry, feet from 1 south entry.

The ultimate analysis of a composite sample made by combining face samples 31 31263, 31264, and 31265 is given under laboratory No. 31267.

System of mining, room and pillar. In 1918 the coal was cut by machine and s down with FF black blasting powder by shot firers at 3 p. m., after the miners had the mine. Men employed numbered 180 underground and 14 aboveground. T tipple was of wood with automatic dump cage. The proportion of output shipped run of mine varied. Bar screens 12 feet long, with 1¼-inch spaces, were used, and o third of coal going to screens passed through. Haulage was by three electric locom tives and by mules. Two pickers were employed on the cars. The three loading tra had a capacity for 40 empty and 40 loaded railroad cars. The coal on the cars consis of large lumps; the lumps and screenings on the car had an excellent appearance. the coal was mined in advance work, and the recovery claimed was 75 per cent. T unmined area consisted of 500 or more acres. The probable lifetime of the mine six years. The daily capacity was 1,200 tons, the average output 1,100 tons, and maximum day's run 1,800 tons. The daily output was to be increased.

For description and analyses of other samples of this coal see Bureau of Mines B 85, pp. 37, 199, and Bull. 123, pp. 37, 184.

DUGGER. VANDALIA NO. 22 MINE.

Analyses 31274 to 31277 (p. 36). Bituminous coal, bituminous coal field, fr Vandalia No. 22 mine, a shaft mine 2½ miles southwest of Dugger, on the Pennsylva R. R. Coal bed, No. 4, of the Indiana Geological Survey; Carboniferous (Alleghe age, Carbondale formation. Bed is 2 to 6 feet thick; dip, in southwest directi The bed contains a middle band of coal and shale. Rolls are present, but not freque Roof, shale of light color; floor, fairly smooth and hard clay; cover, at points of sa pling, 290 to 300 feet. The bed was sampled by J. J. Bourquin and T. Fraser November 14, 1918, as described below:

Sections of coal bed in Vandalia No. 22 mine.

Section	A.	B.	C.
Laboratory No	31275	31276	312
Roof, shale.	Ft. in.	Ft. in.	Ft.
"Rash" coal	a ½	....	a
Coal	1 2	1 10	1
"Sulphur"	Lens at side.	¼	......
Coal	1 7	1 2	......
Middle band or carbonaceous shale parting	a 2½	a 1	
Coal	1 2¾	9	1
Floor, hard clay.			
Thickness of bed	4 2½	3 10¼	2
Thickness of coal sampled	3 11¾	3 9¼	2

a Not included in sample. b Not regular.

Section A (sample 31275) was cut at face of main air course. Section B (sam 31276) was cut at face of 1 west entry, main north entry. Section C (sample 312 was cut at face of main south entry.

The ultimate analysis of a composite sample made by combining face samp 31274, 31275, and 31276 is given under laboratory No. 31277.

System of mining, room and pillar, in panels. At time of sampling the coal cut by machine and shot down at any time by the mine boss with permissible exp sive, which was used also to brush roof or floor. Men employed numbered 16 underground and 4 aboveground. The tipple was of wood; a temporary car dump was employed. Haulage was by mules. One picker was employed on the cars. The two loading tracks had capacity for 20 empty and for many loaded railroad cars. The lump coal on cars consisted of medium lumps and had a good appearance. The entire production of coal was taken out in advance work. The unmined area consisted of 1,000 acres. The estimated lifetime of the mine was 10 years. The capacity of the mine was 30 tons a day, the daily average 30 tons, and the maximum day's run 50 tons. The daily output was to be increased shortly to 200 tons and was eventually to reach 800 tons. The mine had been abandoned some years before and was being reopened. The entries at time of sampling were being driven through low coal to develop adjacent higher and better coal.

DUGGER. AYRDALE NO. 27 MINE.

Analyses 31290 to 31294 (p. 36). Bituminous coal, bituminous coal field, from Ayrdale No. 27 mine, a shaft mine 3 miles north of Dugger, on the Southeastern R. R., with Chicago, Indianapolis & Louisville connections. Coal bed, No. 4, of the Indiana Geological Survey; Carboniferous (Allegheny) age, Carbondale formation. Bed is 4 to 5½ feet thick; dip, varying; cleat, indistinct. Occasional rolls are encountered. A middle band of carbonaceous shale is present. Roof, gray shale, no roof coal; floor, hard, smooth clay; cover at points of sampling, 190 to 200 feet. The bed was sampled by T. Fraser and J. J. Bourquin on November 19, 1918, as described below:

Sections of coal bed in Ayrdale No. 27 mine.

Section	A.		B.		C.		D.	
Laboratory No.	31290		31291		31292		31293	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.								
Coal	1	10¾	1	10¼	2	0	2	4
Carbonaceous shale		a ¼		a 2½		a ½		a 2
Coal		a ¼		a 3	2	3½	2	4
Shale		a ¼	Streak.		....		....	
Coal		4½		1	....		....	
"Sulphur"		a ¼		½	....		....	
Coal	1	11¾	1	9	....		....	
Floor, hard clay.								
Thickness of bed	4	4½	4	2¼	4	4	4	10
Thickness of coal sampled	4	3	3	11¾	4	3½	4	8

a Not included in sample.

Section A (sample 31290) was cut 50 feet from 2 east entry, 5 northeast entry. Section B (sample 31291) was cut 50 feet from 3 south entry, 3 southeast entry. Section C (sample 31292) was cut at face of 23 room, 5 north entry, east. Section D (sample 31293) was cut at face of 5 room, 1 west entry, 1 north entry, 3 east, north entry.

The ultimate analysis of a composite sample made by combining face samples 31290, 31291, 31292, and 31293 is given under laboratory No. 31294.

System of mining room and pillar. In 1918 the coal was cut by machine and shot down with FF black powder by miners at 3 p. m., FF black powder being used for brushing roof or floor. Men employed numbered 150 underground and 14 aboveground. The tipple was of wood with self-dumping cage. About 50 per cent of the coal was shipped as run of mine. The coal was screened over shaking screens with holes 1½ inches, 2½ inches, and 4 inches in diameter. The lump coal was coked at the average daily rate of 350 tons. Haulage was by mules and by two electric locomotives. Two pickers were employed on the cars. The four loading tracks had capacity for 40 empty and 40 loaded railroad cars. The appearance of the coal, medium lumps, and of the screenings on the cars was good. The entire production was mined in advance work, and the total recovery claimed was 75 per cent. The unmined area consisted of about 500 acres. The estimated lifetime of the mine was 6 years. The capacity o mine was 1,200 tons a day, the average daily production 700 tons, and the maxir day's run 1,700 tons. The output was to be doubled.

Sullivan. Vandalia No. 17 Mine.

Analyses 31268 to 31273 (p. 37). Bituminous coal, bituminous coal field, from dalia No. 17 mine, a shaft mine, 140 feet deep, 5 miles east of Sullivan, on the Penr vania R. R. Coal bed, No. 6 of the Indiana Geological Survey; Carboniferous (A gheny) age; Carbondale formation. Bed is 5 to 6 feet thick and dips irregularl southwest direction, with cleat running north and south. Characteristic "clay ve are occasionally encountered. Two thin shale partings occur near the center and near the bottom of the coal. Roof, shale, good quality; floor, smooth, soft clay; c at points of sampling, 140 feet. The bed was sampled by T. Fraser and J. J. Bour on November 15, 1918, as described below:

Sections of coal bed in Vandalia No. 17 mine.

Section	A.	B.	C.	D.	E
Laboratory number	31268	31270	31269	31271	31
Roof, shale.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft.
Coal and "sulphur"	½	a 1½	....	a 2	....
Coal	1 6½	8½	1 1	1 6½	
Shale and "sulphur"	a 2½	Streak.	Streak.	....	St
Coal	4½	1 0	7	....	
Shale	a ½	a ¾	a 1½	a 1	
Coal	1 0	5½	6½	3	
Coal, shale and "sulphur"	a 1	a ¼	1	a 3	
Coal	1 1	2 2	2 1	2 0	2
Shale	a 1	½	1½	a 3	
Coal	4	8	5	9½	
Bottom coal	4½	a 4½	2½	....	....
Floor, clay.					
Thickness of bed	5 2	5 7½	5 3	5 4	5
Thickness of coal sampled	4 9	5 ½	5 1½	4 7	4

a Not included in sample.

Section A (sample 31268) was cut at face of 1 room, 5 north, east, 1,000 feet from s bottom. Section B (sample 31270) was cut at face of 13 room, 4 south, east en Section C (sample 31269) was cut at face of 9 room, 2 south, west. Section D (san 31271) was cut opposite 13 room, at face of 3 north, east. Section E (sample 31272) cut in face, 2 west, 2 north, west.

The ultimate analysis of a composite sample made by combining face samples 31 31269, 31270, 31271, and 31272 is given under laboratory No. 31273.

System of mining room and pillar in panels. In 1918 the coal was cut by mac and shot down by miners, at time of leaving the mine, with FF black blasting pow The tipple was of steel, and the coal was dumped from automatic dump cages conveyor, then to picking tables, where two men removed the impurities, the bar screens 12 feet long with 1½-inch openings. Haulage was by two electric l motives and by mules. The three loading tracks had capacity for 50 empty many loaded railroad cars. The lump coal on cars was in medium lumps and h good appearance. All the coal was taken out in advance work, and a total reco of 75 per cent was claimed. The probable area to be mined from this opening 1,500 or more acres. The estimated lifetime of the mine was 15 years. The d capacity of the mine was 2,000 tons, the daily average production 900 tons, and maximum day's run 1,200 tons. The daily output was to be increased.

Sullivan. Vandalia No. 28 Mine.

Analyses 31282 to 31285 (p. 37). Bituminous coal, bituminous coal field, f Vandalia No. 28 mine, a shaft mine 7 miles east of Sullivan, on the Chicago, T Haute & Southeastern R. R., with Chicago, Indianapolis & Louisville connecti

Coal bed, No. 4 of the Indiana Geological Survey; Carboniferous (Allegheny) age; Carbondale formation. Bed is 5 to 6½ feet thick. The dip varies, running southwest, with indistinct cleat. Occasional rolls are encountered. Roof, shaly sandstone, with no roof coal; floor, smooth hard clay; cover at points of sampling, 211 feet. The bed was sampled by J. J. Bourquin and T. Fraser on November 20, 1918, as described below:

Sections of coal bed in Vandalia No. 28 mine.

Section	A.		B.		C.	
Laboratory No.	31283		31284		31282	
Roof, sandy shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
"Rash" coal		1	...	...	...	...
Coal	3	0	2	11½	3	1
Carbonaceous shale		[a] 2½		[a] 3		[a] 4
Coal		5½		9	2	7
"Mother coal" and "sulphur"	Streak.			½	...	...
Coal	2	4	2	0	...	...
Floor, smooth hard clay.						
Thickness of bed	6	1	5	11¾	6	0
Thickness of coal sampled	5	11½	5	8¾	5	8

[a] Not included in sample.

Section A (sample 31283) was cut 100 feet north of air shaft. Section B (sample 31284) was cut at face of 1 east entry, south, 60 feet from air shaft. Section C (sample 31282) was cut 100 feet south of air shaft.

The ultimate analysis of a composite sample made by combining face samples 31282, 31283, and 31284 is given under laboratory No. 31285.

In 1918 this mine was new; it was to be operated on the room-and-pillar system. Permissible explosive was used for shooting the coal. Men employed numbered 19 underground and 5 aboveground. The coal was being hoisted from air shaft, and a steel tipple was being erected. No screens had been installed. Haulage was by mules. There was one temporary loading track. The unmined area consisted of approximately 2,000 acres. The estimated lifetime of the mine was 20 years. A large part of the coal was to be coked. The daily average production at time of sampling was 50 tons, which was to be increased to 2,000 tons.

VERMILION COUNTY.

Clinton. Clinton No. 4 or Crown Hill No. 4 Mine.

Analyses 31257 to 31261 (p. 37). Bituminous coal, bituminous coal field, from Clinton or Crown Hill No. 4 mine, a shaft mine 3½ miles southwest of Clinton, on the Chicago & Eastern Illinois R. R. Coal bed, No. 4 of the Indiana Geological Survey; Carboniferous (Allegheny) age; Carbondale formation. Bed is 3 to 5½ feet thick; dip, varying; cleat, indistinct. Faults and rolls are encountered. Roof, good shale; floor, hard, smooth clay; cover at points of sampling, 205 feet. The bed was sampled by T. Fraser on November 25, 1918, as described below:

Sections of coal bed in Clinton No. 4 mine.

Section	A.		B.		C.		D.	
Laboratory No.	31258		31257		31259		31260	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	10½	1	7	2	6	2	6
Bone		½		1		[a] 1½	...	...
Coal		9¼		11	2	4	...	...
Bone and shale parting		1½	...	...	...	...		[a] 1
Shale, bone, and coal	...	...		[a] 4	...	...	...	...
Coal	2	4½	2	1	...	...	1	6
Floor, hard clay.								
Thickness of bed	5	2¼	5	0	4	11½	4	1
Thickness of coal sampled	5	2¼	4	8	4	10	4	0

[a] Not included in sample

Section A (sample 31258) was cut at face of 1 room, 15 south entry, 16 west entry. Section B (sample 31257) was cut at face of 8 south entry. Section C (sample 31259) was cut at face of 3 east entry, 8 south entry. Section D (sample 31260) was cut at face of 7 room, 1 north entry, main west entry.

The ultimate analysis of a composite sample made by combining face samples 31257, 21258, 31259, and 31260 is given under laboratory No. 31261.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down with black powder by two shot firers at 3.15 p. m., after the miners had left the mine; black powder was used for brushing roof and floor. Men employed numbered 130 underground and 14 above ground. The tipple was of steel, and self-dumping cages were used. Haulage was by eight electric locomotives. The coal was screened in shaking screens with holes 1½, 2½, and 4 inches in diameter. All the coal was taken out in advance work, and a recovery of 75 per cent was claimed. The capacity of the mine was 1,000 tons a day, the daily average production 800 tons, and the maximum day's run 1,000 tons.

VIGO COUNTY.

Coal Bluff. Vigo 74 Mine.

Analyses 26118 to 26124 (p. 37). Bituminous coal, bituminous coal field, from Vigo 74 mine, a shaft mine 1 mile northwest of Coal Bluff, on the Big Four R. R. Coal bed, Minshall; Carboniferous (Allegheny) age, Carbondale formation. Bed is 4 to 5 feet thick; dip, southwest; roof, shale; floor, soft clay; cover at points of sampling, 140 to 180 feet. The bed was sampled by H. I. Smith on September 2, 1916, as described below:

Sections of coal bed in No. 74 mine.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	26118		26119		26120		26121		26122		26123	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.												
Bony coal and "sulphur"						a 2		a 2		a 1½		
Coal	a 2	2½		a 2½		5½	2	6½	2	3½	2	2½
Coal with "sulphur" streaks						1½						
Coal						8						
"Sulphur" and "mother coal"				a 1½		¼		¼		¼		
Coal			2	½	1	4		3		2½		
Bony coal		1½		¼		¼		¼		¼		a 1½
Coal		2½	2	1½	2	2	1	11	2	1		a 2½
Bony coal		1½		a 2		a 2		a 1½		a 1½		a 1½
Coal	a 2	1½									2	1½
Floor, clay.												
Thickness of bed	4	9½	4	8¼	5	1½	5	0	4	10½	4	9½
Thickness of coal sampled		5½	4	2¼	4	9½	4	8¾	4	7½	4 .	4

a Not included in sample.

Section A (sample 26118) was cut at face of 12 east south entry, near mouth of 14 room. Section B (sample 26119) was cut at face of 6 room, 100 feet inby 14 west south entry. Section C (sample 26120) was cut 50 feet inby 16 east entry, on main south entry. Section D (sample 26121) was cut at face of 34 room, 7 west entry, 200 feet from entry. Section E (sample 26122) was cut at 2 breakthrough, 6 room, 3 north entry, 7 west entry. Section F (sample 26123) was cut at face of 12 east south entry, near mouth of 14 room (same as section A).

The ultimate analysis of a composite sample made by combining face samples 26119, 26120, 26121, 26122, and 26123 is given under laboratory No. 26124.

System of mining, room and pillar. In 1916 the coal was shot from the solid, but some time after the samples were taken mining machines were installed. Black blasting powder was used to shoot down the coal. The tipple was of wood. At time of sampling the output was 400 tons a day, all of it from advance workings. Bar screens with 1¼-inch spaces were used. Haulage was by mules and main and tail rope. The coal was picked on cars by two men. The two loading tracks had capacity for 25 empty and 50 loaded railroad cars. The appearance of the coal on the cars was very blocky and bright. The estimated lifetime of the mine in 1916 was 10 years. The capacity of the mine was 1,200 tons a day, and the maximum day's run over 1,100 tons.

LIGGETT. VANDALIA NO. 82 MINE (NO. 3 BED).

Analyses 31286 to 31289 (p. 37). Bituminous coal, bituminous coal field, from Vandalia No. 82 mine, a shaft mine, 467 feet deep, at Liggett, 5 miles west of Terre Haute. Two beds are worked, No. 3 and No. 5, but No. 3 only was investigated. Coal bed, Carboniferous (Allegheny) age, Carbondale formation. Bed is 5 feet 4 inches to 6 feet 6 inches thick; dip, irregular. Occasional faults are encountered. There is a middle band of shale, coal, and "sulphur," also numerous streaks of "sulphur." Roof, shale; floor, smooth, hard clay; cover at points of sampling, 460 feet. No. 3 bed was sampled by J. J. Bourquin and T. Fraser on November 22, 1918, as described below:

Sections of coal bed in Vandalia No. 82 mine.

Section	A.		B.		C.	
Laboratory No.	31286		31288		31287	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, sandstone.						
Coal		2½		2¾		¾
"Sulphur"	Streak.			¼	Streak.	
Coal		7	1	1½	2	2½
Carbonaceous shale		⅜	....		....	
Coal		1½	....		....	
"Sulphur"	Streak.		Streak.			½
Coal		7		10½		2
"Sulphur"		¼	Streak.			¼
Coal		9½		6¾		8¾
Shale and "sulphur"		¼		¼	....	
Coal	1	0		9	....	
Shale and coal	[a]1	1½	[a]1	0	[a]1	2
Coal	1	2	1	9	1	7¾
Floor, hard clay.						
Thickness of bed	5	7⅞	6	4	6	½
Thickness of coal sampled	4	6⅜	5	4	4	10½

[a] Not included in sample.

Section A (sample 31286) was cut at face of 4 south entry. Section B (sample 31288) was cut at face of 2 west entry, 900 feet from shaft. Section C (sample 31287) was cut at face of main east entry.

The ultimate analysis of a composite sample made by combining face samples 31286, 31287, and 31288 is given under laboratory No. 31289.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down with permissible explosive by shot firers at any time during the shift. Permissible explosive and dynamite were used for brushing roof or floor. Men employed numbered 8 underground and 3 aboveground. The temporary tipple was of wood. All of the coal was shipped as run of mine. At time of sampling no steps had been taken toward preparing coal for the market. Haulage was by mules. The entire production was mined in the advance work and a recovery of 75 per cent was claimed. The mine was just being developed.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 123, pp. 38, 187.

KANSAS.

CHEROKEE COUNTY.

STONE CITY. MAYER NO. 9 MINE.

Analyses 27222 to 27225 (p. 38). Bituminous coal, Kansas field, from Mayer
mine, a shaft mine, 155 feet deep, about ½ mile northeast of Stone City and 3½ miles
east of West Mineral, on a spur off the main line of the Missouri, Kansas & Texas
Coal bed, Weir-Pittsburg, known locally as Cherokee; Carboniferous age (Pe
vanian), Cherokee shale. Thickness of bed averages about 3½ feet. Roof, har
shale; floor, pyritiferous fire clay, locally called "blackjack"; cover at points o
pling, 155 feet. The bed was sampled by J. J. Forbes and J. F. Davies on Dec
28, 1916, as described below:

Sections of coal bed in Mayer No. 9 mine.

Section	A.		B.		C.	
Laboratory No.	27222		27223		27224	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, hard blue shale.						
"Rash"		1				
Coal		11				
Slate band		¼				
Coal		4				
"Mother coal"		⅜				
Coal	1	1	0	.85	0	.85
"Sulphur" band		⅜		.1		.1
Coal	1	1	2	.73	2	.73
Floor, "blackjack".						
Thickness of bed	3	7	3	.68	3	.68
Thickness of coal sampled	3	7	3	.68	3	.68

Section A (sample 27222) was cut at face of 1 east entry, north entry. Sect
sample (27223) was cut in last crosscut between straight and back north entries.
tion C (sample 27224) was cut in last crosscut between straight and back
entries. Section D (sample 27225) was cut at 1 east entry, north entry.

System of mining, room and pillar. In 1916, FF black powder was used in bl
down the coal, and 40 per cent dynamite was used in cutting through horse
shooting off the solid was the method employed exclusively. The coal was und
with mining machines. About 73 men were employed at the mine. The co
conveyed to the shaft bottom by mules. At time of sampling the daily produ
was 300 tons.

CRAWFORD COUNTY.

EDISON. WEAR NO. 21 MINE.

Analyses 30293 to 30295 (p. 38). Bituminous coal, Kansas field, from Wear
mine, a shaft mine in SW. ¼ of sec. 13, T. 29 S., R. 24 E., about 2 miles east of F
and ½ mile north of Edison, having railroad connections with the Santa Fe, Mi
Pacific, and St. Louis & San Francisco Railroads. Coal bed, Weir-Pittsburg, l
known as the Cherokee; average thickness, about 3 feet 4 inches of clean coal.
poor, a rather soft gray limy shale, brushed on entries to a height of about
floor, fire clay, 8 feet thick; cover at points of sampling, 200 feet.

The bed was sampled by J. J. Rutledge on March 8, 1918, as described below:

Sections of coal bed in Wear No. 21 mine.

Section	A.	B.
Laboratory No.	30293	30294
Roof, shale.	Ft. in.	Ft. in.
Coal	14	14
"Sulphur"	a 2	a 2
Coal	2¾	2¾
"Sulphur"	a ¼	a ¼
Coal	21½	21½
Floor, fire clay.		
Thickness of bed	3 4½	3 4½
Thickness of coal sampled	3 2¼	3 2¼

a Not included in sample.

Section A (sample 30293) was cut at face of 1 room, 1 stub north, 5 west, main east. Section B (sample 30294) was cut at face of 1 room, 1 stub north, 5 west, 1 north, main east.

The ultimate analysis of a composite sample made by combining face samples 30293 and 30294 is given under laboratory No. 30295.

System of mining, room and pillar, with double entry. In 1918 the coal was blasted off the solid by FF black blasting powder; dynamite was used for brushing the roof. All shots were fired by two shot firers after all other persons had left the mine. The tipple had a wood frame covered with corrugated iron. None of the coal was shipped as run of mine. Sizes of coal, lump, nut, and slack. There was track capacity for 30 empty and 30 loaded railroad cars. Haulage was by mules. The unmined area comprised 160 acres. The probable lifetime of the mine was four years. The capacity of the mine at time of sampling was 800 tons a day, and the average daily output was equal to the capacity.

KENTUCKY.

CHRISTIAN COUNTY.

MANNINGTON. WILLIAMS MINE.

Analyses 70506 to 70508 (p. 38), mine samples. Analyses 70509 to 70511 (p. 39), tipple samples. Bituminous coal, western Kentucky field, from Williams mine, a slope mine at Mannington, Ky., on the Louisville & Nashville R. R. Coal bed known locally as the Empire; Carboniferous age, Pottsville group. Bed is about 4 feet thick. The roof and floor are shale, which readily parts from the coal. The mine was sampled by N. H. Snyder on January 28, 1919, as described below:

Sections of coal bed in Williams Mine.

Section	A.	B.	C.
Laboratory No.	70506	70507	70508
Roof, shale.	Ft. in.	Ft. in.	Ft. in.
Bone	3½	a 1½	a 1
Shale	....	....	a 2½
Bone	....	....	a 1
Shale parting	¼	a ½	a ¾
Coal	1 ¼	8	10
Shale parting	¼	¼	¼
Coal	2 1½	2 4	2 5¼
Shale parting	¼	¼	¼
Coal	6¾	9	4
Floor, shale.			
Total thickness of bed	4 ¾	3 11½	4 ¼
Bed sampled	4 ¾	3 9½	3 7

a Not included in sample.

Section A (sample 70506) was cut from face of 1 room, 2 north entry, 80 feet from e
Section B (sample 70507) was cut from face of 4 room, 2 west entry, 110 feet from e
Section C (sample 70508) was cut from face of 1 south entry.

System of mining, room and pillar. At time of sampling the coal was shot fro solid by FF blasting powder. Men employed numbered 42 underground and surface. The coal was shipped as run of mine. Haulage was done by mules in the and by steam on the slope. The coal was picked on cars by two pickers. At ti sampling the mine had been in operation one year. The capacity of the mine wa tons, which were being shipped daily. In September, 1919, the capacity of the was 300 tons a day, at which time there were 55 men underground and 7 on su A new tipple was built.

Three tipple samples (70509, 70510, and 70511) were taken at the Williams mi N. H. Snyder on January 23 to 27, 1919. The coal was loaded directly into the rai cars from a wooden tipple. Samples were accumulated by taking successive shovelfuls of coal from the railroad cars at intervals after the mine cars had dumped and the two pickers had cleaned the coal. Samples were accumulated galvanized-iron bucket and carried to a steel plate 4 by 5 feet, with two sides fla and there crushed with a tamper and sledge. Crushing, mixing, and quartering done by the standard method. Three 1,000-pound samples were taken in this wa reduced to 3-pound mailing-can size for laboratory.

LETCHER COUNTY.

Fleming. Acme Mine.

Analyses 29845 to 29847 (p. 39). Bituminous coal, eastern Kentucky field, Acme, a drift mine, 1 mile west of Fleming, on the Louisville & Nashville R. R. bed, Elkhorn; Carboniferous age, Pottsville group. Small rolls or horseback encountered, but are not large enough to present much trouble in mining. In district the bed lies about 1,500 feet above sea level. Bed is 5 to 7 feet thick. runs northwest, with cleat. Roof, hard smooth shale; floor, smooth hard shale; ditions of roof and floor, very good. The bed was sampled by J. M. Webb and Bourquin on January 16, 1918, as described below:

Sections of coal bed in Acme mine.

Section	A.	
Laboratory No.	29845	29
	Ft. in.	*Ft*
Roof, hard smooth black shale.		
Coal	1 11⅝	1
Bone	⅝	.....
Muck and coal	.....	
Coal	2 11¼	3
Floor, hard smooth shale.		
Thickness of bed	4 11⅝	5
Thickness of coal sampled	4 11⅝	5

Section A (sample 29845) was taken at 16 room neck, 20 feet from face of 3 e
Section B (sample 29846) was taken 20 feet from face of 2 entry, 10 feet outby 15 r

The ultimate analysis of a composite sample made by combining samples 2 and 29846 is given under laboratory No. 29847.

System of mining, room and pillar. No mining machines were used, and all the was blasted off the solid and shot down with FFF black powder by two shot after the miners left at 11.00 a. m. and in the evening. A little permissible expl was used to brush the roof or floor. Men employed numbered 45 underground 15 above ground. The coal was dumped over a wooden tipple and down a c

212 feet long, lined with sheet iron, with deflectors every 10 feet. All the coal was shipped as run of mine. There were no pickers. The coal consisted of medium-sized lumps and was fairly bright. In 1918 all the coal was taken out in the advance work. The unmined area consisted of 50 acres. The estimated lifetime of the mine was 8 years. Haulage was by mules. There was one loading track, with capacity for 10 empty and 12 loaded railroad cars. The capacity of the mine in 1917 was 350 tons a day, the average daily output 300 tons, and the maximum day's run 350 tons.

WEBSTER COUNTY.

CLAY. WEST KENTUCKY NO. 7 MINE.

Analyses 30747 to 30751 (p. 39): Bituminous coal, Western Kentucky field, from West Kentucky No. 7 mine, a shaft mine 1 mile west of Clay, on the Illinois Central and Louisville & Nashville Railroads. Coal bed, No. 12 of the Kentucky Geological Survey; Carboniferous age, Pottsville group. Bed varies from 6 feet 6 inches to 8 feet in thickness and dips 3° north, north 17° east. Very few rolls or horsebacks are encountered. Main roof, "soapstone" or shale 4 or more feet thick, which disintegrates readily where exposed to air; top coal, from 1 foot to 2 feet thick, is left in place; floor, hard, smooth fire clay. The bed was sampled by W. B. Plank on June 17, 1918, as described below:

Sections of coal bed in West Kentucky No. 7 mine.

Section	A.		B.		C.		D.	
Laboratory No.	30749		30748		30747		30750	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "soapstone" and coal	a1	4	a1	6	a1	6	a2	0
Coal	1	1	2	10		10½	2	8
"Mother coal"		½						
"Sulphur"						½		
Coal	1	2			1	1½		
Bony coal		1¼		½		1		1
Coal		2¼		2		3½		3
Bony coal		a3		a1		a1		a2½
Coal	2	4½	2	8	2	2	2	6½
Bony coal								a3
Floor, fire clay.								
Thickness of bed	6	6¾	7	3½	6	2	8	0
Thickness of coal sampled	4	10½	5	8	4	6	5	5½

a Not included in sample.

Section A (sample 30749) was cut at the face of 10 room, 2 south entry, 7 right east dip, 100 feet from entry, 3,000 feet east of shaft. Section B (sample 30748) was cut at the face of 24 room, 3 left entry, east dip, 250 feet from entry, 1,400 feet northeast of shaft. Section C (sample 30747) was cut at the face of 11 room, 14 south entry, 2 left entry, main rise, 150 feet from entry, 5,100 feet southeast of shaft. Section D (sample 30750) was cut at the face of 3 south entry, 3 left entry, main rise, 220 feet from 3 left entry, 2,800 feet south of shaft.

The ultimate analysis of a composite sample made by combining equal amounts of samples 30747, 30748, 30749, and 30750 is given under laboratory No. 30751.

The mine is developed on the double-entry, room-and-pillar, panel plan. In 1918 cutting was done by machine in the coal and shots were fired at night by the shot firers with permissible explosives. Men employed numbered 140 underground and 15 aboveground. The tipple was of steel, equipped with picking table, where impurities were removed by four to six pickers. Self-dumping cages were used, and the coal was sized on shaking screens, with holes 2½ and 1¼ inches in diameter, into slack, pea, egg, nut, and lump sizes. Thirty per cent of the coal going to screens passed through. The lump coal went to a picking conveyor, which delivered to the railroad car. Very little of the output was shipped as run of mine. Haulage was by four electric locomoti and by mules. The four loading tracks had capacity for 50 empty and 50 loaded r road cars. The lump coal and screenings on the cars had a good appearance. Fo one per cent of the coal was taken in advance work, and the recovery was 46 per c The unmined area consisted of approximately 600 acres. The estimated lifetim the mine was about 8 years. The daily average output was about 1,000 tons and maximum day's production 2,250 tons. It was planned to increase the daily prod tion to 1,800 tons.

MARYLAND

ALLEGANY COUNTY.

ALLEGANY. TYSON NO. 3 MINE.

Analyses 26506 (p. 39). Semibituminous coal, Georges Creek field, from Tyson 3 mine, 1¼ miles northeast of Allegany, on the Cumberland & Pennsylvania R. Coal bed, Tyson; Carboniferous age, Monongahela formation. Roof and floor, sh cover at point of sampling, 100 feet. The bed was sampled in 3 room, 2 right, by Maryland Geological Survey on June 23, 1916, and showed coal 3 feet 11½ inches thi with no impurities to be discarded in mining. The average daily production at ti of sampling was 75 to 100 tons.

BARRELVILLE. BOND MINE.

Analyses 26985 (p. —). Semibituminous coal, Georges Creek (?) field, from B mine, ½ mile northeast of Barrelville, on switch of the Cumberland & Pennsylvania R Coal bed, Brookville, known as Bluebaugh; Carboniferous age, Allegheny formati Roof, shale overlaid by massive sandstone; floor, sand shale; cover at point of s pling, 135 feet. The bed was sampled by the Maryland Geological Survey on vember 20, 1916, as described below:

Section of coal bed in Bond mine.

	Ft.
Roof, shale.	
Coal[a]	
Shale[a]	1
Coal	
Shale[a]	
Coal	1
Shale[a]	
Coal	
Shale	
Coal	
Floor, shale.	
Thickness of bed	5
Thickness of coal sampled	2

This sample was taken at rib of straight heading, 180 feet northeast of 1 left headi At time of sampling, the mine was not in operation.

BARRELVILLE. EMRICK NO. 1 MINE.

Analysis 26504 (p. 40). Semibituminous coal, Georges Creek field, from Em No. 1 mine, ½ mile southwest of Barrelville, on the Cumberland & Pennsylv R. R. Coal bed, Bluebaugh (Brookville); Carboniferous age, Allegheny formati Roof and floor, shale; cover at point of sampling, 203 feet. The bed was sample

[a] Not included in sample.

ace of main heading, 2,100 feet from mine mouth, by the Maryland Geological Survey on June 20, 1916, as described below:

Section of coal bed in Emrick No. 1 mine.

	Ft.	in.
Roof, shale.		
Coal	2	7
Shale [a]		2
Coal		9
Floor, shale.		
Thickness of bed	3	6
Thickness of coal sampled	3	4

The mine is small, producing about 300 tons a month at time of sampling.

BARRELVILLE. PARKER MINE.

Analysis 26539 (p. —). Semibituminous coal, Georges Creek field, from Parker mine, ½ mile northeast of Barrelville, on switch of the Cumberland & Pennsylvania R. R. Coal bed locally known as Parker; Carboniferous age, Allegheny formation. Roof, at places shale, "draw slate," and at others sandstone; floor, sand shale; cover at point of sampling, about 80 feet.

Section of coal bed in Parker mine.

	Ft.	in.
Roof, at places, shale.		
"Draw slate" [a]		2½
Coal	1	11
Floor, sand shale.		
Thickness of bed	2	1½
Thickness of coal sampled	1	11

This sample was taken in 2 room on right at top of dip heading. At time of sampling the mine was not worked.

BARRELVILLE. PRATT MINE.

Analysis 26542 (p. 40). Semibituminous coal, Georges Creek field, from Pratt mine, 1 mile southwest of Barrelville. Coal bed, Brush Creek; Carboniferous age, Conemaugh formation. Roof, gray shale; floor, black shale; cover at point of sampling, 80 to 90 feet. The bed was sampled by the Maryland Geological Survey on September 12, 1916, as described below:

Section of coal bed in Pratt mine.

	Ft.	in.
Roof, shale.		
Coal	1	8
Bone [a]		5¾
Floor, shale.		
Thickness of bed	2	1¾
Thickness of coal sampled	1	8

This sample was taken at face of main heading, 80 feet from entry. At time of sampling the mine was not shipping.

BARTON. MOSCOW NO. 3 MINE.

Analysis 26533 (p. 40). Semibituminous coal, Georges Creek (?) field, from Moscow No. 3 mine, ¾ mile north of Barton, on the Cumberland & Pennsylvania R. R. Coal bed, Bakerstown; Carboniferous age, Conemaugh formation. Roof and floor, shale;

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[a] Not included in sample.

cover at point of sampling, about 250 feet. The bed was sampled by the M
Geological Survey on September 23, 1916, as described below:

Section of coal bed in Moscow No. 3 mine.

Roof, shale.
- Bone [a]......
- Coal......
- Bone and shale [a]......
- Coal......

Floor, shale.
- Thickness of bed......
- Thickness of coal sampled......

This sample was taken at face of 4 room, 2 left heading. During 1915 th
was not steadily in operation; during 1916 the output varied from 100 to 150 t
day.

BARTON. SWANTON MINE.

Analyses 26978 and 26986 (p. 40). Semibituminous coal, Georges Creek (
from Swanton mine, at Barton, on the Cumberland & Pennsylvania R. R. C
Bakerstown; Carboniferous age, Conemaugh formation. Roof and floor,
cover at point of sampling, 800 feet. The bed was sampled by the Marylan
logical Survey on November 21, 1916, as described below:

Section of coal bed in Swanton mine.

Roof, shale.
- Bone [a]......
- Coal......

Floor, shale.
- Thickness of bed......
- Thickness of coal sampled......

Section A (sample 26978) was taken at right rib, face of 6 right heading, 1,
from entry. The daily output at time of sampling was 100 to 125 tons.

The bed was also sampled by the Maryland Geological Survey on Novem
1916, as described below:

Section of coal bed in Swanton mine.

Roof, shale.
- Coal......
- Shale [a]......
- Coal......

Floor, shale.
- Thickness of bed......
- Thickness of coal sampled......

This sample was taken at face of 2 right butt, main entry, about 150 feet fro
mouth, where the cover was 350 feet. At time of sampling the mine was
operation.

BORDEN SHAFT. CONSOLIDATION NO. 12 MINE.

Analysis 26528 (p. 40). Semibituminous coal, Georges Creek field, from Co
tion No. 12 mine, at Borden Shaft, on main line of the Cumberland & Penns
R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. R
floor, shale; cover at point of sampling, 200 feet. The bed was sampled

[a] Not included in sample.

Maryland Geological Survey on September 4, 1916, at "Klondike" heading, off left empty slant, as described below:

Section of coal bed in Consolidation No. 12 mine.

	Ft.	in.
Roof, shale.		
Coal	6	6½
Shale [a]		½–¾
Coal		4½
Shale [a]		½
Coal		11¼
Shale [a]		¼
Coal		11¼
Floor, shale.		
Thickness of bed	8	11
Thickness of coal sampled	8	9½

The daily output at time of sampling was about 100 tons.

ECKHART. WASHINGTON NO. 2 MINE.

Analysis 26507 (p. 40). Semibituminous coal, Georges Creek field, from Washington No. 2, a drift mine near Eckhart, on the Eckhart branch of the Cumberland & Pennsylvania R. R. Coal bed, Tyson, or Upper Sewickley; Carboniferous age, Monongahela formation. Roof, hard, sandy shale; floor, shale; cover at point of sampling, 80 feet. The bed was sampled by the Maryland Geological Survey on June 26, 1916, in 6 room, 4 left heading, and showed coal 4 feet 2 inches thick, with no impurities to be discarded in mining.

For analysis of other samples from this mine see Bureau of Mines Bull. 22, p. 109.

ELLERSLIE. ELLERSLIE CLAY MINE.

Analyses 26987 and 26988 (p. —). Bituminous coal from Ellerslie clay mine, 2 miles west of Ellerslie. Coal beds known as Mercer and Quakertown; Carboniferous age, Pottsville formation. Roof and floor of Mercer bed, shale; roof of Quakertown bed, shale; floor, fire clay; cover at point of sampling in Mercer bed over 120 feet, in Quakertown bed over 150 feet. The beds were sampled by the Maryland Geological Survey on November 20, 1916, as described below:

Section of Mercer coal bed in Ellerslie clay mine.

	Ft.	in.
Roof, shale.		
Coal	1	2
Fire clay [a]	4	3
Coal	1	3½
Shale [a]		5
Coal	1	4
Floor, shale.		
Thickness of bed	8	5½
Thickness of coal sampled	3	9½

Sample 2698 was cut at 1 right butt, 1 right heading, 1,000 feet from entry. At time of sampling the mine was not in operation.

[a] Not included in sample.

Section of Quakertown coal bed in Ellerslie clay mine.

	Ft.	in
Roof, shale.		
Coal	1	
Shale[a]		
Coal		
Floor, fire clay.		
Thickness of bed	2	
Thickness of coal sampled	1	

Sample 26988 was cut at right rib, 2 right heading, 20 feet from main heading, 1,2 feet feet from entry. At time of sampling the mine was not worked.

FRANKLIN STATION. MILLER & GREENE NO. 1 MINE.

Analysis 26544 (p. —). Semibituminous coal, Georges Creek (?) field, from Mil & Greene No. 1 mine, at Franklin Station, on the Cumberland & Pennsylvania R. Coal bed, Parker (Clarion); Carboniferous age, Allegheny formation. Roof, san stone; floor, bastard fire clay; cover at point of sampling, 300 feet. The bed w sampled by the Maryland Geological Survey on August 14, 1916, as described belo

Section of coal bed in No. 1 mine.

	Ft.	in.
Roof, sandstone.		
Coal	1	2½
Clay binder[a]		1½–
Coal		5¾
Shale binder[a]		1½
Coal		6
Floor, bastard fire clay.		
Thickness of bed	2	5 –
Thickness of coal sampled	2	2½–

This section was taken in butt off main heading. At time of sampling the dai output was 125 to 150 tons.

FROSTBURG. CONSOLIDATION NO. 9 MINE.

Analysis 26510 (p. 41). Semibituminous coal, Georges Creek field, from Consoli tion No. 9, a drift mine, 1½ miles northeast of Frostburg, on the Cumberland & Penns vania R. R. Coal bed, Tyson (Upper Sewickley); Carboniferous age, Monongahe formation. Roof and floor, shale; cover at point of sampling, about 100 feet. T bed was sampled by the Maryland Geological Survey on September 26, 1916, in ma way of 1 room, 2 right, where the entire seam was composed of 3 feet 7 inches of co no portions being discarded in mining. The average daily output at time of sampli was 625 tons.

FROSTBURG. CONSOLIDATION NO. 14 MINE.

Analyses 68177, 68215, and 30164; also five tipple samples—30092, 68176, 681 68199, and 30165 (p. 41). Semibituminous coal, Frostburg district, from Consolid tion No. 14 mine, a drift mine 1¼ miles north of Frostburg, Md., on the Cumberland Pennsylvania R. R. Coal bed, Pittsburgh, known in this field as the "Big Vein Carboniferous age, Monongahela formation. Average thickness of bed, 14 feet; b lies flat; faint cleat; no faults, rolls, or horsebacks; roof, black shale; floor, hard sha Roof and floor shale showed no tendency to become mixed with the coal in sh

[a] Not included in sample.

ments. The bed was sampled by E. Stebinger on December 30, 1917, as described below:

Section of coal bed in Consolidation No. 14 mine.

Section	A.		B.	
Laboratory No.	68177		68215	
	Ft.	*in.*	*Ft.*	*in.*
Roof, black shale.				
Top coal, clean, lustrous	1	9	1	5½
Shale, black		[a]7		[a]9
Coal, soft	2	1	1	3
Coal, soft		1	....	
Coal, soft		10	....	
Shale, black		1½	....	
"Sulphur" streak	....			¼
Coal		5½		9¾
Coal, soft	....			1½
Coal	....			10
Shale, black		[a]1		[a]1½
Coal, soft, lustrous		8	....	
Coal	....			16½
Shale		½		[a]1
Coal	1	4	1	0
Floor, hard shale.				
Thickness of bed	8	½	6	11¾
Thickness of coal sampled	7	¼	6	¾

[a] Not included in sample.

Section A (sample 68177) was cut 125 feet from mouth of Clifton opening in air course. Section B (sample 68215) was cut in oil-house heading, opposite room 25.

The ultimate analysis of a composite sample made by combining face samples 68177 and 68215 is given under laboratory No. 30164. The ultimate analysis of a com posite sample made by combining tipple samples 68176, 68198, and 68199 is given under laboratory No. 30165.

Tipple samples 68176, 68198, and 68199 represented run of mine coal being loaded; sample 30164 was a composite of these samples. Tipple sample 30092 represented run of mine coal.

In 1917 the mine had capacity of 50 tons a day, and the actual average at time of sampling was 50 tons a day. It had a wooden tipple, used no coal-cutting machines, and had mule haulage. The coal was undercut by hand and shot down by black powder. The probable lifetime of the mine was 10 years. All tonnage from the mine was to be derived from pillar workings. It was expected the tonnage would soon be increased to 250 tons a day. The coal was all shipped as run of mine and was picked on car by one picker. Track capacity, 10 cars.

GANNONS STATION. WASHINGTON NO. 1 MINE.

Analysis 26979 (p. 41). Semibituminous coal, Georges Creek (?) field, from Washington No. 1 mine, near Gannons station, on the Cumberland & Pennsylvania R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, about 300 feet. The bed was sampled by the Maryland Geological Survey on November 22, 1916, as described below:

Section of coal bed in Washington No. 1 mine.

	Ft.	in.
Roof, shale.		
Coal	2	8
Shale, hard [a]		10½
Coal		3½
Bone [a]		½–1
Coal	1	5
Floor, shale.		
Thickness of bed	5	3½–4
Thickness of coal sampled	4	4½–5

This sample was cut at 4 right air course, 2,200 feet west of entry. The daily output at time of sampling was 150 tons.

[a] Not included in sample.

HOFFMAN. CONSOLIDATION NO. 3 MINE.

Analysis 26526 (p. 41). Semibituminous coal, Georges Creek field, from Cons tion No. 3 mine, at Hoffman, on the Cumberland Pacific R. R. Coal bed, Pittsb Carboniferous age, Monongahela formation. Roof and floor, shale; cover at po sampling, about 200 feet. The bed was sampled by the Maryland Geological S on August 1, 1916, as described below:

Section of coal bed in Consolidation No. 3 mine.

Roof, shale.	
Coal	
Shale [a]	
Coal	
Shale [a]	
Coal	
Shale [a]	
Coal	
Floor, shale.	
Thickness of bed	
Thickness of coal sampled	

This section was cut at north side, main heading. The daily output at ti sampling was 1,150 to 1,200 tons.

LITTLE ALLEGANY. UNION NO. 1 MINE.

Analysis 26529 (p. 41). Bituminous coal, Georges Creek field, from Union mine, ½ mile north of Little Allegany, on a branch of the Cumberland & Pennsyl R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Roo floor, shale; cover at point of sampling, 185 feet. The bed was sampled b Maryland Geological Survey on September 22, 1916, at face of 5 room, 4 left hea as described below:

Section of coal bed in Union No. 1 mine.

	F
Roof, shale.	
Coal	
Bone [a]	
Coal	
Bone [a]	
Coal	
Bone [a]	
Coal	2
Floor, shale.	
Thickness of bed	4
Thickness of coal sampled	4

The daily output at the time of sampling was 550 tons.

LONACONING. GEORGES CREEK NO. 3 MINE.

Analysis 26509 (p. 41). Semibituminous coal, Georges Creek field, from mine, at Lonaconing, on Western Maryland R. R. Coal bed, Tyson; Carboni age, Monongahela formation. Roof and floor, shale; cover at point of sampling, 340 to 350 feet. The bed was sampled by the Maryland Geological Survey on tember 23, 1916, in Broadback's room off 3 right, at which point the coal was 6½ inches thick, with no impurities. The daily output of the mine at ti sampling was 400 tons.

[a] Not included in sample.

LONACONING. KINGSLEY MINE.

Analysis 26984 (p. 41). Semibituminous coal, Georges Creek(?) field, from Kingsley mine, near Lonaconing, on west side of Koontz Run, on the Western Maryland R. R. Coal bed, Waynesburg; Carboniferous age, Monongahela formation. The bed was sampled by the Maryland Geological Survey on November 28, 1916, as described below:

Section of coal bed in Kingsley mine.

	Ft.	in.
Roof, not noted.		
Shale [a]		2
Coal	2	1½
Shale [a]		3
Coal [a]		2
Shale [a]		9
Coal	1	1½
Bone		1
Coal		2
Bone [a]		¾
Coal [a]		1½
Shale [a]		1
Coal [a]		1
Bone [a]		1¼
Coal		6
Shale		½
Coal		5
Shale [a]		1½
Coal	2	7
Floor, not noted.		
Thickness of bed	8	11½
Thickness of coal sampled	7	½

Sample 26894 was cut at right rib of main heading at face 600 feet from entry. The daily output at time of sampling was 50 to 70 tons.

LONACONING. TEST OPENING.

Analysis 26540 (p. 41). Semibituminous coal, Georges Creek field, from test opening ¾ mile northeast of Lonaconing. Coal bed known as Franklin; Carboniferous age, Conemaugh formation. Roof and floor, shale; cover at point of sampling, about 150 feet. The bed was sampled by the Maryland Geological Survey on September 28, 1916, as described below:

Section of Franklin coal bed in test opening near Lonaconing.

	Ft.	in.
Roof, shale.		
Shale, coal, and bone in streaks [a]	1	2
Coal, dirty	1	5
Shale [a]		6
Coal		4½
Shale [a]		6
Coal	1	5½
Floor, shale.		
Thickness of bed	5	5
Thickness of coal sampled	3	3

This sample was taken at about 100 feet south 55° east from opening. At time of sampling the mine was not worked.

[a] Not included in sample.

LORD. CONSOLIDATION NO. 7 MINE.

Analysis 26530 (p. 41). Semibituminous coal, Georges Creek field, from Cons tion No. 7 mine, ½ mile west of Lord village, on a branch of the Cumberland & sylvania R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela form Roof and floor, shale; cover at point of sampling, about 350 feet. The be sampled by the Maryland Geological Survey on September 27, 1916, in upper s of the Midway, as described below:

Section of coal bed in Consolidation No. 7 mine.

Roof, shale.	I
Coal	6
Shale[a]	
Coal	
Shale[a]	
Coal	1
Shale[a]	
Coal	
Floor, shale.	
Thickness of bed	8
Thickness of coal sampled	8

The daily output at the time of sampling was 900 tons.

LUKE. DEVON MINE.

Analysis 26511 (p. 41). Semibituminous coal, Georges Creek field, from Dev mile north of Luke, on the West Virginia Pulp & Paper Co's R. R. Coal Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, cover at point of sampling, 300 feet. The bed was sampled by the Maryland Geol Survey on August 15, 1916, at face of main heading, 3,000 feet from mouth, as desc below:

Section of coal bed in Devon mine.

Roof, shale.	Ft.
Coal	
Bone[a]	
Coal	1
Shale[a]	
Coal	2
Floor, shale.	
Thickness of bed	5
Thickness of coal sampled	4

The average daily output at time of sampling was 250 tons.

MIDLAND. CONSOLIDATION NO. 8 MINE.

Analyses 68195, 68192, and 30162; also tipple samples 68203, 68209, 68211, and 30163, each representing a half-day's run over tipple, run-of-mine coal (p Semibituminous coal, Georges Creek field, from Consolidation No. 8 mine, s mine in Ocean Township, ½ mile southwest of Midland, on the Cumberland & sylvania R. R. Coal bed, Pittsburgh, known in this field as "Big Vein;" Carbo ous age, Monongahela formation. Average thickness of bed is 14 feet; bed lie with long rolls; no strong cleat; no faults; a few rolls or horsebacks. The bed wa pled by E. Stebinger on December 30, 1917. Tipple samples were also take E. Stebinger, each representing a half-day's run over tipple.

[a] Not included in sample.

Sections of bed in Consolidation No. 8 mine.

Section	A.		B.	
Laboratory No.	68195		68192	
	Ft.	in.	Ft.	in.
Roof, coal.				
Coal, dull with bright layers		6		9
Coal, hard, bright				11
Coal, bright, soft			1	1
Coal, hard, with dull streaks				11
Coal, soft	4	10	2	11
Shale				a2
Coal				6
Black shale				1
Coal			2	0
Floor, sandy shale.				
Thickness of bed	5	4	9	4
Thickness of coal bed sampled	5	4	9	1

a Not included in sample.

Section A (sample 68195) was cut at face of 59 room, Keating heading. Section B (sample 68192) was cut in 8 room, 3 right.

The ultimate analysis of a composite sample made by combining face samples 68192 and 68195 is given under laboratory No. 30162. The ultimate analysis of a composite sample made by combining tipple samples 68203, 68209, 68211, and 68213 is given under laboratory No. 30163.

The capacity of the mine is 275 tons a day; average shipments at time of sampling, 275 tons. Men employed numbered 95 underground and 5 aboveground. The tipple was of wood. Haulage was by electric cable and mules. No coal-cutting machines were used; the coal was undercut by hand and shot down by black powder. The output was all shipped as run of mine and was picked on cars by one picker. There was track capacity for 20 loaded and 20 empty cars. About 50 acres were still unmined. The probable lifetime of the mine was about 10 years.

MONTELL. MONTELL TUNNEL (MERTON'S) MINE.

Analyses 26977 and 26505 (p. —). Semibituminous coal, Georges Creek (?) field, from Montell Tunnel (Merton's) mine, at Montell, on the Western Maryland R. R. Coal beds, Lower Kittanning and Bluebaugh; Carboniferous age, Allegheny formation. Roof, shale; floor in Lower Kittanning bed, shale; in Bluebaugh bed, rock and "wild coal;" cover at point of sampling, 300 feet in Lower Kittanning bed and 360 feet in Bluebaugh bed. The beds were sampled by the Maryland Geological Survey on August 3 and November 20, 1916, as described below:

Section of Lower Kittanning coal bed in Montell Tunnel (Merton's) mine.

	Ft.	in.
Roof, shale.		
Coal		10½
Shale a		4
Coal	1	1½
Shale a		11
Coal	1	7½
Shale a		1
Coal	2	1
Floor, shale.		
Thickness of bed	7	½
Thickness of coal sampled	5	8½

Sample 26977 was cut at Frederick heading, Lower Kittanning, 4,600 feet southeast from mouth of tunnel. The daily output at time of sampling was 80 to 100 tons.

Sample 26505 was cut at face of 1 left in Bluebaugh bed.

a Not included in sample.

Section of Bluebaugh coal bed in Montell Tunnel mine.

	Ft.
Roof, shale.	
Coal	
Shale	a 1
Coal	1
Shale	
Coal	
"Wild coal"	a 1
Floor, rock.	
Total thickness of bed	6
Thickness of coal sampled	3

MORRISON. GIN SANG MINE.

Analysis 26532 (p. —). Semibituminous coal, Georges Creek (?) field, from Sang mine at Morrison, on the Cumberland & Pacific R. R. Coal bed, Bakerst Carboniferous age, Conemaugh formation. Roof, bastard fire clay; floor, shale; c at point of sampling, 150 to 200 feet. The bed was sampled at one point by the M land Geological Survey on August 14, 1916, as described below:

Section of coal bed in Gin Sang mine.

	Ft
Roof, bastard fire clay.	
Bone[a]	1
Coal	
Bone[a]	
Coal	2
Floor, shale.	
Total thickness of bed	4
Thickness of coal sampled	2

This sample was cut at main heading right. The output per day at time of samp was 64 tons.

MOUNT SAVAGE. BALD KNOB MINE.

Analyses 71053 to 71056 (p. 42), and analyses 71130 to 71133 (p. 43), and 7113 71137 (p. 43), car samples. Semibituminous coal from the Bald Knob mine, a mine 1½ miles north of Mount Savage, on the Cumberland & Pennsylvania R The main operation is in the Pittsburgh or Big Vein; Carboniferous age, Monong formation. Bed is 5 to 6 feet thick; roof and floor, shale, which parts readily from coal. A new opening is being driven into a 3-foot vein 17 feet above the Big V this is believed to be the Tyson. Main roof, shale; immediate roof, 18 inches of b The mine was sampled at three points in the Big Vein and one point in the 3 vein by N. H. Snyder and H. A. Goodman on June 12, 1919, as described below:

Sections of coal bed in Big Vein.

Section	A.		B.		C
Laboratory No.	71053		71054		71(
Roof, shale.	Ft.	in.	Ft.	in.	Ft.
Coal	2	2¼		10	
Shale		a 1⅛		¾	
Coal		5¼	1	5	
Shale		a 1¼		a 1¼	
Coal	2	2¼		10¾	
Shale	......			a 1	
Coal	......		2	4½	
Shale	......		......		
Coal	......		......		1
"Sulphur"	......		......		
Coal	......		......		
Floor, shale.					
Thickness of bed	5	1	5	9½	5
Thickness of coal sampled	5	1	5	9½	5

[a] Not included in sample.

Section of coal bed in 3-foot vein.

Section	D.
Laboratory No.	71056
	Ft. in.
Roof, shale and bone	1 6
Coal	1 8
Shale	[a] 1
Coal	2
Soft shale	[a] 2
Coal	1 1
Floor, shale.	
Thickness of bed	4 8
Thickness of coal sampled	3 2

[a] Not included in sample.

Section A (sample 71053) was cut at face of 7 room on main heading, 1,300 feet from opening, Big Vein. Section B (sample 71054) was cut from face of 2 right heading, 900 feet from opening, Big Vein. Section C (sample 71055) was cut at face of 5 room, 2 left heading, 1,400 feet from opening, Big Vein. Section D (sample 71056) was cut from face of main heading, 700 feet from opening, 3-foot vein.

The mine is opened by a drift. System of mining, room and pillar. In 1919 coal was undercut by hand and shot down with black powder. The daily capacity of the mine was 250 tons. Men employed numbered 44 underground and 10 on the surface. Haulage was by mules. Coal was run down slope (¼ mile) to the tipple by cable operated by electricity. The coal was shipped as run of mine and was picked on cars by two pickers. A new opening 17 feet above the main opening was being driven into a 3-foot vein, believed to be the Tyson vein. Heading had been driven in about 700 feet.

Car samples 71130 to 71133 and 71134 to 71137 (p. 43) were taken from two cars loaded and shipped from the mine June 16, 1919, under the supervision of N. H. Snyder. The cars were sampled at the Government Fuel Yard, Washington, D. C., June 25, 1919, by R. J. Swingle. A 1,000-pound sample was collected from each car by taking successive large shovelfuls of coal at intervals under the cars as they were being dumped. Samples were crushed and quartered by mechanical crusher at the Bureau of Mines laboratory, Washington, D. C.

MOUNT SAVAGE. NO. 6 FIRE CLAY MINE.

Analysis 26580 (p. 43). Semibituminous coal, Georges Creek (?) field, from No. 6 fire clay mine, 2½ miles northwest of Mount Savage. Coal bed, Mount Savage (Mercer); Carboniferous age, Pottsville formation. Roof and floor, shale; cover at point of sampling, about 300 feet. The bed was sampled by the Maryland Geological Survey on November 6, 1916, at butt opening, main heading, about 600 feet from entry, as described below:

Section of coal bed in No. 6 fire clay mine.

	Ft.	in.
Roof, shale.		
Coal		3¾
Struggle (?) [a]		¼
Coal		5
Shale [a]		1
Coal		3¾
Stone [a]		¼
Coal		2½
Shale [a]		½
Coal		1½

[a] Not included in sample.

Roof, shale—Continued.	F
Shale [a]	
Coal	
Shale [a]	
Coal	
Bone [a]	
Coal	
Floor, shale.	
Thickness of bed	2
Thickness of coal sampled	1

The daily output of the mine at time of sampling was three tons.

MOUNT SAVAGE. HENRY MULLANEY'S MINE.

Analysis 26543 (p. 43). Semibituminous coal, Georges Creek (?) field, from H
Mullaney's mine, ¾ mile east of Mount Savage, about 50 feet south of the Cumbe
& Pennsylvania R. R. Coal bed, Lower Freeport; Carboniferous age, Allegheny
mation. Roof, bastard fire clay; floor, black shale; cover at point of samplin
to 80 feet. The bed was sampled by the Maryland Geological Survey on Septe
12, 1916, at face of main heading, 120 feet from mouth, as described below:

Section of coal bed in Henry Mullaney's mine.

Roof, bastard fire clay.	
Bone [a]	
Parting [a]	
Coal	1
Parting [a]	
Bone [a]	
Parting [a]	
Coal, bony	1
Binder [a]	
Coal	
Bone [a]	
Bone and shale [a]	
Floor, black shale.	
Thickness of bed	4
Thickness of coal sampled	2

At time of sampling no shipping was done.

OCEAN. CONSOLIDATION NO. 1 MINE.

Analysis 26527 (p. 43). Semibituminous coal, Georges Creek field, from Co
dation No. 1 mine, near Ocean station, on the Cumberland & Pennsylvania
Coal bed, Pittsburgh ("Big Vein"); Carboniferous age, Monongahela formation. C
at point of sampling, 160 feet. The bed was sampled by the Maryland Geolo
Survey on August 1, 1916, at face of Spitzman's heading, as described below:

Section of coal bed in Consolidation No. 1 mine.

Roof, shale.	F
Coal	5
Shale [a]	
Coal	
Shale [a]	

[a] Not included in sample.

	Ft.	in.
Roof, shale—Continued.		
Coal	1	0
Shale[a]		½
Coal	1	7
Floor, shale.		
Thickness of bed	9	2
Thickness of coal sampled	9	0

The daily output at time of sampling was 1,650 tons.

OCEAN. CONSOLIDATION NO. 1 MINE.

Analyses 68217, 68218, 68226, 68178, 68181, and 30179; also tipple samples 68182, 68197, 68216, 68221, and 30180 (p. 43), taken from 237 2-ton cars at the tipple. Bed is 5 to 9 feet thick; roof 1½ to 2 feet of "top coal," above which is shale, about 8 inches thick, and 2½ to 4 feet of shale and coal "rash," above which lies sandstone; floor, shale and bottom coal, with smooth surface. The bed was sampled by E. T. Hancock on December 30, 1917; tipple samples also were taken by E. T. Hancock.

Sections of coal bed in Consolidation No. 1 mine.

Sections	A.		B.		C.		D.		E.	
Laboratory No.	68181		68218		68226		68178		68217	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, top coal.										
Coal	5	10	5	10	5	7	6	9	5	8
Shale		a 1		a 1		a 1½		a 1		a 1½
Coal with streaks of shale		6		a 6		3½		6		3½
Shale		a 1½		a 1		a 1½		a 1½		a 1½
Coal with streaks of shale	2	2	a 1	10	1	10	2	1¾	1	8
Floor, shale, and coal.										
Thickness of bed	8	8½	8	4	7	11	9	7¼	7	10½
Thickness of coal sampled	8	6	5	10	7	8½	9	4¾	7	7½

[a] Not included in sample.

Section A (sample 68181) was cut in 5 room, Old Lye heading inside 20 heading. Section B (sample 68218) was cut in 4 room, 9 heading off Hawkins heading. Section C (sample 68226) was cut in Spitzmans heading 210 feet outside of 2 right. Section D (sample 68178) was cut at face of rock heading at 2 right. Section E (sample 68217) was cut at face of 7 room, 9 right off straight slope.

The ultimate analysis of a composite sample made by combining face samples 68178, 68181, 68217, 68218, and 68226 is given under laboratory No. 30179. The ultimate analysis of a composite sample made by combining tipple samples 68182, 68197, 68216, and 68221 is given under laboratory No. 30180.

In 1917 the capacity of the mine was from 900 to 1,000 tons a day, and the average daily shipments were 950 tons. There was a wooden tipple at mine. Haulage was by mule and by compressed air. The coal did not seem to stick to roof, and the roof did not fall to any great extent, nor did it become mixed with the coal to excess in shipments. The coal was cut mostly by hand. The coal was all shipped run of mine and was picked by one picker in mine, one on dump, and one in car. No coal was coked. The two loading tracks had capacity for 30 empty and 20 loaded railroad cars.

SHORT GAP. STANTON-GEORGES CREEK NO. 1 MINE.

Analysis 26521 (p. 43). Semibituminous coal, Georges Creek field, from Stanton-Georges Creek No. 1 mine, at Short Gap, 1¼ miles east of Clarysville, on a branch of the Cumberland & Pennsylvania R. R. Coal bed, Upper Freeport; Carboniferous

[a] Not included in sample.

age, Allegheny formation. Roof, sandstone; floor, shale; cover at point of sampl 225 feet. The bed was sampled by the Maryland Geological Survey on August 3, 1 at face of 3 room, 4 right, as described below:

Section of coal bed in Stanton-Georges Creek No. 1 mine.

	Ft
Roof, sandstone.	
Coal	
Shale [a]	
Coal	2
Shale [a]	
Coal	1
Floor, shale.	
Thickness of bed	5
Thickness of coal sampled	4

The daily output of the mine at time of sampling was 75 tons.

WESTERNPORT. TACOMA MINE.

Analysis 26520 (p. 43). Semibituminous coal, Georges Creek field, from Taco mine, ¼ mile north of Westernport, on the Cumberland & Pennsylvania R. R. C bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, shale or ro floor, shale; cover at point of sampling, about 90 feet. The bed was sampled 8 room, 1 right heading, by the Maryland Geological Survey on September 26, 1 as described below:

Section of coal bed in Tacoma mine.

	Ft
Roof, shale or rock.	
Coal	
Bone [a]	1
Coal	
Shale [a]	
Coal	2
Floor, shale.	
Thickness of bed	4
Thickness of coal sampled	3

The daily output of the mine at time of sampling was 200 tons.

GARRETT COUNTY.

BARNUM (VA.). MONROE NO. 1 MINE.

Analysis 26983 (p. 43). Semibituminous coal, Upper Potomac basin, from N mine, near Barnum, Va., on the Western Maryland R. R. Coal bed, Lower Kittanni Carboniferous age, Allegheny formation. Roof, sandstone; floor, shale; cover at p of sampling, about 500 feet. The bed was sampled at one point by the Maryl Geological Survey on November 24, 1916, as described below:

Section of coal bed in No. 1 mine.

	Ft.
Roof, sandstone.	
Bone [a]	
Coal	1
Rock [a]	
Coal	1

[a] Not included in sample.

Roof, sandstone—Continued.	Ft.	in.
Binder [a]		½
Coal	1	0
Bone [a]		2
Floor, shale.		
Thickness of bed	4	11
Thickness of coal sampled	4	½

This sample was cut at right rib of 6 left heading (50 feet from main heading), 1,500 feet west of entry. The daily output at time of sampling was 100 tons.

Barton. Monroe No. 2 Mine.

Analysis 26982 (p. 43). Semibituminous coal, Georges Creek field, from No. 2 mine, near Barton, on the Western Maryland R. R. Coal bed, Bakerstown; Carboniferous age, Conemaugh formation. Roof and floor, shale; cover at point of sampling, about 100 feet. The bed was sampled by the Maryland Geological Survey on November 24, 1916, as described below:

Section of coal bed in No. 2 mine.

Roof, shale.	Ft.	in.
Bone [a]		8
"Black jack" [a]		4
Coal	2	4
Floor, shale.		
Thickness of bed	3	4
Thickness of coal sampled	2	4

This sample was cut at face of 7 right heading, 1,200 feet northwest of entry. The daily output of the mine at time of sampling was 100 tons.

Bayard Station. Nethkin Mine.

Analysis 26524 (p. 44). Semibituminous coal, Upper Potomac basin, from Nethkin mine, ½ mile east of Bayard station, on the Western Maryland R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, 250 feet. The bed was sampled by the Maryland Geological Survey on August 31, 1916, as described below:

Section of coal bed in Nethkin mine.

Roof, shale.	Ft.	in.
Bone [a]		3
Coal		10½
Bone [a]		4½
Coal		3
Bone [a]		3
Coal		4½
Bone [a]		½
Coal	2	4
Floor, shale.		
Thickness of bed	4	9
Thickness of coal sampled	3	10

This sample was cut at face of 2 left heading. The weekly output at time of sampling was 50 to 100 tons.

[a] Not included in sample.

BLAINE. HAMILL NO. 2 MINE.

Analysis 26980 (p. 44). Semibituminous coal, Upper Potomac basin, from Hamill No. 2 mine, ¾ mile east of Blaine, on the Western Maryland R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, 400 feet. The bed was sampled by the Maryland Geological Survey on November 24, 1916, as described below:

Section of coal bed in No. 2 mine.

	Ft.	in.
Roof, shale.		
Coal [a]		7
Bone		1
Coal		6½
Bone		½
Coal		8½
Bone		¼
Coal		6½
Shale [a]		2½
Coal		2
Bone		¼
Coal	1	7
Shale [a]		1
Bony coal		7
Floor, shale.		
Thickness of bed	5	2
Thickness of coal sampled	4	3½

This sample was cut at air course, 2 left heading at boundary line, 1,600 feet northwest of opening. The daily output at time of sampling was 200 tons.

BLAINE. PEERLESS NO. 3 MINE.

Analysis 26981 (p. 44). Semibituminous coal, Upper Potomac basin, from Peerless No. 3 mine, 1 mile east of Blaine, on the Western Maryland R. R. Coal bed, Upper Freeport bed; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, 200 feet. The bed was sampled by the Maryland Geological Survey on November 24, 1916, as described below:

Section of coal bed in Peerless No. 3 mine.

	Ft.	in.
Roof, shale.		
Coal	1	1½
Bone [a]		1½
Coal	3	0
Floor, shale.		
Thickness of bed	4	3
Thickness of coal sampled	4	1½

This sample was cut at face of 1 room, 5 left heading, 1,000 feet from entry. The daily output at time of sampling was 300 tons.

BLOOMINGTON. BLOOMINGTON NO. 7 MINE.

Analysis 26512 (p. 44). Semibituminous coal, Georges Creek (?) field, from No. 7, 1 mile west of Bloomington, on the Baltimore & Ohio R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of

[a] Not included in sample.

ampling, over 500 feet. The bed was sampled by the Maryland Geological Survey n August 23, 1916, as described below:

Section of coal bed in No. 7 mine.

	Ft.	in.
Roof, shale.		
Coal		8
Bone[a]		8½
Coal	1	10
Bone[a]		2½
Coal	1	10½
Floor, shale.		
Thickness of bed	5	3½
Thickness of coal sampled	4	4½

This sample was cut at face of 6 room, 3 left heading. The average daily output at ime of sampling was 100 to 125 tons.

CHAFFEE. CHAFFEE MINE.

Analysis 26514 (p. 44). Semibituminous coal, from Chaffee mine, 2 miles northwest of Chaffee, on a switch on the Western Maryland R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, sandstone; floor, shale; cover at point of sampling, over 350 feet. The bed was sampled by the Maryland Geological Survey on August 30, 1916, as described below:

Section of coal bed in Chaffee mine.

	Ft.	in.
Roof, sandstone.		
Coal		8
Shale[a]	1	0
Coal		7
Bone, binder[a]		1
Coal	1	8
Bone, binder[a]		1
Coal	1	4
Floor, shale.		
Thickness of bed	5	5
Thickness of coal sampled	4	3

This sample was taken at face of main heading, over a mile from mouth of mine. The daily output at time of sampling was 400 tons.

CRELLIN. GUTHRIE MINE.

Analysis 26989 (p. 44). Bituminous coal, Upper Youghiogheny basin, from Guthrie mine, 2 miles southwest of Crellin, about 1 mile southeast of the Preston R. R. Coal bed. Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, 30 feet. The bed was sampled by the Maryland Geological Survey on November 23, 1916, as described below:

Section of coal bed in Guthrie mine.

	Ft.	in.
Roof, shale.		
Coal	1	6
Bone[a]		1½
Coal		3
Bony coal		3½

[a] Not included in sample.

Roof, shale—Continued.

Coal

Bone [a]

Coal

Bone, shale, "sulphur" [a]

Coal

Bone [a]

Coal

Floor, shale.

Thickness of bed

Thickness of coal sampled

This sample was taken at face of 18 left room, main heading, 850 feet northw
opening. The daily output at time of sampling was 10 to 15 tons.

FRIENDSVILLE. McCULLOH MINE.

Analysis 26519 (p. 44). Bituminous coal, Lower Youghiogheny basin
McCulloh mine, 1½ miles south of Friendsville. Coal bed, Lower Kittanning
boniferous age, Allegheny formation. Roof and floor, shale; cover at point o
pling, 300 feet. The bed was sampled by the Maryland Geological Survey o
tember 20, 1916, as described below:

Section of coal bed in McCulloh mine.

Roof, shale.

Coal

Bone [a]

Coal

Floor, shale.

Thickness of bed

Thickness of coal sampled

This sample was cut at face of new heading, 50 feet above old heading. At t
sampling the daily output was 50 bushels.

GANNONS STATION. WASHINGTON NO. 5 MINE.

Analysis 26531 (p. 44). Semibituminous coal, Georges Creek field, from Wash
No. 5 mine, opposite Gannons station, on the Cumberland & Pennsylvania
Coal bed, Bakerstown; Carboniferous age, Conemaugh formation. Roof and
shale; cover at point of sampling, 100 to 150 feet. The bed was sampled b
Maryland Geological Survey on August 11, 1916, as described below:

Section of coal bed in Washington No. 5 mine.

	Ft.
Roof, shale.	
Bone [a]	
Shale [a]	
Bone [a]	
Bone or "black jack" [a]	
Coal	2
Floor, shale.	
Thickness of bed	3
Thickness of coal sampled	2

This sample was cut at face of 2 south heading. At time of sampling the dai
put was 220 tons.

[a] Not included in sample.

GORMAN. STRATHMORE MINE.

Analysis 26523 (p. 44). Semibituminous coal, Upper Potomac basin, from Strathmore, 1½ miles east of Gorman, on the Western Maryland R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, over 450 feet. The bed was sampled by the Maryland Geological Survey on August 26, 1916, as described below:

Section of coal bed in Strathmore mine.

	Ft.	in.
Roof, shale.		
Coal		7
Shale, binder [a]		1½-2
Coal	1	6
Shale, binder [a]		1 -1½
Coal		5
Bone, binder [a]		3½-4
Coal	1	1
Shale, binder [a]		4
Coal		8
Floor, shale.		
Thickness of bed	5	1 -2½
Thickness of coal sampled	4	3

This section was cut in 7 room, 2 right heading. At time of sampling the daily output was 60 tons.

GRANTSVILLE. BEACHEY'S MINE.

Analysis 26541 (p. 44). Bituminous coal, Castleman basin, from Beachey's mine, 1½ miles west of Grantsville and 2 miles west of Jennings Bros. R. R. Coal bed, locally known as Grantsville; Carboniferous age, Conemaugh formation. Roof and floor, shale; cover at point of sampling, 80 feet. The bed was sampled by the Maryland Geological Survey on September 13, 1916, as described below:

Section of coal bed in Beachey's mine.

	Ft.	in.
Roof, shale.		
Coal		10½
Shale [a]		1
Coal	1	11
Shale [a]		1½
Bony coal		7
Floor, shale.		
Thickness of bed	3	7
Thickness of coal sampled	3	4½

This sample was cut at 6 room, 2 right heading. The daily output at time of sampling was 300 bushels.

HARRISON. DODSON NO. 3 MINE.

Analysis 26513 (p. 45). Semibituminous coal, Upper Potomac basin, from Dodson No. 3 mine, 1 mile east of Harrison, on the Western Maryland R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at

[a] Not included in sample.

point of sampling, over 400 feet. The bed was sampled by the Maryland Geolog
Survey on August 29, 1916, as described below:

Section of coal bed in No. 3 Dodson mine.

	Ft.
Roof, shale.	
Coal	
Bone, binder [a]	
Coal	
Bone, Binder [a]	
Coal	
Shale, binder [a]	
Coal	1
Shale, binder [a]	
Coal	1
Floor, shale.	
Thickness of bed	4
Thickness of coal sampled	3

This sample was cut in 4 butt, 1 left heading. At time of sampling the daily ou
was 200 tons.

HARRISON. DODSON NO. 5 MINE.

Analysis 26537 (p. 45). Semibituminous coal, Upper Potomac basin, from Do
No. 5 mine, 1 mile west of Harrison, on the Western Maryland R. R. Coal bed, U
Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale; cov
point of sampling, about 400 feet. The bed was sampled by the Maryland Geolog
Survey on August 29, 1916, as described below:

Section of coal bed in No. 5 Dodson mine.

	Ft.
Roof, shale.	
Bone [a]	.....
Coal	
Bone [a]	
Floor. shale.	
Thickness of bed	
Thickness of coal sampled	

This sample was cut at 2 room, 1 right heading. At time of sampling the d
output was 200 tons.

HUBBARD. AJAX HOCKING NO. 1 MINE.

Analysis 26515 (p. 45). Semibituminous coal, Upper Potomac basin, from
Hocking No. 1 mine, opposite Hubbard, on the Western Maryland R. R. Coal
Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, s
cover at point of sampling, 80 to 100 feet. The bed was sampled by the Mary
Geological Survey on September 1, 1916, as described below:

Section of coal bed in Ajax Hocking No. 1 mine.

	Ft.
Roof, shale.	
Coal	
Shale, binder [a]	
Coal	1
Shale, binder [a]	
Coal	1

[a] Not included in sample.

Floor, shale.

Thickness of bed	2	10½
Thickness of coal sampled	2	6¾

This sample was taken in 3 room, off 1 right heading. The daily output at time of sampling was 100 to 125 tons.

LONACONING. KOONTZ MINE.

Analysis 26508 (p. 45). Semibituminous coal, Georges Creek field, from Koontz mine, 2 miles northwest of Lonaconing, on a siding of the Western Maryland R. R. Coal bed, Tyson; Carboniferous age, Monongahela formation. Roof and floor, shale; cover at point of sampling, over 150 feet. The bed was sampled by the Maryland Geological Survey on August 10, 1916, at face of main heading, over 1¼ miles from entry, the sample representing 3 feet 5 inches of coal. At time of sampling the daily output was 250 tons.

LONACONING. NEW OPENING.

Analysis 26522 (p. 45). Semibituminous coal, Georges Creek field (?), from a new opening, 3 miles northwest of Lonaconing; no railroad. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof and floor, shale; cover at point of sampling, 90 feet. The bed was sampled by the Maryland Geological Survey on August 10, 1916, at face of main heading, 350 feet inside from opening, the sample representing 4 feet 3 inches of coal. At time of sampling the mine was not shipping.

OAKLAND. CHISHOLM MINE.

Analysis 26517 (p. 45). Semibituminous coal, Upper Youghiogheny basin, from Chisholm mine, Strathmore, 4½ miles north of Oakland; no railroad. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, shale; floor, shale and bastard fire clay; cover at point of sampling, 75 feet. The bed was sampled by the Maryland Geological Survey on September 18, 1916, as described below:

Section of coal bed in Chisholm mine.

Roof, shale.	Ft.	in.
Coal	1	4
Bone [a]		2½–3
Coal		3
Floor, shale and fire clay.		
Thickness of bed	1	9½–10
Thickness of coal sampled	1	7

This sample was cut in 1 room, 1 left heading. The daily output at time of sampling was 5 tons.

OAKLAND. JOHN SINES MINE.

Analysis 26538 (p. 45). Bituminous coal, Upper Youghiogheny basin, from John Sines mine, 8 miles north of Oakland. Coal bed, Mercer; Carboniferous age, Pottsville series. Thickness at point of sampling, 1 foot 4½ inches; roof and floor, shale; cover at point of sampling about 50 feet. The bed was sampled by the Maryland Geological Survey on September 19, 1916.

The sample was taken at main heading, 70 feet from mine mouth and represented 1 foot 3 inches of coal. At time of sampling the mine was abandoned.

[a] Not included in sample.

OAKLAND. O. R. LEIGHTON MINE.

Analysis 26536 (p. 45). Bituminous coal, Upper Youghiogheny basin, from C
Leighton mine, 6 miles northwest of Oakland or 1¾ miles southwest of Swallow F
Coal bed, "Galitzen"; Carboniferous age, Conemaugh (?) formation. Roof and f
shale; cover at point of sampling, 40 feet. The bed was sampled by the Mary
Geological Survey on September 19, 1916, as described below:

Section of coal bed in O. R. Leighton mine.

	F
Roof, shale.	
Bony coal [a]	
Shale [a]	
Coal	
Shale [a]	
Coal	1
Bone [a]	
Coal	
Bone [a]	
Coal	
Floor, shale.	
Thickness of bed	2
Thickness of coal sampled	2

This sample was cut at face of heading in new opening, 60 feet from entry.
daily output at time of sampling was 60 bushels.

OAKLAND. TAYLOR SINES MINE.

Analysis 26525 (p. 45). Bituminous coal, Upper Youghiogheny basin, from Ta
Sines mine, 6½ miles northwest of Oakland or ¾ mile southwest of Swallow F
Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof and f
shale; cover at point of sampling, about 500 feet. The bed was sampled by
Maryland Geological Survey on September 19, 1916, the sample representing 3
2½ inches of coal. The sample was taken at left rib of main heading, just we
left heading. At the time of sampling the mine was not worked.

OAKLAND. E. Z. TOWER MINE.

Analysis 26534 (p. 45). Bituminous coal, Upper Youghiogheny field, from E
Tower mine, 3½ miles north of Oakland; no railroad. Coal bed, "Galitzen"; Ca
niferous age, Conemaugh (?) formation. Roof and floor, shale; cover at point of s
pling, 180 feet. The bed was sampled by the Maryland Geological Survey on S
tember 18, 1916, as described below:

Section of coal bed in E. Z. Tower mine.

	Ft
Roof, shale.	
Coal	
Shale	
Coal	1
Shale	
Coal	
Floor, shale.	
Thickness of bed	2
Thickness of coal sampled	2

This sample was cut at face of main heading. The daily output at time of samp
was 4 tons.

[a] Not included in sample.

SWALLOW FALLS. J. W. BEEGHLY MINE.

Analysis 26535 (p. 45). Bituminous (?) coal, Upper Youghiogheny basin, from J. W. Beeghly mine, 2 miles southwest of Swallow Falls or 7 miles northwest of Oakland; no railroad. Coal bed, "Galitzen"; Carboniferous age, Conemaugh (?) formation. Roof and floor, shale; cover at point of sampling, 55 to 65 feet. The bed was sampled by the Maryland Geological Survey on September 19, 1916, in 2 room, 1 heading, the sample representing 2 feet 5 inches of coal. At time of sampling the daily output was 60 bushels.

SWALLOW FALLS. L. G. SHAEFFER MINE.

Analysis 26518 (p. 45). Bituminous coal, Upper Youghiogheny basin, from L. G. Shaeffer mine, 1 mile east of Swallow Falls or 6 miles north of Oakland. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof and floor, shale, cover at point of sampling, 150 feet. The bed was sampled by the Maryland Geological Survey on September 18, 1916, as described below:

Section of coal bed in L. G. Shaeffer mine.

	Ft.	in.
Roof, shale.		
Bony coal [a]	1	5½
Shale and bastard fire clay [a]		1½
Shale [a]		1½
Coal	2	0
Floor, shale.		
Thickness of bed	3	8½
Thickness of coal sampled	2	0

This sample was taken in 2 room, 3 right heading. The daily output at time of sampling was 4 tons.

MISSISSIPPI.

CHOCTAW COUNTY.

REFORM. MISSISSIPPI O. & G. C. J. S. MINE.

Analyses 25914 and 25915 (p. 45). Lignite, lignite field, from Mississippi O. & G. C. J. S. mine, ½ mile south of Reform, ½ mile west of the New Orleans, Mobile & Chicago R. R. Lignite bed, Tertiary age; Wilcox formation. Roof, carbonaceous clay; floor, fire clay. The bed was sampled on August 18, 1916, by O. B. Hopkins. as described below:

Sections of coal bed in Mississippi O. & G. C. J. S. mine.

Sections	A.		B.	
Laboratory No.	25914		25915	
Roof, carbonaceous clay.	Ft.	in.	Ft.	in.
Lignite, fairly good	[a] 1	3		
Lignite, dirty		[a] 7		
Lignite		[a] 2		
Carbonaceous clay		[a] 5½		
Lignite, dirty		[a] 8		
Lignite, good	3	9	[a] 1	2½
Lignite, earthy, and clay			[a] 1	9
Lignite, good			2	4
Lignite, covered with water and not sampled			[a] 1+	0
Floor, fire clay.				
Thickness of bed	6	10½	6	3½+
Tickness of lignite sampled	3	9	2	4

[a] Not included in sample.

The sections measured and sampled were at face of main entry, 100 feet from mine mouth.

[a] Not included in sample.

MONTANA.

BIG HORN COUNTY.

LODGEGRASS. LOCAL PROSPECT.

Analysis 26149 (p. 46). Subbituminous coal from local prospect in sec. 33, T. R. 37 E., about 13 miles southeast Lodgegrass, on Chicago, Burlington & Quincy Coal bed, Carney; Tertiary age, Fort Union formation. Roof, sandstone; floor, s The bed was sampled on August 31, 1916, by R. W. Howell, about 50 feet n west of opening of prospect. The sample represented 8 feet 1 inch of coal, thickness of the bed except for 6 inches of carbonaceous shale between the and the sandstone roof.

LOCAL PROSPECT.

Analysis 29370 (p. 46). Subbituminous coal, in sec. 33, T. 7 S., R. 37 E. bed, Carney; Tertiary age; Fort Union (?) formation. The bed was sample October 4, 1917, by A. J. Collier. The sample was gathered at face of main entr feet from mouth of prospect, and represented 8 feet of coal.

BROADWATER COUNTY.

LOMBARD. WESTERN MINE.

Analyses 28556 and 28557 (p. 46). Coking coal, Lombard field, from We mine, a slope mine 1 mile west of Lombard, on the Northern Pacific R. Coal bed, not named; Cretaceous age, Cascade (?) formation. Thicknes bed varies from 1 to 30 feet, at points of sampling, 6 feet; roof, main, 14 feet of friable coal; cover at points of sampling, about 400 feet. The bed was sampled J. J. Forbes on May 25, 1917. The samples each represented 6 feet of coal, the e thickness of the coal sampled. Section A (sample 28556) was cut in 1 stub r north entry. Section B (sample 28557) was cut in 1 stub room, north entry. Co this property is found in pockets. The property was abandoned in 1911; prior to the work done was chiefly prospecting.

CARBON COUNTY.

RED LODGE. RED LODGE NO. 4 MINE.

Analyses 29466 to 29470 (p. 46). Subbituminous coal, Bear Creek (?) field, Red Lodge No. 4 mine, a slope mine at Red Lodge, in sec. 27, T. 7 S., R. 20 E. the Northern Pacific R. R. Coal bed, No. 4; Tertiary age, Fort Union format Bed is 8 feet 6 inches to 11 feet 6 inches thick and dips 6° to 22°; cover at poin sampling, 800 feet; elevation of mouth of mine above sea level, 5,545 feet; roof, sh limestone, and sandstone; floor, clay or sandstone. The bed was sampled by C Allen on November 26, 1917, as described below:

Sections of coal bed in Red Lodge No. 4 mine.

Section	A.		B.		C.		D.	
Laboratory No.	29469		29466		29468		29467	
Roof, A, shale and sandstone; B, shale; C, clay and limestone; D, limestone and shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Bone		1						
Coal	2	4	3	2	1	9½		
Shale		½		ᵃ2		½		ᵃ2
Coal		10	2	7		5	2	2½
Shale		ᵃ3½		¼				
Clay						1		1½
Coal	1	2½		5	2	6	6	2
Bone		1						
Clay						1		
Coal	1	10			3	10		
Dirt		1						
Coal	1	1						
Shale		¾		¾				
Coal	1	2	3	6				
Dirt		¾						
Coal		4½						
Dirt		½						
Coal		6						
Shale		½						
Coal	1	1½						
Floor, A, clay; B, clay; C, fire clay; D, sandstone.								
Thickness of bed	11	3	9	11	8	9	8	8
Thickness of coal sampled	10	11½	9	9	8	9	8	6

ᵃ Not included in sample.

Section A (sample 29469) was cut from 1 room, 8 east entry. Section B (sample 29466) was cut from 46 room, 10 east entry. Section C (sample 29468) was cut from 129 room, 9 east entry. Section D (sample 29467) was cut from 45 room, 12 east entry.

The result of an ultimate analysis of a composite sample made by mixing samples 29466, 29467, 29468, and 29469 is given under laboratory No. 29470.

System of mining, room and pillar. The coal is mined by bearing in at top and then shooting up bottom coal. In 1917 black blasting powder was used and the coal was shot by the miners just before leaving the mine. Haulage on the slopes was by direct-connected steam engine, with a single rope; electric motors were employed for distributing empties and gathering loaded cars. The mine had track capacity for 200 empty and 120 loaded cars. The daily average was 2,300 tons, 70 per cent of which was lump coal and the rest screenings. The unmined area consisted of 1,000 acres. The probable lifetime of the mine was 15 years.

WASHOE. WASHOE MINE.

Analyses 28622 to 28626 (p. 46). Subbituminous coal, Red Lodge or Bear Creek field, from Washoe mine, a slope mine at Washoe, on the Montana, Wyoming & Southern R. R. Coal bed, Bear Creek No. 3; Tertiary age; Fort Union formation. Average thickness of bed is 9½ feet; dip, 4 to 7 per cent south; roof, shale; floor, clay; cover at point of sampling, 500 feet. The bed was sampled by C. A. Allen on June 1, 1917, as described below:

Sections of coal bed in Washoe mine.

Section	A.		B.		C.		D.	
Laboratory No.	28625		28624		28623		28622	
Roof, clay.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	3	1	6	2	5	11	5	7
Clay		½		ᵃ6		ᵃ3		ᵃ4
Coal	2	2½	1	8	3	4	2	7
Clay		ᵃ4						
Coal		9						
Coal, dirty				6				
Clay		½						
Coal	2	½	1	6				
Coal, in floor	ᵃ1	0						
Floor, clay.								
Total, thickness	9	6	10	4	9	6	8	6
Thickness of coal sampled	8	2	9	8	9	3	8	2

ᵃ Not included in sample.

Section A (sample 28625) was taken from left side neck of 13 room, 15 feet in from 2 east entry. Section B (sample 28624) was taken 20 feet back from face in 1 east back entry. Section C (sample 28623) was taken from upper end of parting in main north, near 4 east entry. Section D (sample 28622) was taken from left rib 9 room, 50 feet in room from 3 east entry.

The ultimate analysis of a composite sample made by combining samples 28622, 28623, 28624, and 28625 is given under laboratory No. 28626.

System of mining, room and pillar. In 1917 the coal was undercut by machine and shot down by black powder. A large part of the mining was done by hand. The average output was 785 tons a day. Practically all the coal was shipped as run of mine to the smelter of the Anaconda Copper Mining Co.

GALLATIN COUNTY.

PROSPECT.

Analysis 26729 (p. 47). Bituminous coal from prospect in sec. 3, T. 9 S., R. 3 E. Geologic relations unknown. Sampled on October 31, 1916, by D. D. Condit. Coal at point of sampling was 4 feet thick. Sample, which was cut at face of drift, 30 feet from mouth of prospect, was weathered.

MUSSELSHELL COUNTY.

ROUNDUP. ROUNDUP A MINE.

Analyses 28999 to 29004 (p. 47). Subbituminous coal, Bull Mountain field, from Roundup A mine, a slope mine 1 mile west of Roundup, in sec. 23, T. 8 N., R. 25 E., on the Chicago, Milwaukee & St. Paul R. R. Coal bed, Roundup; Tertiary age, Fort Union formation. Average thickness of bed, 6 feet; flat, except near outcrop; dips, 0° to 20°; roof, good; clayey sandstone; floor, clay; cover at points of sampling, 45 to 175 feet. The bed was sampled by C. A. Allen on August 10, 1917, as described below:

Sections of coal bed in Roundup A mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	28999	29003	29001	29000	29002
Roof, clayey sandstone.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Bone, coal, and shale	a 4	a 6			
Shale			a 6	a 4½	a 3½
Coal	5 11	5 9	5 8	5 9	5 2
Coal	a 4		a 2	(a)	a 8
Floor, clay.					
Thickness of bed	6 7	6 3	6 4	6 1½	6 1½
Thickness of coal sampled	5 11	5 9	5 8	6 1½	5 2

a Not included in sample.

Section A (sample 28999) was taken from right rib, 20 feet from face in 40 room, 2 back entry off of 2 west. Section B (sample 29003) was taken from main, 1 west, 600 feet from slope. Section C (sample 29001) was taken from north rib of 7 west parting, just off main slope. Section D (sample 29000) was taken from face of 3 room in 1 north off of 2 west, 15 feet from entry. Section E (sample 29002) was taken from south rib of main east entry, 200 feet west of pumps.

The ultimate analysis of a composite sample made by mixing samples 28999, 29003, 29001, 29000, and 29002 is given under laboratory No. 29004.

System of mining, room and pillar. In 1917 the coal was undercut by machines and shot down by black powder. The daily average output was 1,100 tons. Track capacity was for 60 empty and 60 loaded railroad cars. The unmined area consisted of 320 acres. The estimated lifetime of the mine was eight years.

PHILLIPS COUNTY.

SPENCER MINE.

Analysis 27221 (p. 47). Lignite, from Spencer mine, in sec. 18, T. 24 N., R. 33 E. Lignite bed, not named; Tertiary age, Fort Union formation. The bed was sampled on September 23, 1917, by A. J. Collier.

Section of coal bed in Spencer mine.

	Ft.	in.
Roof, sandstone.		
Bone [a]		3
Parting [a]		1
Lignite	2	10
Clay [a]	1	0
Lignite	1	0
Shale [a]		7
Lignite [a]		1
Floor, shale.		
Thickness of bed	5	10
Thickness of lignite sampled	3	10

The sample was cut at face of main entry, 15 feet south of mouth of mine.

NEVADA.

MINERAL COUNTY.

YERINGTON. PROSPECT.

Analysis 30792 (p. 47). Subbituminous coal, field not named, from a prospect 35 miles south of Yerington, Lyon County, in sec. 1, T. 7 N., R. 27 E., on the Nevada Copper Belt R. R. Coal bed, not named; unknown age, unknown formation. The bed was sampled by D. E. Winchester on June 7, 1918, as described below:

Section of coal bed in Yerington prospect.

	Ft.	in.
Roof, shale.		
Coal, sampled	1	8
Shale, brown		3
Coal, sampled		11
Shale, black		1
Coal, sampled		3
Shale, black	1	1
Coal, sampled		8
Floor, not noted.		
Thickness of bed	4	11
Thickness of coal sampled	3	6

The bed was sampled at face of entry, 30 feet from mouth of prospect. Sample was weathered.

NEW MEXICO.

RIO ARRIBA COUNTY.

LUMBERTON. PROSPECT.

Analysis 31076 (p. 74). Bituminous coal, Monero district, from a prospect drift, in NE. ¼ sec. 8, T. 31 N., R. 1 W., 1½ miles southwest of Lumberton, on the narrow-gage line of Denver & Rio Grande R. R. Coal bed, not named; Upper Cretaceous age, Mesaverde formation. Bed is 7 feet 6 inches thick and is nearly horizontal; cleat, not

[a] Not included in sample.

noted; general character of the bed, not noted; roof and floor, not noted; c
the point of sampling, 30 feet. The bed was sampled by M. R. Campbell on S
ber 15, 1918, as described below:

Section of coal bed in Lumberton prospect.

Roof, not noted.
- Coal [a] ....
- Coal ....
- Bone [a] ....
- Coal ....
- Bone [a] ....
- Coal ....

Floor, not noted.
- Thickness of bed ....
- Thickness of coal sampled ....

The bed was sampled at face of drift, 50 feet from mouth of prospect. Co
have been slightly weathered.

MONERO. OLD SIMS MINE.

Analysis 29279 (p. 47). Bituminous coal, Monero field, from Old Sims mine, i
¼, sec. 7, T. 31 N., R. 1 E., 1 mile southwest of Monero, on the narrow-gage line
Denver & Rio Grande R. R. Coal bed, Upper; Upper Cretaceous age, Mes
formation. Coal bed was sampled on September 22, 1917, by H. Bassler. S
measured on wall of entry 135 feet from mine mouth. Sample represented 3
inches of bed, which was the entire thickness of bed except 8 inches of bone at t
Sample was weathered, as entry was driven 18 years before the sampling was
Cover at point of sampling, 30 feet.

SAN JUAN COUNTY.

FARMINGTON. BILL THOMAS MINE.

Analysis 29249 (p. 48). Bituminous coal, San Juan field, from Bill Thomas m
NW. ¼, sec. 22, T. 32 N., R. 13 W.; no railroad connection. Coal bed, Carbonero;
Cretaceous age, Fruitland (?) formation. Lower part of bed, 39 feet 8 inches
Sampled on September 18, 1917, by H. Bassler. Section of coal bed sampled
follows:

Section of part of coal bed in Bill Thomas mine.

Roof, coal and shale.
- Coal ....
- Shale [a] ....
- Coal ....

Floor, shale.
- Thickness of part of bed ....
- Thickness of coal sampled ....

Sample was obtained 500 feet northwest of mine mouth, where cover is 50 feet

FARMINGTON. JONES MINE.

Analysis 29250 (p. 48). Bituminous coal, San Juan field, from Jones mine o
Darnell in SE. ¼ sec. 21, T. 32 N., R. 13 W., 18 miles northeast of Farmingt
railroad connection. Coal bed, Carbonero; Upper Cretaceous age, Fruitland
tion. Upper part of bed 39 feet 6 inches thick; at point sampled 8 feet 4 inches
Sampled on September 18, 1917, by H. Bassler.

[a] Not sampled.

Section of coal bed in Jones mine.

	Ft.	in.
Roof, coal and shale.		
Coal	1	11
Shale [a]		5
Coal	1	0
Shale [a]	1	0
Coal	4	0
Floor, shale.		
Thickness of bed	8	4
Thickness of coal sampled	6	11

Sample obtained 500 feet south 60° west of mouth of mine.

FARMINGTON. MARCELIUS MINE.

Analysis 29025 (p. 48). Subbituminous (?) coal, San Juan field, from Marcelius mine, in SW. ¼ sec. 28, T. 30 N., R. 15 W., 16 miles northwest of Farmington; no railroad connection. Coal bed, Carbonero; Upper Cretaceous age, Fruitland formation. Sampled on August 14, 1917, by J. B. Reeside, jr.

Section of coal bed in Marcelius mine.

	Ft.	in.
Roof, not noted.		
Coal	4	6
Shale [a]		2
Coal		5
Shale [a]		½
Coal	1	6
Shale [a]		2
Coal	4	6
Shale [a]		2
Coal		6
Floor, not noted:		
Thickness of bed	11	11½
Thickness of coal sampled	11	5

Sample cut in main slope, 300 feet from mine mouth. Coal was somewhat weathered.

FARMINGTON. PROSPECT.

Analysis 29026 (p. 48). Subbituminous (?) coal, San Juan field, from prospect drift in NW. ¼ sec. 16, T. 30 N., R. 15 W., 16 miles northwest of Farmington. Coal bed, upper part of Carbonero bed; Upper Cretaceous age, Fruitland formation. Bed was sampled on August 14, 1917, by J. B. Reeside, jr.

Section of coal bed in Farmington prospect.

	Ft.	in.
Roof, not noted:		
Coal	2	7
Shale [a]		½
Coal	3	8
Bone [a]	1	1
Floor, not noted:		
Thickness of bed	7	4½
Thickness of coal sampled	6	3

Sample was cut at face of entry, 50 feet from mouth of prospect and was weathered. Thickness of cover at point sampled, 70 feet.

[a] Not included in sample.

FARMINGTON. SHIPROCK INDIAN SCHOOL MINE.

Analysis 29006 (p. 48). Bituminous (?) coal, San Juan field (?), from m
Shiprock Indian School in SW. ¼ sec. 21, T. 30 N., R. 16 W., 25 miles west of
ington; no railroad connection. Coal bed, not named; Upper Cretaceous age,
verde formation. Coal bed was sampled on August 11, 1917, by H. Basle
point sampled bed was 6 feet 4 inches of thick, clear coal, and was all inclu
sample. Sample was cut at a point 350 feet down main entry and 150 feet u
entry. The coal was mined to supply the Indian school.

SOCORRO COUNTY.

CARTHAGE. GOVERNMENT MINE.

Analyses 30214 to 30216 (p. 48). Bituminous coal, Carthage field, from G
ment mine, a slope mine at Carthage, on the New Mexico Midland R. R. Co
Carthage; Cretaceous age, Mesaverde formation. Bed is 5 to 7 feet thick. S
faults and dikes were encountered. Roof, in some parts, a soft sandstone, in
parts a black shale; floor, chiefly sandstone; cover at points of sampling,
350 feet. The bed was sampled by D. Harrington on March 5, 1918, as des
below:

Sections of coal bed in Government mine.

Section	A.
Laboratory No.	30215
	Ft. in.
Roof, shaly sandstone.	
Coal	1 0
Bone	1
Shale	......
Coal	3 6
Shale, light-colored	a 3
Coal	1 0
Bone, dark	a 3
Coal	7
Floor, shale.	
Thickness of bed	6 8
Thickness of coal sampled	6 2

a Not included in sample.

Section A (sample 30215) was taken in 2 room, off 22 slant, off main entry. S
B (sample 30214) was taken in 3 room, off second left, rise room.

The ultimate analysis of a composite sample made by combining equal a
of face samples 30215 and 30214 is shown under laboratory No. 30216 F.

System of mining, room and pillar. In 1918 all of the coal was hand mine
powder was used in shooting the coal, the only explosives used being for going t
rock dikes. Haulage was by rope. The average daily output was 150 tons.

NORTH DAKOTA.

WARD COUNTY.

BURLINGTON. CONON MINE.

Analyses 31702 to 31705 (p. 48). Lignite from Conon mine, ½ mile east of Burli
on the Minneapolis, St. Paul & Sault Ste. Marie R. R. Coal bed, Lignite; T
(Eocene) age; Fort Union formation. Bed is 10 to 11 feet thick and lies
horizontal; at places dips 1° to southwest; roof, clay over top coal; top coal
when pillar is drawn; floor, 1 foot of coal, then clay; cover at points of sam
100 feet. The bed was sampled by J. G. Schoning on March 28, 1919, as des
below:

Sections of coal bed in Conon mine.

ection	A.		B.		C.	
aboratory No.	31702		31703		31704	
oof, clay.	Ft.	in.	Ft.	in.	Ft.	in.
Roof coal	a 2	6	a 3	0	a 3	0
Coal	2	1	1	4		10
Clay		a 1½	.....	.....	.....	.....
Coal, mushy	.....	.....		9		8
Coal	4	3½	4	5	4	0
loor, coal.						
Thickness of bed	6	6	6	6	5	6
Thickness of coal sampled	6	4½	6	6	5	6

a Not included in sample.

Section A (sample 31702) was cut at rib 20 feet from face of main entry, 700 feet east f pit mouth. Section B (sample 31703) was cut at face of 2 room, 2 east main entry, 00 feet from opening. Section C (sample 31704) was cut at face of 3 room, main back ntry, 600 feet east of mine mouth.

The ultimate analysis of a composite sample made by combining samples 31702, 1703, and 31704 is given under laboratory No. 31705.

System of mining, room and pillar. The coal was shot from the solid with FFF lack powder, and in places a little hand cutting was done. Men employed numbered 8 underground and 4 aboveground. The tipple was of wood. At the time of sampling he output was 50 tons a day, 25 per cent of which was derived from advance workings. None of the coal was shipped as run of mine, but all was screened over 2-inch bar creens. Haulage was by mule and rope. The coal was picked on wagons by eamsters and hauled by team to track. The lumps on the cars were large and clean. The estimated lifetime of the mine was 50 years. The capacity of the mine was 50 tons a day, which was equal to the maximum day's run.

WILLIAMS COUNTY.

Ray. Pittsley Mine.

Analyses 29251 and 29253 (p. 49). Lignite from mine of S. F. Pittsley in sec. 29, T. 155 N., R. 96 W., 10 miles southwest of Ray, on the Great Northern R. R.; no railroad connection. Lignite bed, not named; Eocene age, Fort Union formation. Bed is 14 feet 5 inches thick; roof and floor, not recorded. Lignite bed was sampled on September 11, 1917, by A. J. Collier, as follows:

Section of lignite bed in S. F. Pittsley mine.

	A. No. 29251		B. No. 29253	
	Ft.	in.	Ft.	in.
Lignite	a 8	7	a 8	7
Clay		a 2		2
Lignite	3	8	5	8
Lignite	a 2	0	.....	.....
Thickness of bed	14	5	14	5
Thickness of lignite sampled	3	8	5	8

a Not included in sample.

The samples were gathered in 1 left entry, 100 feet north of mine mouth.

WHEELOCK. JIM MONUEN MINE.

Analysis 29252 (p. 49). Lignite from mine of Jim Monuen, in sec. 29, T. 155
97 W., 7 miles southeast of Wheelock, on the Great Northern R. R.; no railroa
nection. Lignite bed, not named; Eocene age, Fort Union formation. Obs
thickness of bed, 13½ feet; roof and floor, not recorded. Bed lies flat. Sampl
September 12, 1917, by A. J. Collier. Sample was cut in 2 left entry, 300 fee
of mine mouth, and represented 8 feet of lignite, over which was 5 feet 6 inches of li

OHIO.

COLUMBIANA COUNTY.

EAST LIVERPOOL. DELANEY COAL BANK.

Analysis 25592 (p. 49). Bituminous coal, Lisbon field, from Delaney coal ba
miles north of east from East Liverpool, on Smith Ferry Road, in section 36, Liv
Township. Coal bed, Middle Kittanning; Carboniferous age; Allegheny form
Roof, bony coal, with dark-olive shale above; floor, clay. The bed was sampl
July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Delaney coal bank.

Roof, bony coal.	Ft
Bony coal[a]	
Coal	
Clay[a]	
Coal	
Floor, clay.	
Thickness of bed	
Thickness of coal sampled	

The section was measured 65 feet north of mine mouth.

EAST LIVERPOOL. DUCK COAL BANK.

Analysis 25589 (p. 49). Bituminous coal, Lisbon field, from Duck coal ba
miles northeast of East Liverpool, on Smith Ferry Road, in section 36, Liv
Township. Coal bed, Middle Kittanning; Carboniferous age, Allegheny form
Roof, bony coal 3 to 5 inches, with dark-olive shale above; floor, clay. The be
sampled on July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Duck coal bank.

Roof, bony coal and dark-olive shale.	
Bony coal[a]	
Coal	
Clay[a]	
Coal	
Floor, clay.	
Thickness of bed	
Thickness of coal sampled	

The section was measured 50 feet east of north of mine mouth.

[a] Not included in sample.

EAST LIVERPOOL. GASTON COAL BANK.

Analysis 25583 (p. 49). Bituminous coal, Lisbon field, from Gaston coal bank, 2¾ miles northeast of East Liverpool, in N. ½ sec. 28. Coal bed, Upper Freeport; Carboniferous (Freeport) age, Allegheny formation. Roof, up to 3 inches bituminous shale, with massive sandstone above; floor, fire clay. The coal was sampled on July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Gaston coal bank.

	Ft.	in.
Roof, shale and sandstone.		
Bone and some coal [a]		1
Coal		9
Clay parting		⅛
Coal		4
Clay parting		⅛
Coal	1	¼
Clay parting [a]		½
Coal		5½
Clay bench [a]		1½
Coal		3½
Clay		3
Floor, fire clay.		
Thickness of bed	6	1½
Thickness of coal sampled	2	10½

The section was measured in the mine 65 feet northeast of mine mouth.

EAST LIVERPOOL. JOHNSON COAL BANK.

Analysis 25588 (p. 49). Bituminous coal, Lisbon field, from Johnson coal bank, 1½ miles north of East Liverpool, in section 33, middle. Coal bed, Middle Kittanning, Carboniferous age, Allegheny formation. Roof, massive sandstone; floor, fire clay. The bed was sampled on July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Johnson coal bank.

	Ft.	in.
Roof, sandstone.		
Bone, some coal [a]		1½
Coal	1	5
Clay band [a]		1
Coal		4½
Clay parting		¼
Coal		4½
Floor, fire clay.		
Thickness of bed	2	4½
Thickness of coal sampled	2	2

The section was measured 50 feet north of mine mouth.

EAST LIVERPOOL. KINSEY COAL BANK.

Analysis 25585 (p. 49). Bituminous coal, Lisbon field, from Kinsey coal bank, 2½ miles north of East Liverpool, in SW. ¼ sec. 28. Coal bed, Lower Freeport; Carboniferous age, Allegheny formation. Roof, sandy shale; floor, fire clay. The bed was sampled on July 15, 1916, by J. H. Hance, as described below:

[a] Not included in sample.

Section of coal bed in Kinsey coal bank.

Roof, sandy shale.
- Bone and black shale [a]
- Coal
- Clay parting
- Coal
- Clay parting
- Coal
- Clay parting
- Coal
- Clay parting [a]
- Bony coal [a]
- "Sulphur" clay band [a]
- Coal
- "Sulphur" streak and clay [a]
- Coal
- Clay [a]
- Coal

Floor, fire clay.
- Thickness of bed
- Thickness of coal sampled

The section was sampled in mine 65 feet north of entry mouth.

East Liverpool. Malone's Coal Bank.

Analysis 25590 (p. 49). Bituminous coal, Lisbon field, from Malone's coal ½ mile north of East Liverpool, in section 24, center. Coal bed, Lower Kitt Carboniferous age, Allegheny formation. Roof, massive sandstone; floor, fir The bed was sampled on July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Malone's coal bank.

Roof, massive sandstone.
- Shale, chocolate [a]
- Coal, with streaks of bone
- "Sulphur" streaks [a]
- Coal
- "Sulphur" streak and clay [a]
- Coal

Floor, fire clay.
- Thickness of bed
- Thickness of coal sampled

The section was measured in the mine 15 feet northeast of opening.

East Liverpool. Moore's Coal Bank.

Analysis 25586 (p. 49). Bituminous coal, Lisbon field, from Moore's coal 3½ miles northeast by north of East Liverpool, in SE. ¼ sec. 23. Coal bed, Lowe port; Carboniferous age, Allegheny formation. Roof, sandy shale; floor, cla clay?). The bed was sampled on July 15, 1916, by J. H. Hance, as described

[a] Not included in sample.

Section of coal bed in Moore's coal bank.

	Ft.	in.
Roof, sandy shale.		
Shale, black bituminous[a]		6
Coal		5½
Coal		8
Bony coal		1
Coal		4
"Sulphur" clay band[a]		1½
Coal	1	8½
Bony coal[a]		2
Floor, clay (fire clay?).		
Thickness of bed	4	½
Thickness of coal sampled	3	3

The section was measured in the mine 60 feet southwest from entry mouth.

EAST LIVERPOOL. SMITH COAL BANK.

Analysis 25584 (p. 49). Bituminous coal. Lisbon field, from Smith coal bank, 4 miles northeast by north of East Liverpool, in W. ½ sec. 24. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, sandy shale; floor, fire clay. The bed was sampled on July 15, 1916, by J. H. Hance, as described below:

Section of coal bed in Smith coal bank.

	Ft.	in.
Roof, sandy shale.		
Bony coal[a]		1
Coal	1	2¾
Clay parting[a]		¼
Coal		7
Clay[a]		1
Coal		6½
Clay[a]		3
Floor, fire clay.		
Thickness of bed	2	6½
Thickness of coal sampled	2	4¼

The section was measured in the mine 125 feet east from entry mouth.

NEW SALISBURY. McCLAIN MINE.

Analysis 25892 (p. 50). Bituminous coal, Lisbon field, from McClain mine, an entry mine ½ mile northeast of New Salisbury, in section 34, Yellow Creek Township, on the Pennsylvania R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, chocolate-colored shale and sandstone; floor, clay. The bed was sampled on August 16, 1916, by J. H. Hance, as described below:

Section of coal bed in McClain Fire Brick Co. mine.

	Ft.	in.
Roof, shale and sandstone.		
Shale, chocolate-colored[a]		3½
Clay, black bituminous[a]		¼
Coal	1	3¼
Clay and pyrite[a]		1¾
Coal	1	10½
Clay band[a]		1¼
Coal		10½

[a] Not included in sample.

Floor, clay.
Thickness of bed..
Thickness of coal sampled..

The section was measured 900 feet east of entry or mine mouth.

WELLSVILLE. AINSWORTH'S COAL BANK.

Analysis 25898 (p. 50). Bituminous coal, Lisbon field, from Ainsworth's coal
Wellsville, in section 5, Yellow Creek Township. Coal bed, Lower Kittar
Carboniferous age, Allegheny formation. Roof, shale; floor, clay. The bed wa
pled on August 22, 1916, by J. H. Hance, as described below:

Section of coal bed in Ainsworth's coal bank.

Roof, shale.
Shale [a]..
Clay, shale, bone [a]..
Coal, irregular partings...
Floor, clay.
Thickness of bed...
Thickness of coal sampled..

The section was measured 30 feet south 16° east of mine mouth.

WELLSVILLE. DANGELO COAL BANK.

Analysis 25896 (p. 50). Bituminous coal, Lisbon field, from Dangelo coal
Wellsville, in section 15, Yellow Creek Township, on the Pennsylvania R. R.
bed, Mahoning (Sharon?); Carboniferous age, Pottsville (?) series. Roof, shal
sandstone; floor, clay. The bed was sampled on August 17, 1916, by J. H. Ha
described below:

Section of coal bed in Dangelo coal bank.

Roof, shale and sandstone.
Coal...
Clay and pyrite [a]..
Coal...
Clay and pyrite [a]..
Coal...
Sand parting [a]...
Coal...
Floor, clay.
Thickness of bed...
Thickness of coal sampled..

The section was measured 40 feet south of mine mouth.

WELLSVILLE. HOUSEHOLDER'S COAL BANK.

Analysis 25894 (p. 50). Bituminous coal, Lisbon field, from Householder'
bank, 1½ miles northwest of Wellsville, in section 11, Yellow Creek Township,
Pennsylvania R. R. Coal bed, Upper Freeport; Carboniferous age, Alleghen
mation. Roof, sandstone; floor, clay. The bed was sampled on August 18, 19
J. H. Hance, as described below:

[a] Not included in sample.

Section of coal bed in Householder's coal bank.

	Ft.	in.
Roof, sandstone.		
Bony coal[a]		1
Coal		4¾
Clay, black		⅝
Coal		7½
Clay		¼
Coal		9
Clay and bone[a]		¾
Coal		9
Floor, clay.		
Thickness of bed	2	8⅞
Thickness of coal sampled	2	7⅛

The section was measured 20 feet south 35° west from mine opening.

WELLSVILLE. SHECKLER COAL BANK.

Analysis 25895 (p. 50). Bituminous coal, Lisbon field, from Sheckler coal bank, Wellsville, in section 5, Yellow Creek Township, on the Pennsylvania R. R. Coal bed, Lower Freeport; Carboniferous age, Allegheny formation. Roof, shale; floor, clay. The bed was sampled on August 18, 1917, by J. H. Hance, as described below:

Section of coal bed in Sheckler coal bank.

	Ft.	in.
Roof, shale.		
Clay shale, bituminous[a]		3½
Coal, dirty		1¼
Coal		4¼
Clay, black		¼
Coal		6
Bone band[a]		1
Coal		10
Floor, clay.		
Thickness of bed	2	2¼
Thickness of part sampled	1	9¾

The section was measured 55 feet north 10° west of mine opening.

WELLSVILLE. SMITH'S COAL BANK.

Analysis 25893 (p. 50). Bituminous coal, Lisbon field, from Smith's coal bank, 3 miles northwest of Wellsville, in section 18, Yellow Creek Township. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, sandy shale and shaly sandstone; floor, clay. The bed was sampled on August 19, 1916, by J. H. Hance, as described below:

Section of coal bed in Smith's coal bank.

	Ft.	in
Roof, sandy shale and shaly sandstone.		
Bony coal		1
Coal	1	0
Clay, black		3/16
Coal		6½
Clay, black		½
Coal		3½

[a] Not included in sample.

Roof, sandy shale and shaly sandstone—Continued.	Ft.	in.
Clay, black		¼
Coal		6½
Clay, black		¼
Coal	1	9¼
Floor, clay.		
Thickness of bed	4	3 11/16
Thickness of coal sampled	4	3 11/16

The section was measured 150 feet west 12° south of mine opening.

WELLSVILLE. WOOSTER'S CLAY MINE.

Analysis 25897 (p. 50). Bituminous coal, Lisbon field, from Wooster's clay mine, Wellsville, in section 9, on the Pennsylvania R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, shale and clay; floor, clay. The bed was sampled on August 17, 1916, by J. H. Hance, as described below:

Section of coal bed in Wooster's clay mine.

Roof, shale and clay.	Ft.	in.
Bituminous shale [a]		8
Coal	1	1¼
Clay [a]		⅜
Coal	1	3¾
Clay		0
Floor, clay.		
Thickness of bed	3	1⅜
Thickness of coal sampled	2	5

The section was measured 100 feet south 80° west of entry mouth.

WELLSVILLE. WOOSTER'S COAL BANK.

Analysis 25900 (p. 50). Bituminous coal, Lisbon field, from Wooster's coal bank, Wellsville, in section 9, on the Pennsylvania R. R. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, chocolate-colored shale; floor, clay. The bed was sampled on August 17, 1916, by J. H. Hance, as described below:

Section of coal bed in Wooster's coal bank.

Roof, shale.	Ft.	in.
Clay, black [a]		1
Coal	2	4
Bone [a]		¾
Floor, clay.		
Thickness of bed	2	5¾
Thickness of coal sampled	2	4

The section was measured 340 feet west of entry mouth.

WEST POINT. WEST POINT MINE.

Analyses 25580 to 25582 (p. 50). Bituminous coal, Lisbon field, from West Point mine, West Point, on the Youngstown & Ohio R. R. (electric). Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, up to 3 feet bituminous shale under massive sandstone; floor, fire clay. The coal was sampled on July 6, 1916, by J. H. Hance, as described below:

[a] Not included in sample.

Sections of coal bed in Kirk-Dunn Coal Co. West Point mine.

Section	A.		B.	
Laboratory No	25580		25581	
	Ft.	in.	Ft.	in.
Roof, shale under sandstone.				
Shale, chocolate				a6
Shale, bituminous, coaly	a2	3		a5
Coal	1	3¼	1	0
"Mother coal"		a½		
"Sulphur" clay streak				1/16
Coal		5		4
"Sulphur" clay streak		a½		a1/16
Coal		7	1	10
Coal with 1/16-inch "mother coal"		5		
Coal		8		
Clay band, bituminous		a1½		a2¼
Coal	1	0	1	0
Floor, fire clay.				
Thickness of bed	6	9¾	5	3⅜
Thickness of coal sampled	4	4¼	4	2 1/16

a Not included in sample.

Section A (sample 25580) was measured 1,800 feet west of south of main entry. Section B (sample 25581) was measured 500 feet northeast of entry.

The ultimate analysis of a composite sample made by mixing samples 25580 and 25581 is given under laboratory No. 25582.

JEFFERSON COUNTY.

CREAM CITY. CREAM CITY MINE.

Analysis 25899 (p. 51). Bituminous coal, Lisbon field, from Cream City mine, Cream City, on the Pennsylvania R. R. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, chocolate-colored shale; floor, clay. The bed was sampled on August 16, 1916, by J. H. Hance, 340 feet north 20° east from entry mouth. Sample represented 2 feet 4½ inches of coal, the entire thickness of the bed sampled.

EMPIRE. CULP'S COAL BANK.

Analysis 25784 (p. 51). Bituminous coal, Pittsburgh No. 8 field, from Culp's coal bank, 2½ miles south of west of Empire, in section 9, Knox Township, on the Pennsylvania R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Roof, sandstone; floor, bone and clay. The bed was sampled on August 1, 1916, by J. H. Hance, as described below:

Section of coal bed in Culp's coal bank.

	Ft.	in.
Roof, sandstone.		
Coal		9½
Clay, sandy		½
Coal, few irregular partings	1	4½
Clay		⅛
Coal		2½
Clay a		⅛
Coal		8½
Clay		½
Coal		3
Clay		½

a Not included in sample.

Roof, sandstone—Continued.	Ft.	in.
Coal		5½
Clay [a]		1/16
Bone [a]		3
Floor, bone and clay.		
Thickness of bed	4	2 1/16
Thickness of coal sampled	3	10⅜

The section was measured 275 feet south 35° west from mouth of main entry

IRONDALE. BANFIELD MINE.

Analysis 25785 (p. 51). Bituminous coal, Steubenville field, from Banfield mine, at Irondale, in section 26, Saline Township. Coal bed, Lower Freeport; Carboniferous age, Allegheny formation. Roof, sandy shale; floor, clay. The bed was sampled on August 11, 1916, by J. H. Hance, as described below:

Section of coal bed in Banfield Clay Co. mine.

Roof, shale.	Ft.	in.
Clay, shale [a]		1¾
Bone and pyritiferous coal [a]		3
Pyrite, sandy band [a]		2½
Coal	1	1¾
Clay with pyrite [a]		1
Coal	1	2
Floor, clay.		
Thickness of bed	2	9¾
Thickness of coal sampled	2	3¾

The section was measured 250 feet south 10° west from main entry mouth, where there were 120 feet of cover.

IRONDALE. BANFIELD NO. 3.

Analysis 25787 (p. 51). Bituminous coal, Lisbon field, from Banfield clay mine No. 3, at Irondale, section 26, Saline Township. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, bituminous shale and clay; floor, clay. The bed was sampled on August 11, 1916, by J. H. Hance, as described below:

Section of coal bed in Banfield Clay mine No. 3.

Roof, bituminous shale and clay.	Ft.	in.
Bony coal [a]		2¼
Coal		4
Clay, black		¼
Coal	2	0
Bone, with pyrite [a]		1¼
Floor, clay.		
Thickness of bed	2	8¼
Thickness of coal sampled	2	4¼

The section was measured 400 feet south, 57° east, from main entry.

[a] Not included in sample.

IRONDALE. EAST OHIO NO. 2 MINE.

Analysis 25901 (p. 51). Bituminous coal, Lisbon field, from East Ohio No. 2 mine at Irondale, in section 26, Saline Township. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, clay; floor, clay. The bed was sampled on August 16, 1916, by J. H. Hance, as described below:

Section of coal bed in East Ohio Sewer Pipe Co. No. 2 mine.

	Ft.	in.
Roof, clay.		
Coal		4¾
Clay		¼
Coal		9½
Clay and pyrite [a]		¾
Coal		10½
Clay and pyrite [a]		1
Coal	1	1¼
Pyrite, coal, clay [a]		2¾
Floor, clay.		
Thickness of bed	3	6¾
Thickness of coal sampled	3	2¼

The bed was measured 3,000 feet east of mouth of main entry.

IRONDALE. NICHOLSON COAL BANK.

Analysis 25788 (p. 51). Bituminous coal, Lisbon field, from Nicholson coal bank, Irondale, in section 26, Saline Township. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, shale and sandstone; floor, bone and fire clay. The bed was sampled on August 11, 1916, by J. H. Hance, as described below:

Section of coal bed in Nicholson coal bank.

	Ft.	in.
Roof, shale, and sandstone.		
Shale, bituminous		0
Clay, bituminous [a]		¾
Coal		10⅞
Clay, black		1/16
Coal		5¾
Pyrite band, irregular		1/16
Coal	1	11½
Clay, bench [a]		1¼
Coal		10
Bone [a]		2½
Floor, clay.		
Thickness of bed	4	6¼
Thickness of coal sampled	4	2¼

The section was measured 600 feet west, 10° south, of mouth of main entry.

YELLOW CREEK. LOCAL MINE.

Analysis 25786 (p. 51). Bituminous coal, Pittsburgh or No. 8 field, from mine near New Somerset, 5 miles south of Yellow Creek, Carter Run, in section 16, Knox Township, on the Pennsylvania R. R. Coal bed, Pittsburgh, Carboniferous age, Monongahela formation. Roof, bituminous shale and sandstone; floor, bone and clay. The bed was sampled on August 1, 1916, by J. H. Hance, as described below:

---

[a] Not included in sample.

Section of coal bed in local mine.

	Ft
Roof, bituminous shale and sandstone:	
Shale, coaly	
Coal	
Clay, sandy	
Coal	
Clay	
Coal	
Clay	
Coal	
Clay [a]	
Coal	
Clay, black	
Coal, parting up to ⅛ inch	
Clay, bony [a]	
Coal, few irregular partings	1
Floor, bone and clay.	
Thickness of bed	3
Thickness of coal sampled	3

The section was measured 150 feet south, 5° west, of mouth of main entry.

YELLOW CREEK. YELLOW CREEK MINE.

Analysis 25890 (p. 51). Bituminous coal, Lisbon field, from Yellow Creek m
in section 14, Saline Township, at Yellow Creek, on the Pennsylvania R.
Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, s
and sandstone; floor, clay. The bed was sampled on August 16, 1916, by J. H. Ha
as described below:

Section of coal bed in Yellow Creek mine

	Ft.
Roof, shale and sandstone.	
Shale, bituminous [a]	
Coal	4
Clay [a]	
Coal	1
Clay [a]	
Coal	1
Bone [a]	
Floor, clay.	
Thickness of bed	7
Thickness of coal sampled	6

The section was measured 30 feet west of mouth of entry.

	Ft
Roof, shale and sandstone.	
Bony coal [a]	
Coal	1
Bone and clay [a]	
Coal	1
Bone and clay [a]	
Coal	1

[a] Not included in sample.

Floor, clay.	Ft.	in.
Thickness of bed	4	0¼
Thickness of coal sampled	3	7½

The bed was measured 50 feet southwest of opening.

OKLAHOMA.

COAL COUNTY.

LEHIGH. FOLSOM MORRIS NO. 5 MINE.

Analyses 30707 to 30712 (p. 51). Bituminous coal, Oklahoma field, from Lehigh(?) No. 5 mine, a shaft mine 3,000 feet northeast of Lehigh, in sec. 14, T. 1 S., R. 10 E., on the Missouri, Kansas & Texas R. R. Coal bed, McAlester; Carboniferous (Allegheny) age, McAlester shale. Bed is 3 feet 6 inches to 5 feet thick and dips 5° east. "Sulphur" bands and bony coal are encountered in mining. Roof, poor, a friable dark-gray shale; floor, rough, a soft shale. The bed was sampled by W. H. McCoubrey and J. B. Hynal on May 16, 1918, as described below:

Sections of coal bed in No. 5 mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	30707	30708	30709	30710	30711
Roof, dark gray shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Shale		[a] 1	[a] 2½		1/16
Bony coal					1½
Coal, clean	7	2	1 2	2	1 1½
"Sulphur" band	1/16				1/16
Shale band		[a] ½		1/16	
"Sulphur" and coal band			1/16		
Coal, clean	9½	4	8½	3 7	2
"Sulphur" band	1/16	1/16			½
"Sulphur" and coal band			1/16		
Coal, clean	5½	2½	4½		1½
"Sulphur" band	1/16	1/16	3/32		1/16
Coal, clean	7	6½	2 3		1 ½
Coal, soft	1½				
"Sulphur" band		1/16			½
Coal, clean	5½	1 3			9
"Sulphur" band		1/16			1
Coal, clean		6			1 0
Coal, soft	1				
"Sulphur" band		1/16			
Coal, clean	9	1 7			
Floor, bony coal.					
Thickness of bed	3 10 1/16	4 8¾	4 8¾	3 9 1/16	4 5 11/16
Thickness of coal sampled	3 10 1/16	4 7¼	4 6¼	3 9 1/16	4 4 11/16

[a] Not included in sample.

Section A (sample 30707) was cut at face of 1 south entry, 8½ slope, top entry. Section B (sample 30708) was cut at face of 11 south entry, 5½ slope, bottom entry. Section C (sample 30709) was cut at face of 4 south entry, 5½ slope, bottom entry. Section D (sample 30710) was cut at face of 14 north entry, 5 slope, top entry. Section E (sample 30711) was cut at face of 13 north entry, 5 slope, top entry.

The ultimate analysis of a composite sample made by combining face samples 30707, 30708, 30709, 30710, and 30711 is given under laboratory No. 30712.

System of mining, double entry, room and pillar. In 1918 the coal was sheared by hand and shot down with black powder by the shot firers. Men employed numbered 226 underground and 20 aboveground. The tipple was of wood. The output was shipped as run of mine. Haulage was by tail rope and mules. Coal was picked on the car by one picker. There were four loading tracks, with capacity for 25 empty

[a] Not included in sample.

and 35 loaded railroad cars. Sixty per cent of the coal was mined in advance
The daily capacity of the mine in 1918 was 600 tons, the daily average 450 ton
the maximum day's run 600 tons.

For description and analyses of other samples from this mine see Bureau of
Bull. 22, pp. 149, 674.

LEHIGH. FOLSOM MORRIS NO. 8 MINE.

Analyses 30713 to 30718 (p. 52). Bituminous coal, Oklahoma field, from F
Morris No. 8 mine, a shaft mine, 1½ miles east of Lehigh, in sec. 24, T. 1 S., R.
on the Missouri, Kansas & Texas, the Chicago, Rock Island & Pacific, and the
son, Topeka & Sante Fe Railroads. Coal bed, McAlester; Carboniferous (Alleg
age, McAlester shale. Bed is 4 to 5 feet thick and dips 4° east; it contains bands o
coal and "sulphur;" roof, very poor, of shale; floor, rough, of soft shale; ent
600 feet above sea level; vertical depth to landings (below entrance), 608 feet.
bed was sampled by W. H. McCoubrey and J. B. Hynal on May 17, 1918, as des
below:

For description and analyses of other samples from this mine see Bureau of
Bull. 22, pp. 149, 675.

Sections of coal bed in No. 8 mine.

Section	A.		B.		C.		D.	
Laboratory No.	30713		30714		30715		30716	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.								
Coal, clean		7				8½		
Bony coal				a 1½				
Cannel coal								2
Shale		1/16		1/16		1/16		1/16
Coal, clean		6½	1	5½		4		4
Shale		1/16						1/16
Coal, soft				½		½		
Coal, clean		2½		7½		½		7½
"Sulphur" band		a ½						
Coal, soft		¼				½		
Coal, clean		8				2		
Shale		1/16		1/16				1/16
Coal, clean	1	9		2½				5
"Sulphur" band		a ½		½		1/16		1/16
Coal, clean		2	1	4		10½		5
"Sulphur"								
Shale						1/16		1/16
Coal, clean					1	8½		11
"Sulphur"						a ½		
Shale								1/16
Coal, clean						1		10
Bony coal								
Floor shale.								
Thickness of bed	4	1/16	3	9½	4	0	3	8¾
Thickness of coal sampled	3	11 1/16	3	7½	3	11½	3	8⅝

a Not included in sample.

Section A (sample 30713) was cut at the face of 6 south entry, main slope, b
entry. Section B (sample 30714) was cut at the face of 6 south entry, plane, top e
Section C (sample 30715) was cut at the face of 7 south entry, plane, top e
Section D (sample 30716) was cut at the face of 5 north entry, main slope, bottom e
Section E (sample 30717) was cut at the face of 6 north entry, plane, top entry.

The ultimate analysis of a composite sample made by combining face samples 3
30714, 30715, 30716, and 30717 is given under laboratory No. 30718.

System of mining, double room and pillar. In 1918 the coal was cut by han
shot down with black powder by four shot firers. Men employed numbered 213 u
ground and 17 aboveground. The tipple was of wood, with self-dumping cage.
total output was shipped as run of mine. The coal was screened through sh
screen 8 by 38 feet, with 4-inch holes. Haulage was by tail ropes and mules

appearance of the lump coal on the cars was good. There were four loading tracks, with capacity for 25 empty and 25 loaded railroad cars. About 60 per cent of the coal was taken out in advance work. The daily capacity was 600 tons, the daily average output 450 tons; maximum day's run was equal to the capacity.

PHILIPS. FOLSOM MORRIS NO. 6 MINE.

Analyses 30719 to 30724 (p. 52). Bituminous coal, Oklahoma field, from Folsom Morris No. 6 mine, a shaft mine, 4,000 feet east of Philips, in sec. 2, T. 1 S., R. 10 E., on the Missouri, Kansas & Texas R. R. Coal bed, McAlester; Carboniferous (Allegheny) age, McAlester shale. Bed is 4 to 5 feet thick and dips 9° east. Few faults are encountered in mining, but the bed contains bone and "sulphur" bands. Roof, very poor, of shale; floor, rough, of soft shale; vertical depth to top of coal, 230 feet. The bed was sampled by W. H. McCoubrey and J. B. Hynal on May 22, 1918, as described below:

Section of coal bed in Folsom Morris No. 6 mine.

Section Laboratory No.	A. 30719	B. 30720	C. 30721	D. 30722	E. 30723
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, gray shale.					
Soft shale	a 3	....	....	a 4	....
Coal, clean	1 0	3	10	4	1 1/2
"Sulphur" band	1/8	1/8	1/16	1/16	1/16
Coal, clean	1 3	2	1 2 1/2	1 3	4
Coal, soft	....	....	....	....	1/2
Coal, clean	....	....	....	....	4 1/2
"Sulphur" band	1/16	1/8	1/16	1/16	1/8
Coal, clean	2 2	1 9	2 7	10	9
"Sulphur" band	....	1/16	....	1/16	1/16
Coal, clean	....	1 2	....	1 11	1 0
"Sulphur" band	....	1/16	....	....	a 1/2
Coal, clean	....	1 7	....	....	8
"Sulphur" band	....	....	....	....	a 1/2
Coal, clean	....	....	....	....	3
Floor, shale.					
Thickness of bed	4 8 3/16	4 11 3/8	4 7 5/8	4 8	4 6 3/4
Thickness of coal sampled	4 5 3/16	4 11 3/8	4 7 5/8	4 4	4 5 3/4

a Not included in sample.

Section A (sample 30719) was cut at face of 10 north entry, 6½ slope, top entry. Section B (sample 30720) was cut at face of 10 north entry, main slope, bottom entry. Section C (sample 30721) was cut at face of 11 south entry, main slope, top entry. Section D (sample 30722) was cut at face of 10 south entry, 6½ slope, top entry. Section E (sample 30723) was cut at face of 10 south entry, main slope, top entry.

The ultimate analysis of a composite sample made by combining face samples 30719, 30720, 30721, 30722, and 30723 is given under laboratory No. 30724.

System of mining, double room and pillar. In 1918 the coal was sheared by hand and shot down with black powder at 5 p. m. by three shot firers. Men employed numbered 180 underground and 20 aboveground. The tipple was of wood, with self-dumping cage. Twenty-five per cent of the output was shipped as run of mine. The coal was screened through shaking screens 8 by 38 feet, with 4-inch holes. Haulage was by tail rope, mules, and one electric locomotive. The coal was picked on the car by one picker. There were four loading tracks, with capacity for 20 empty and 25 loaded railroad cars. The lump coal on the cars had a good appearance. Sixty per cent of the coal was taken out in advance work. The capacity of the mine was 600 tons a day, the daily average output 400 tons, and the maximum day's run 600 tons.

HASKELL COUNTY.

McCurtain. Blue Ridge No. 3 Mine.

Analyses 69353 to 69356, average of mine-face samples (p. 52). Bituminous McCurtain field, from Blue Ridge No. 3 mine, a slope mine, 1 mile northwest of M tain, on the Fort Smith & Western R. R. Coal bed, Panama; Carboniferou Hartshorne sandstone. Bed is 3 feet 11 inches to 4 feet 4 inches thick at poi sampling and dips 7° to 8° north; roof, gray shale; floor, soft shale underlain with shale and "sulphur" band. The bed was sampled by W. H. McCoubrey on Ju 1918, as described below:

Sections of coal bed in No. 3 mine.

Section	A.		B.		C.	
Laboratory No	69353		69354		69355	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, gray shale.						
Coal	2	2	2	1	2	2
Bone		a1		a2		a2
Coal	1	8	2	1	1	7
Bone						
Coal						
Floor, soft shale, with hard shale and "sulphur" band below.						
Thickness of bed	3	11	4	4	3	11
Thickness of coal sampled	3	10	4	2	3	9

a Not included in sample.

Section A (sample 69353) was taken at the face of 7 west entry, main slope. Se B (sample 69354) was taken at the face of 6 west entry, main slope. Section C (sa 69355) was taken at the face of 7 east entry, main slope. Section D (sample 6 was taken at the face of 6 east entry, main slope.

Sixty per cent of the coal was taken out in advance work, and the total rec claimed was 75 per cent. Haulage was by mules and slope rope. The three lo tracks had capacity for 30 empty and 20 loaded railroad cars. System of m room and pillar. The coal was cut both by hand and machine; machine c was in shale at the bottom of the coal. Cuttings were not loaded out with the Permissible explosive and permissible powder were used exclusively for sho down the coal. Men employed numbered 125 underground and 25 on the su A wooden tipple equipped with screens and chutes were used. About 50 per of the production was shipped as run of mine, 55 per cent of screened sizes as lump and egg coal, and 45 per cent of screened sizes as slack. The slack was c and about 275 tons of coke was produced a day. Fragments of roof and floor be mixed with the coal, but miners picked the coal when loading at the face; two p cleaned the coal on the cars. There was an inspector of coal at the tipple, Pract the entire output was shipped to points in Oklahoma, Texas, Missouri, and K for steam and domestic purposes. The capacity of the mine was 500 tons a and the average daily production in June, 1918, was 325 tons.

McCurtain. Blue Ridge No. 4 Mine.

Analyses 29840, 29841, 29843, and 69349 to 69352, mine samples, and 69412 and to 69419, tipple samples (p. 53). Bituminous coal, McCurtain field, from Blue No. 4 mine, a slope mine 1¼ miles west of McCurtain, in sec. 21, T. 8 N., R. 2 on the Fort Smith & Western R. R. Coal bed, Panama; Carboniferous age, H horne sandstone. Bed is 4 to 4 feet 9 inches thick and dips 7 to 9° north, with p defined cleat running east and west. Faults and rolls are encountered, and th a soft "slate" band in the middle of the coal. Except for a few small "sulp balls, the bed is almost free from impurities. The main roof is hard, gray shale, the immediate roof 6 inches of hard "draw slate." Floor, 2 inches of soft fire clay, overlying hard smooth sandy shale; cover at points of sampling, 164 to 282 feet. The bed was sampled by W. H. McCoubrey on December 21, 1917, as described below:

Sections of coal bed in No. 4 mine, sampled in 1917.

Section	A.		B.	
Laboratory No.	29840		29841	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*
Coal, upper bench	1	6	1	5
"Blue band"		[a] 1½		[a] 1
Coal, lower bench	2	9	2	9½
Floor, fire clay.				
Thickness of bed	4	4½	4	3½
Thickness of coal sampled	4	3	4	2½

[a] Not included in sample.

Section A (sample 29840) was cut 40 feet from face of main slope, left rib, north. Section B (sample 29841) was cut at face of 4 west entry, main slope.

The ultimate analysis of a composite sample made by combining face samples 29840 and 29841 is given under laboratory No. 29843.

System of mining, room and pillar. In 1917 cutting was done by machine, except in withdrawing pillars, and the coal shot down with black powder and permissible explosive. Men employed numbered 72 underground and 8 aboveground. The tipple was of wood. None of the output was shipped as run of mine. The coal was screened through bar screens 15 feet in length, having 3½-inch spaces. Rope haulage was used on the slope and mule haulage in the mine. The coal was picked on the cars by two pickers. There were two loading tracks, with capacity for 25 empty and 15 loaded railroad cars. The lumps were large, and the appearance of the lump coal and screenings on the cars was good. The screenings were crushed and coked, but not washed. Fifty-five per cent of the coal was taken in advance work, and the recovery was 75 per cent. The unmined area was 300 acres. The daily capacity of the mine in 1917 was 350 tons, the average output 300 tons, and the maximum day's run 347 tons.

The bed was sampled also by W. H. McCoubrey on June 3, 1918, as described below. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 10, 1918.

Sections of coal bed in No. 4 mine, sampled in 1918.

Section	A.		B.		C.		D.	
Laboratory No.	69352		69349		69351		69350	
Roof, main, shale; immediate, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		7½		1½	1	6	1	1
"Sulphur" band		½		½		[a] ½		[a] ¼
Coal		2		8½		½		8¾
"Sulphur" band		½		[a] ½	....		....	
Bone	....		....			[a] 2	....	
Shale, hard	....		....		....			[a] 2
Coal		9		3		7½	2	2
"Sulphur" band		[a] ½		½		[a] 2	....	
Coal		7½		11	2	0	....	
Bone		[a] 2		[a] 3	....		....	
Coal	2	0	1	9	....		....	
Floor, shale and clay.								
Thickness of bed	4	2¾	4	½	4	6½	4	2
Thickness of coal sampled	4	¼	3	9½	4	2	3	11¾

[a] Not included in sample.

Section A (sample 69352) was taken at the face of 5 west entry, main slope. Se B (sample 69349) was taken at the face of 5 east entry, main slope. Section C (sa 69351) was taken at the face of 5 room, 4 east, main slope. Section D (sample 6 was taken at the face of 4 west entry, main slope.

Tipple samples 69412, 69416, 69417, and 69418 were lump coal, over 1-inch screen; tipple samples 69415 and 69419 were of slack through 1-inch bar screen.

In 1918 permissible explosives were used exclusively for shooting the coal. mine was trying out panel longwall work and resuming the manufacture of col beehive ovens. Men employed numbered 125 underground and 15 abovegro Coal passing through 1¼-inch bar screens was shipped as slack and coked at ra 275 tons of coke daily. The coal was cleaned by two pickers on railroad cars. T was an inspector of coal at the tipple. At time of sampling in 1918 the coal shipped to Oklahoma City for railroad and domestic purposes. The capacity o mine was 500 tons a day, and the average daily output was 325 tons.

McCurtain. Blue Ridge No. 5 Mine.

Analyses 29839, 29842, and 29844 (p. 53). Bituminous coal, McCurtain f from Blue Ridge No. 5 mine, a slope mine 1 mile west of McCurtain, in sec. 21, N., R. 22 E., on the Fort Smith & Western R. R. Coal bed, Panama; Carbonife age, Hartshorne sandstone. Bed is 5 to 6 feet 4 inches thick and dips 16° north west. Cleat running east and west is not well defined. Frequent rolls and f are encountered in mining. There is a band of soft shale in the middle of the Roof, soft, gray shale, with about 10 inches of "draw slate;" floor, smooth, h sandy shale; cover at point of sampling, 115 to 155 feet. The bed was sampled W. H. McCoubrey on December 21, 1917, as described below:

Sections of coal bed in Blue Ridge No. 5 mine.

Section	A.	
Laboratory No.	29839	29
Roof, soft gray shale.	Ft. in.	F
Coal	2 5	
"Blue band"	[a] 1½	
Coal	3 5	
Floor, fire clay.		
Thickness of coal	5 11½	
Thickness of coal sampled	5 10	

[a] Not included in sample.

Section A (sample 29839) was taken in 2 west entry off main slope. Sectio (sample 29842) was taken in 3 room, 2 east entry, off main slope.

The ultimate analysis of a composite sample made by combining face samples 2 and 29842 is given under laboratory No. 29844.

System of mining, room and pillar. In 1917 the coal was shot down with missible explosives by one shot firer. Men employed numbered 38 underground 8 aboveground. The tipple was of wood. The total production was shipped as ru mine. One picker was employed on the car. The coal was in large lumps and h good appearance on the cars. There was one loading track, with capacity for 7 em and 25 loaded railroad cars. About 60 per cent of the coal was taken in advance w and there was a recovery of about 60 per cent. About 300 acres was unmined. daily capacity of the mine in 1917 was 125 tons, the daily average 110 tons, and maximum day's run 170 tons. The output for the year 1917 was 2,000 tons.

STIGLER. STRIP PIT.

Analysis 30344 (p. 53). Bituminous coal, McAlester field, from a strip pit, a small opening 3 miles northwest of Stigler, in sec. 5, T. 9 N., R. 21 E. Coal bed, Stigler; Carboniferous (Allegheny) age, McAlester shale. Bed is about 22 inches thick; floor, clay. The bed was sampled at face by J. J. Rutledge on April 24, 1918, the sample representing 22 inches of coal, the thickness of the bed.

The seam has an overburden of about 12 feet, composed mostly of red clay; 3 to 4 feet of gray shale lie immediately over the coal. The overburden is removed by plows and scrapers, and the coal is broken from the bed by driving iron pins vertically through it. The coal is hauled by teams to the Midland Valley R. R., at Stigler, where part is used locally and part is shipped as blacksmith coal. At time of sampling in 1918 the daily output was 50 tons.

STIGLER. TURNER STRIP PIT.

Analysis 26323 (p. 53). Bituminous coal, high rank, Choctaw field, from H. A. Turner strip pit, 2 miles from Stigler, on the Midland Valley R. R. Coal bed, Stigler (McAlester); Carboniferous age, McAlester shale. Roof, dense, clay shale; floor, clay; no partings. The bed was sampled on October 17, 1916, by D. White near north end of pit. Sample represented 1 foot 10 inches of coal, the entire thickness of bed sampled.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 123, pp. 67, 271.

TAMAHA. NUNNALLY STRIP PIT.

Analysis 26324 (p. 54). Semibituminous coal, Choctaw field, from Floyd Nunnally strip pit, 3½ miles from Tamaha. Coal bed, Stigler (McAlester); Carboniferous age, McAlester shale formation. Roof, clay shale under alluvium; floor, clay. The bed was sampled on October 17, 1916, by D. White. It contains 1 foot 11½ inches clear coal; nothing rejected. The section was measured at active workings in pit.

TAMAHA. OLD SLOPE MINE.

Analysis 30706 (p. 54). Bituminous (?) coal, Stigler field, from Old Slope mine, near Tamaha, in a coal field on the segregated Indian coal lands, in sec. 19, R. 22 E., T. 11 N. Coal bed, Stigler (McAlester (?)); Carboniferous (Allegheny) age, McAlester shale. Roof and floor, soft gray shale. The bed was sampled near mouth of slope by J. J. Rutledge on June 5, 1918. The sample represented 2 feet 5 inches of coal, which is equal to the thickness of the bed. The coal from this mine is of high grade, bright, glossy, and clean. It is used for blacksmith coal and in railroad shops. This part of the coal field is practically virgin, owing to the distance from the railroad. The mine was not in operation.

WHITEFIELD. LIGON STRIP PIT.

Analysis 26325 (p. 54). Bituminous coal, Choctaw field, from J. P. Ligon strip pit, in section 24, 1 mile south and 1 mile west of Whitefield. Coal bed, Stigler; Carboniferous age, McAlester shale. The bed was sampled on October 17, 1916, by D. White. The sample represented 1 foot 8½ inches of coal, the entire thickness of the bed, except 1½ inches of bony coal at the bottom. The section was measured in the face of the stripping.

LATIMER COUNTY.

DEGNAN. M. K. & T. No. 19 MINE.

Analyses 69552, 69542, 69530, 69547, and 69560 (p. 54), average of mine-face sam analyses 69541 and 69544 (p. 55), average of tipple samples (nut 1¼ to 2½ inches); anal 69532 and 69533, (p. 54), lump over 2½ inches, and analyses 69543 and 69548, slack thr 1¼-inch screen (p. 55). Bituminous coal, McAlester field, from M. K. & T. No. 19 mi shaft mine, ¾ mile west of Degnan, on the Missouri, Kansas & Texas R. R. Coal Lower Hartshorne; Carboniferous (Allegheny) age, McAlester shale. Bed is 5 fe inches to 6 feet 4½ inches thick at points of sampling; dip, 12° to 13° northeast; shale, fairly strong; floor, smooth, gray shale. Commercial samples were take the tipple by J. F. Davies and N. H. Snyder on June 19, 1918. The bed was sample W. H. McCoubrey on June 19, 1918, as described below:

Sections of coal bed in M. K. & T. No. 19 mine.

Section	A.	B.	C.	D.	E[illegible]
Laboratory No.	69552	69542	69530	69547	69[illegible]
Roof, strong gray shale.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. [illegible]
Coal	4½	5 3	5½	1 5	2 [illegible]
Shale	1/16	....	1/16	1/16	[illegible]
Coal	1 4	....	1 1½	10½	1 [illegible]
Shale	1/16	....	1/16	1/16	[illegible]
Coal	1 11	....	1 5	3 3½	2 [illegible]
Shale	⅛	....	1/16	....	....
Coal	2 5	....	2 9½	....	....
Floor, shale.					
Thickness of bed	6 ¾	5 3	5 9 11/16	5 7⅛	6 [illegible]
Thickness of coal sampled	6 ¾	5 3	5 9 11/16	5 7⅛	6 [illegible]

Section A (sample 69552) was taken from the face of 5 east entry off main sl Section B (sample 69542) was taken from the face of 2 east entry off inside pl Section C (sample 69530) was taken from the face of 3 east entry off main slope. tion D (sample 69547) was taken from the face of 4 east entry off main slope. Sec E (sample 69560) was taken from the face of 1 east entry off inside plane.

System of mining, room and pillar, entry and air course. The high dip prev the use of mining machines. A permissible explosive was used for shooting the in the slope and in all narrow work; black powder was used in rooms on plane. miner endeavored to pick out impurities when loading the coal at the face. Men ployed numbered 135 in the mine and 26 on the surface. About 35 per cent of output was shipped as lump, 20 per cent as nut, and 45 per cent as slack. Two pic worked on the cars when loading lump coal. An inspector of coal was employe the tipple. At time of sampling 60 per cent of the coal was taken out in adv work, and the total recovery claimed was 60 per cent. Haulage was by mu electric motor, and rope. There were four loading tracks, with capacity for 30 em and 30 loaded railroad cars. The coal was shipped to Galveston, Tex., for bur purposes. The capacity of the mine was 1,000 tons a day, and the average d output at time of sampling was 600 tons.

GOWEN. ROCK ISLAND NO. 40 MINE.

Analyses 30270 to 30277 (p. 55). Bituminous coal, McAlester field, from Rock Isl No. 40 mine, a slope mine about 1 mile west of Gowen, in secs. 22, 23, 26, 27, T. 5 R. 17 E., on the Chicago, Rock Island & Pacific R. R. Coal bed, Lower Hartsho Carboniferous (Allegheny) age, McAlester shale. Bed is 3 to 5 feet thick and c 9° southwest. Immediate roof is gray shale 1 to 20 inches thick; above this is m harder gray shale 10 to 50 feet thick; then coal averaging 3½ feet thick, and above t a hard, fine-grained sandstone about 50 feet thick; floor, gray, hard shale. The bed was sampled by J. J. Rutledge, W. W. Fleming, J. B. Hynal, and W. H. McCoubrey on March 14 and 21, 1918, as described below:

Sections of coal bed in Rock Island No. 40 mine.

Section	A.		B.		C.		D.		E.		F.		G.	
Laboratory No.	30272		30270		30274		30276		30273		30275		30271	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal, clean		2		9	1	2	1	3	2	5	1	11	1	6
Cannel, coal		3½	...	...	...	...	...	...	...	...	...	...	...	...
Coal, clean		4	...	...	...	...	...	...	...	...	...	...	...	...
Black "sulphur" band		¼		¼		1/16		1/16		1/16		1/16	...	...
Coal with black "sulphur" bands	...	...	...	...	...	...	...	...	...	...	...	...	1	0
Coal, clean		6		5		5		7		6		7	1	11½
Black "sulphur" band		¼		¼		1/16		1/16		1/16		1/16	...	...
Coal, clean		11		7¾		1	1	1½	1	5	1	4	...	...
Black "sulphur" band		¼		¼		1/16		1/16	...	...	...	...	...	...
Coal, clean		9	1	6	1	11	1	1½	...	...	...	...	...	...
Black "sulphur" band		¼	...	...	...	...	...	...	...	...	...	...	...	...
Coal, clean	1	0	...	...	...	...	...	...	...	...	...	...	...	...
Floor, shale.														
Thickness of bed	4	½	3	4½	3	7 3/16	4	1 3/16	4	4⅛	3	10⅛	4	5½
Thickness of coal sampled	4	½	3	4½	3	7 3/16	4	1 3/16	4	4⅛	3	10⅛	4	5½

Section A (sample 30272) was cut from face of 8 east entry off 41 slope. Section B (sample 30270) was cut from face room 5 in 9 west entry off 41 slope. Section C (sample 30274) was cut from face of 5 east air course off 41 slope. Section D (sample 30276) was cut from face of 5 west entry off 41 slope. Section E (sample 30273) was cut from face of room 50 in 6 west entry off 40 slope. Section F (sample 30275) was cut from face of 6 east entry off 41 slope. Section G (sample 30271) was cut from face room 15 in 7 west entry off 41 slope.

The result of an ultimate analysis of a composite sample made by combining face samples 30270, 30271, 30273, 30274, 30275, and 30276 is shown under laboratory No. 30277 F.

System of mining, entry and air course, room, and pillar. In 1918 no undercutting was done; some shearing was done by the miner after cutting and cracker shots, but most of the coal was blasted off the solid. Permissible explosive was used in the cutting shots and black blasting powder (FF) for blasting off the solid. Rope and mule haulage were employed. The coal was used for steam purposes. The daily output was 600 tons.

Red Oak. Hilling No. 2 Mine.

Analyses 69613, 69630, and 69634, average of mine-face samples, and analyses 69611, 69622, 69627, and 69629, average of tipple samples (p. 55). Bituminous coal, Red Oak field, from Hilling No. 2 mine, a drift mine 3½ miles southeast of Red Oak, on the Chicago, Rock Island & Pacific R. R. Coal bed, Lower Hartshorne; Carboniferous (Allegheny) age, McAlester shale. Bed is 3 feet 10½ inches to 4 feet 1½ inches thick at points of sampling; dip, 28° north; roof, bony coal overlain by shale; floor, bony coal underlain by shale. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 24, 1918. The bed was sampled by W. H. McCoubrey on June 24, 1918, as described below.

Sections of coal bed in Hilling No. 2 m[illegible].

Section	A.		B.		C.	
Laboratory No.	[illegible]13		69630		696[illegible]	
Roof, shale and bony coal.	[illegible]	*in.*	*Ft.*	*in.*	*Ft.*	
Coal		[illegible]				
Bony coal				3		
Shale						
Coal		[illegible]	1	[illegible]		
Shale band		[illegible]		[illegible]		
Coal		[illegible]		4		
Shale band		[illegible]		$\frac{1}{16}$		
Coal	[illegible]	8[illegible]		5		
Shale band		[illegible]		$\frac{1}{16}$		
Coal	1	[illegible]		2[illegible]		
Shale band				[illegible]		
Coal			1	10		
Shale						
Coal					1	
Floor, bony coal and shale.						
Thickness of bed	4	[illegible]	4	1[illegible]	4	
Thickness of coal sampled	4	[illegible]	4	1[illegible]	4	

Section A (sample 69613) was taken at the face of 2 eas[illegible] course, main slo[illegible]
Section B (sample 69630) was taken at the face of east plan[illegible] [illegible]in slope. Sectio[illegible] (sample 69634) was taken at the face of 1 east entry, main slope.

System of mining, room and pillar, entry and air course. In 1918 the coal was mi[illegible] by hand and shot down with black blasting powder. Men employed numbered [illegible] in the mine and 4 on the surface. The coal was dumped over a gooseneck du[illegible] and the entire output was shipped as run of mine. The coal was cleaned by one pic[illegible] on the cars; the miner picked the coal at the face. At the time of sampling 50 [illegible] cent of the coal was taken out in advance work, and the total recovery claimed [illegible] 50 per cent. Haulage was by mules. There were two loading tracks, with capac[illegible] for 15 empty and 20 loaded railroad cars. At time of sampling the coal was shipp[illegible] to points in Oklahoma and Texas for steam purposes. The capacity of the mine [illegible] 150 tons a day, and the average daily output was 40 tons.

WILBURTON. DEGNAN-MCCONNELL NEW NO. 5 MINE.

Analyses 69509, 69510, 69513, 69516, and 69517, average of mine-face samp[illegible] analyses 69511, 69512, 69514, and 69515, average of tipple samples, and analyses 27[illegible] to 27535 (p. 55). Bituminous coal from Degnan-McConnell New No. 5 mine, a s[illegible] mine 1½ miles northwest of Wilburton, sec. 8, T. 5 N., R. 19 E., on the Misso[illegible] Kansas & Texas R. R. Coal bed, Upper Hartshorne; Carboniferous (Allegheny) [illegible] McAlester shale. Bed is 3 feet 9½ inches to 4 feet 8½ inches thick at point[illegible] sampling. Occasional rolls occur in the seams, but no large faults have been fou[illegible] Dip, 9° north; roof and floor, hard, gray shale. Commercial samples were take[illegible] the tipple by J. F. Davies and N. H. Snyder on June 8, 1918. The bed was samp[illegible] by N. H. Snyder and J. F. Davies on June 17, 1918, as described below:

Sections of coal bed in Degnan-McConnell New No. 5 mine.

Section	A.		B.		C.		D.		E.
Laboratory No.	69509		69510		69513		69516		695[illegible]
Roof, shale	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*
Coal	4	½	2	3½	3	9½	4	8½	3
"Sulphur"				[illegible]					
Coal			1	5½					
Floor, shale									
Thickness of bed	4	½	3	9½	3	9½	4	8½	3
Thickness of coal sampled	4	½	3	9½	3	9½	4	8½	3

Section A (sample 69509) was measured at face of 6 east entry. Section B (sample 69510) was measured at main east entry. Section C (sample 69513) was measured at 12 west entry. Section D (sample 69516) was measured at 10 east entry. Section E (sample 69517) was measured at 10 west entry.

System of mining, room and pillar, entry and air course. In 1918 the coal was undercut by electric chain machines or sheared by hand in narrow work on the plane only. Machine cuttings were loaded out with the coal. Black powder was used on plane in rooms and permissible explosive for shooting down the coal and in machine work. All holes were drilled and shots prepared by the miners, but were tamped and fired from within the mine by shot firers using safety fuse, after all other employees had left the mine. Men employed numbered 159 underground and 15 on the surface. At the time of sampling 60 per cent of the coal was taken out in advance work, and the total recovery claimed was 60 per cent. Haulage was by mule power and a rope haulage system. There were four loading tracks, with capacity for 30 empty and 30 loaded railroad cars. Haulage was by mules and by rope in 1917, at which time no pillars had been drawn, and recovery was about 50 per cent. At time of sampling the coal was dumped from self-dumping cages and shipped as run of mine. The coal was cleaned by two pickers on the cars, and there was an inspector at the tipple. The coal was carefully picked by miners when loading at the face. The coal was shipped to various points in Texas, Oklahoma, and Kansas for domestic and steam purposes. The capacity of the mine was 600 tons a day, and the average daily output at time of sampling was 550 tons.

The bed was sampled by J. J. Rutledge, J. F. Davies, and W. W. Fleming on January 27, 1917, as described below:

Sections of coal bed in New No. 5 mine, sampled in 1917.

Section	A.		B.		C.		D.	
Laboratory No.	27531		27532		57534		27533	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, gray shale.								
Coal, clean	1	8	1	10½	2	9¾	2	1
"Mother coal"		¼	....		....		....	
"Sulphur"	....			1/16		1/16	....	
"Sulphur," black	....		....		....			⅛
Coal, clean		7½		3½	1	¼	1	9⅝
"Sulphur"		[a] ½	....		....		....	
Coal, clean		8	....		....		....	
"Mother coal"		¼		¼	....		....	
Coal, clean		10½	1	6	....		....	
Floor, hard gray sandy shale.								
Thickness of bed	3	11	3	8¼	3	10	3	10¾
Thickness of coal sampled	3	10½	3	8¼	3	10	3	10¾

[a] Not included in sample.

Section A (sample 27531) was taken from 12 west entry, where 17 room will be turned, 1,200 feet west main shaft. Section B (sample 27532) was taken from 2 room, A entry, 600 feet northeast of main shaft. Section C (sample 27534) was taken from face 15 room, 10 east entry, 1,100 feet southeast main shaft. Section D (sample 27533) was taken from 3 room, B entry, 200 feet north of main shaft.

The ultimate analysis of a composite sample made by combining face samples 27531, 27532, and 27534 is shown under laboratory No. 27535 F.

LE FLORE COUNTY.

BOKOSHE. SLOPE MINE NO. 3.

Analyses 26801 and 26802 (p. 56). Semibituminous coal, Choctaw field, from slope mine No. 3, ¾ mile northeast of Bokoshe station, in T. 8 N., R. 24 E., on the Midland Valley R. R. Coal bed, Hartshorne (Panama); Carboniferous age, McAlester shale. Roof, shale; floor, hard clay. The bed, which averages about 5 feet thick was sampled by benches on November 3, 1916, by R. V. L. Stratton, as described below:

Sections of coal bed in slope mine No. 3.

Section	A.	B.
Laboratory No.	26801	26802
	Ft. in.	*Ft. in.*
Roof, shale.		
Coal, top bench	2 10	[a]2
Coal, bottom bench	[a]3 7	3
Floor, hard clay.		
Thickness of bed	6 5	6
Thickness of coal sampled	2 10	3

[a] Not included in sample.

Sample 26801 was measured in 5 east entry, off slope 1,700 feet east of mine mouth top bend; 26802 was sampled from bottom bench.

CALHOUN. CENTRAL NO. 8 MINE.

Analyses 69461, 69468, 69469, 69470, and 69473, average of face samples; analyses 69460, 69462, 69478, and 69480, average of tipple samples of run of mine coal through 8-inch bar screen; and analyses 69463 and 69483, average of tipple samples of lump over 8-inch bar screen (p. 56). Bituminous coal from Central No. 8 mine, a slope mine at Calhoun, on the Potean Valley R. R. Coal bed, Lower Witteville; Carboniferous age, Savanna (?) formation. Bed is 4 feet ¾ inch to 4 feet 6 inches thick; dip, 6°; roof and floor, hard shale with "sulphur" bands. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 14, 1918. The coal bed was sampled by W. H. McCoubrey on June 14, 1918, as described below:

Sections of coal bed in Central No. 8 mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	69473	69470	69468	69461	69469
Roof, gray shale with "sulphur" bands.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal, clean	7	4	6½	6½	1
"Sulphur" band	1/16	¼	....	¼	....
"Sulphur" and shale band	....	....	½	....	....
Coal, clean	9	1 ½	1 ½	10½	....
"Sulphur" band	¼	....	....	....	....
Coal, clean	1½	....	....	....	....
"Sulphur" band	½	....	....	....	....
Shale band "sulphur" and coal	....	....	[a]3½	....	....
Coal, clean	1½	....	8	....	....
Shale band and "sulphur"	[a]3½	[a]4	....	....	....
Shale band, "sulphur," and coal	....	....	[a]2½	....	....
Coal, clean	7	8½	8½	....	....
Shale band and coal	....	....	....	[a]3	[a]
Coal, clean	....	....	....	7½	
"Sulphur" and shale	....	....	½	....	....
Shale band and coal	[a]1½	[a]1	....	[a]1½	[a]
Coal, clean	1 8½	1 6½	1 0	1 7½	1
Floor, sandy shale with "sulphur" bands.					
Thickness of bed	4 11/16	4 ¾	4 5⅝	4 ¾	4
Thickness of coal sampled	3 11 11/16	3 7½	3 11½	3 8½	3 1

[a] Not included in sample.

Section A (sample 69473) was cut at face of 8 east entry, main slope. Section B (sample 69470) was cut at face of 11 west entry, main slope. Section C (sample 69468) was cut at face of 13 west entry, main slope. Section D (sample 69461) was cut at face of 7 east entry, main slope. Section E (sample 69469) was cut at face of 12 west entry, main slope.

System of mining, room and pillar. The coal was undercut in the bed by machines and shot down with permissible and black powder by shot firers after regular shift. Men employed numbered 189 underground and 30 aboveground. In 1918, about 60 per cent of the coal was taken out in advance work, and the total recovery claimed was 60 per cent. The unmined area consisted of 900 acres. The estimated lifetime of the mine was 15 years. Haulage was by mules and rope. There were three loading tracks, with capacity for 30 empty and 30 loaded railroad cars. The coal was dumped over a wooden tipple equipped with modern screens. A coal inspector at the mine was employed by the Kansas City & Southern R. R., which takes a large part of the output of the mine, and two pickers cleaned the coal as it was loaded on the railroad cars; the miners picked the coal at the face, but pieces of roof became mixed with the coal loaded out. At the time of sampling the mine was loading 8-inch war lump, an unusual size in this field. The general appearance of the coal on the railroad cars was good. In March, 1919, the mine was loading nothing but run of mine. A modern shaker screen was used 10 feet wide and 40 feet long, with perforations from ⅞ inch to 2 inches and 6-inch or 8-inch bars.

HOWE. HOWE-MCCURTAIN NO. 3 MINE.

Analyses 69464, 69465, and 69482, average of mine-face samples, and analyses 69466, 69467, 69479 to 69485, average of tipple samples (p. 57). Bituminous coal, Howe field, from Howe-McCurtain No. 3 mine, a slope mine 3 miles southwest of Howe, on the Chicago, Rock Island & Pacific R. R. Coal bed, Lower Hartshorne; Carboniferous age, McAlester shale. Average thickness of bed, 3 feet 6 inches; dip, 10° northeast; roof, sandstone and fairly strong gray shale; floor, soft shale and bone, in places no bone; usually under main seam lies 1 foot of clean coal, which is left down in rooms and taken up in roadways; 1 foot 3 inches of bone and coal; about half of bottom coal is good. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 15, 1918. The bed was sampled by W. H. McCoubrey on June 15, 1918, as described below:

Sections of coal bed in Howe-McCurtain No. 3 mine.

Section	A.		B.		C.	
Laboratory No.	69464		69465		69482	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, fairly strong shale.						
Bone		2¼				
Coal		5		7		1½
Shale and "sulphur" band		1/16		a ⅛		¼
Coal		2		1⅛		5
Shale and "sulphur" band		½		a ⅛		1
Coal	2	2	1	⅛		4½
"Sulphur" band		a 1½		a ¼		½
Coal		6		1	1	4
"Sulphur"				½		1/16
Coal			1	8		8
Floor, soft shale and bone.						
Thickness of bed	3	7 5/16	3	6	3	2
Thickness of coal sampled	3	5 13/16	3	5½	3	1

a Not included in sample.

Section A (sample 69464) was taken from face of 4 west entry, main slope. Section B (sample 69465) was taken from face of 6 west entry. Section C (sample 69482) was taken from face of 30 room, 5 entry, main slope.

System of mining, room and pillar, entry and air course. Mining machines were not used, but the coal was shot off the solid with black blasting powder. Men employed numbered 41 underground and 7 on the surface. At time of sampling 60 per cent of the coal was taken out in advance work, and a total recovery of 60 per cent was claimed.

Haulage was entirely by mules. There were two loading tracks, with capacity fo empty and 15 loaded railroad cars. The coal was dumped over a gooseneck dump a shipped as run of mine. The coal was cleaned by one picker on the railroad ca There was an inspector of coal at the tipple. Pieces of roof, floor, and partings appear in the coal as loaded on the railroad cars. In June, 1918, at time of sampling, the c was shipped to McCurtain, Okla., where it was used for coking purposes; in 1919, t entire output was coked at the mine and very little of the coal was shipped. T capacity of the mine was 300 tons a day, and the average daily production at time sampling was 125 tons.

WILLIAMS. WILLIAMS NO. 1 MINE.

Analyses 69409 to 69411, average of mine-face samples; analyses 69407 and 694 average of tipple samples of lump over 2½ inches; analyses 69413 and 69414, of sla through 1¼-inch screen, and analyses 69406 and 69420, of nut over 1¼ inches, throu 2½-inch screen (p. 57.) Semibituminous coal, Williams field, from Williams No mine, a slope mine 1 mile west of Williams, on a spur of the Midland Valley R. Coal bed, Panama (Lower Hartshorne); Carboniferous age, McAlester shale. Bed 3 feet 11 inches to 4 feet 2 inches thick; dip, 7° to 9°; roof, strong, gray shale; flo shale with bands of coal or of "sulphur." Commercial samples were taken at t tipple by J. F. Davies and N. H. Snyder on June 12, 1918. The bed was sampl by W. H. McCoubrey on June 12, 1918, as described below:

Sections of coal bed in Williams No. 1 mine.

Section	A.		B.		C.	
Laboratory No	69409		69410		6941[illegible]	
	Ft.	in.	Ft.	in.	Ft.	
Roof, strong shale.						
Bony coal		[a] 4		1		[a]
Coal		2		6½		
"Sulphur"		1/16		1/16		
Coal		¼	....			
Shale and "sulphur"		¼	....			
Coal, clean	1	9½	1	7½	1	
"Black sulphur" band		¼	....		....	
Coal, clean		6	....		....	
"Sulphur" band and coal mixed	....			¼		
"Black sulphur" band		⅛	....		....	
Coal, clean		9		3	1	
"Sulphur" band	....			⅛	....	
Coal, clean	....			1	....	
Sulphur band	....			¼	....	
"Soft coal and sulphur" band	....		....			
Coal, clean	....		1	6½		
Floor, shale and "sulphur," A, bony coal.						
Thickness of bed	3	11 1/16	4	2 1/16	3	[illegible]
Thickness of coal sampled	3	7 1/16	4	2 1/16	3	[illegible]

[a] Not included in sample.

Section A (sample 69409) was taken from face of 6 west entry, main slope. Secti B (sample 69410) was taken from face of 7 west entry, main slope. Section C (sam 69411) was taken from face of 8 west entry, main slope.

System of mining, room and pillar, entry and air course. Mining machines w not used. All the coal was blasted off the solid with permissible explosive a black powder by the shot firers. Men employed numbered 75 underground and on the surface. In 1918, 50 per cent of the coal mined in advance work, a the recovery claimed was 50 per cent. Haulage was by mule and slope rope. Th were three loading tracks, with capacity for about 25 empty and 20 loaded railro cars. The coal was dumped over a crossover dump. One picker was employed the cars of lump coal and two boys on the cars of nut coal to clean the coal. There w no inspector of coal at the tipple. The miners were said to pick the coal at the fa

The coal was shipped to Kansas City for domestic and steam purposes. The capacity of the mine was 500 tons a day, and the average daily production at time of sampling was 325 tons a day.

For description and analyses of other samples of this coal see Bureau of Mines Bul. 123, pp. 67, 272.

PITTSBURG COUNTY.

ALDERSON. ROCK ISLAND NO. 5 MINE.

Analyses 30660 to 30667 (p. 58). Bituminous coal, McAlester field, from Rock Island No. 5 mine, a shaft mine in sec. 22, T. 5 N., R. 15 E., ¼ mile southwest of Alderson, on the Chicago, Rock Island & Pacific R. R. Coal bed, McAlester; Carboniferous (Allegheny) age, McAlester shale. Bed is 2 feet 6 inches to 3 feet 4 inches thick and dips 5° to 10° southwest. A few faults are encountered. The coal was very clean, with practically no bands or impurities. Roof is very poor gray shale and floor is smooth hard shale. The bed was sampled by W. H. McCoubrey and J. B. Hynal on May 1 and 3, 1918, as described below.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 65, 253.

Sections of coal bed in Rock Island No. 5 mine.

Section	A.	B.	C.	D.	E.	F.	G.
Laboratory No.	30660	30661	30662	30663	30664	30665	30666
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, gray shale.							
Coal, bony	[a] 2						
Coal, clean		6½	4	2		3½	4½
Black "sulphur" band		1/32	1/32	1/32		1/32	1/32
Coal, clean		1 0	5½	6½		2½	1 5
Coal with "sulphur" bands	8			4			
Coal, clean	5½			3½			
Black "sulphur" band	1/32	1/32	1/32	1/32		1/32	1/32
Coal, clean	2 4	3	1 1	2½		5½	2 1
Black "sulphur" band		1/32	1/32	1/32		1/32	
Coal, clean		5	1 6	3½		2	
Coal with shale band					1½		
Black "sulphur" band		1/32		1/32	1/32	1/32	
Coal, clean		1 2		3	6½	2 5	
Black "sulphur" band				1/32	1/32		
Coal, clean				1 9	2 8½		
Floor, gray shale.							
Thickness of bed	3 7½	3 4⅝	3 4½	3 10	3 4½	3 6½	3 10½
Thickness of coal sampled	3 5½	3 4⅝	3 4½	3 10	3 4½	3 6½	3 10½

[a] Not included in sample.

Section A (sample 30660) was measured at face of 5 east entry off main west slope.
Section B (sample 30661) was measured at face of 5 west entry off main west slope.
Section C (sample 30662) was measured at face of 7 east entry off main west slope.
Section D (sample 30663) was measured at face of 3 west entry off main west slope.
Section E (sample 30664) was measured at face of 9 west entry off main west slope.
Section F (sample 30665) was measured at face of 4 west entry off 1 slope east side.
Section G (sample 30666) was measured at face of 5 east entry off slope 1 east side of mine.

The ultimate analysis of a composite sample made by combining face samples 30660, 30661, 30662, 30663, 30664, 30665, and 30666 is given under laboratory No. 30667.

System of mining, room and pillar. In 1919 the coal was shot down with permissible explosives exclusively by two shot firers after the miners had left the mine; machines were employed for cutting the coal; at time of sampling, however, some black powder was used in east side workings. Haulage was by mules and two electric motors. In 1918 the entire production was shipped as run of mine. The steel tipple had screens

8 by 12 feet. Sizes of coal were lump, nut, pea, and slack. At the steel tipple t
coal was picked on table by two pickers. There were four loading tracks, w
capacity for 25 empty and 25 loaded railroad cars. The appearance of lump coal a
the screenings on the cars was good. The estimated recovery of the mine was ab
45 to 50 per cent. The unmined area and the lifetime of the mine were unkno
The mine is old and expensive to operate. The daily capacity at time of sampl
was about 500 tons; the daily average 425 tons, and the maximum day's run 500 to

ALDERSON. ROCK ISLAND NO. 38 MINE.

Analyses 30656 to 30659 (p. 58). Bituminous coal, McAlester field, from R
Island No. 38 mine, a slope and shaft mine ½ mile east of Alderson, in secs. 24 and
T. 5 N., Rs. 15 and 16 E., on a spur track of the Chicago, Rock Island & Pacific R.
Coal bed, McAlester; Carboniferous age, Pennsylvania group, McAlester sh
Average thickness of bed, 3 feet 3 inches; dip, 16° southwest; roof, poor, of v
brittle gray shale; floor, rather soft, gray shale that heaves readily. The bed
sampled by W. H. McCoubrey and J. B. Hynal on May 4, 1918, as described bel

Sections of coal bed in Rock Island No. 38 mine.

Section	A.		B.		C.
Laboratory No	30656		30657		3065
Roof, gray shale.	Ft.	in.	Ft.	in.	Ft.
Coal with very thin bands shale		1	....		....
Coal, clean		3½		4	
Coal, soft	....			½	....
Black "sulphur" band		1/16		1/16	
Coal, clean		6	1	9	
"Sulphur" and soft coal		½	....		....
Shale band	....			1/16	....
Coal, clean		1		6½	....
Black "sulphur" band	....			1/16	
"Sulphur" and soft coal		½	....		....
Coal, clean		11		4	
Black "sulphur" band		1/16	....		
Coal, clean	1	7	....		
Black "sulphur" band	....		....		
Coal, clean	....		....		
Black "sulphur" band	....		....		
Coal, clean	....		....		
Floor, soft gray shale.					
Thickness of bed	3	6 1/16	3	1½	2
Thickness of coal sampled	3	6 1/16	3	1½	2

Section A (sample 30656) was taken from face of 9 west entry off main slope. S
tion B (sample 30657) was taken from face of 6 east entry off main west slope. Sect
C (sample 30658) was taken from face of main east entry off main slope.

The ultimate analysis of a composite sample made by combining face sam
30656, 30657, and 30658, is given under laboratory No. 30659.

System of mining, entry and air course, room and pillar. In 1918 all coal
blasted off the solid with FF black blasting powder; permissible explosive was u
exclusively in the cutting shots in narrow places. Haulage was by rope and m
The daily output of the mine in 1918 was 100 tons.

BUCK. BUCK NO. 22 MINE.

Analysis 26150 (p. 58). Bituminous coal, McAlester field, from Buck No.
mine, a slope mine 1 mile east of Buck and 5 miles from McAlester, in sec. 12,
5 N., R. 15 E., on the Missouri, Kansas & Texas R. R. Coal bed, Upper Hartsho
Carboniferous age, McAlester shale. Bed is 2 feet 10 inches thick; dip, 12° sou
west, with cleat; roof, gray shale; floor, gray shale; cover at point of sampling, ab
300 feet. The bed was sampled by J. J. Rutledge and W. W. Fleming, on Septem
22, 1916, as described below:

Section of coal bed in Buck No. 22 mine.

	Ft.	in.
Roof, gray shale.		
Coal		4
"Mother coal"		¼
Coal, clean	2	6
Floor, gray shale.		
Thickness of bed	2	10¼
Thickness of coal sampled	2	10¼

The sample was cut at 1 east bottom entry, 6 feet from face of slope.

System of mining, room and pillar. In 1916 the coal was shot off the solid with FF black blasting powder. Men employed numbered 4 underground and 1 aboveground. The tipple was of wood. Haulage was by mules and slope rope. The coal was picked on car by one picker. There were no loading tracks at time of sampling, as the mine had just been opened; all coal produced was hauled to the railroad by wagon. At time of sampling the output was 12 to 15 tons a day, all of which was derived from advance workings. The entire output was shipped as run of mine. The daily capacity of the mine was 200 tons. In October, 1919, the mine was producing 135 tons a day, and railroad tracks had been laid to the mine.

CARBON. CARBON NO. 2 MINE.

Analyses 69527, 69535, 69546, average of mine-face samples; analyses 69529 and 69531, lump, over 2½ inches; analyses 69545 and 69562, chestnut, ¾ inch to 1¼ inches; analyses 69528 and 69534, nut, 1¼ inches to 2½ inches; and analyses 69540 and 69554, slack, under ¾ inch (p. 58). Bituminous coal, McAlester field, from Carbon No. 2 mine, a slope mine 1 mile east of Carbon, on the Missouri, Kansas & Texas R. R., Wilburton branch. Coal bed, McAlester; Carboniferous age, McAlester shale. Bed is 2 feet 8½ inches to 3 feet 1 inch thick; dip, 18° to 16° north, with a lower dip at face of slope; roof, shale; floor, hard, smooth shale. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 20, 1918. The bed was sampled by W. H. McCoubrey on June 20, 1918, as described below:

Sections of coal bed in Carbon No. 2 mine.

Section	A.		B.		C	
Laboratory No.	69527		69535		69546	
Roof, shale.	Ft.	in.	Ft.	in.	Ft.	in.
Coal		1		1		1½
Shale band		⅛		1/16		1/16
Coal		1	1	3		2½
Shale band with "sulphur"		1/16		1/16		1/16
Coal		1	1	9		7
Shale band		⅛				1/16
Coal		8				11½
Shale band		1/16				1/16
Coal		4				3
Shale band		1/16				1/16
Coal	1	8½				7
Floor, shale.						
Thickness of bed	3	0	3	1⅛	2	8½
Thickness of coal sampled	3	0	3	1⅛	2	8½

Section A (sample 69527) was taken at the face of 5 west entry, main slope. Section B (sample 69535) was taken at the face of 7 east entry, main slope. Section C (sample 69546) was taken at the face of 6 west entry, main slope.

System of mining, room and pillar, entry and air course, the air course being above entry. Mining was by hand, and both black blasting powder and permissible explosives were used for shooting down the coal. Pieces of shale from the roof and floor

became mixed with the coal, but the miner endeavored to pick them out at th
Men employed numbered 67 in the mine and 13 on the surface. In 1918, 50 pe
of the coal was taken out in advance work, and a total recovery of 55 per cen
claimed. Haulage was by mules. The four loading tracks had capacity
empty and 20 loaded railroad cars. The coal was screened and shipped in pre
sizes as follows: Lump, 43 per cent; nut, 15 per cent; chestnut, 11 per cent
slack, 31 per cent of total output of mine. Two men were employed to pick
and move railroad cars. The weigh boss inspected both mine car and railroa
The coal was shipped to various points in Texas, Oklahoma, and Kansas, a
Omaha, Nebr., where it was used for domestic and steam purposes. It is amo
best prepared domestic coals in Oklahoma. At time of sampling the capacity
mine was 300 tons a day, and the average daily output was 200 tons; an incre
labor would be necessary to increase output to capacity.

HAILEYVILLE. HAILEY-OLA NO. 2 MINE.

Analyses 30398 to 30400 (p. 59). Bituminous coal, McAlester field, from Haile
No. 2 mine, a slope mine 1 mile south of Haileyville, in T. 5 N., R. 17 E., o
Chicago, Rock Island & Pacific R. R. Coal bed, Upper Hartshorne; Carboni
(Allegheny) age, McAlester shale. Bed is 3 feet to 3 feet 4 inches thick; dip,
30° west. A few faults are encountered; no rolls or horsebacks. Roof, rough
gray shale, fairly strong, frequent slips; floor, rough, soft, gray shale. The be
sampled by W. H. McCoubrey and J. B. Hynal on April 12, 1918, as described b

Sections of coal bed in Hailey-Ola No. 2 mine.

Section	A.	
Laboratory No.	30398	
	Ft.	*in.*
Roof, shale.		
Coal, bony		[a] 3
Coal, clean	1	5
Coal and fire clay mixed		[a] 2½
Coal, bony		2
Black "sulphur" band	...	...
Coal, clean	...	...
Soft fire clay	...	...
Coal, clean		11
Coal, bony		1
Coal, clean		4
Floor, shale.		
Thickness of bed	3	4½
Thickness of coal sampled	3	1½

[a] Not included in sample.

Section A (sample 30398) was cut at face of 1 south entry, main slope. Sect
(sample 30399) was cut at face of 1 north entry, main slope.

The ultimate analysis of a composite sample made by combining face sa
30398 and 30399 is given under laboratory No. 30400 F.

System of mining, room and pillar. In 1918 coal was shot down with permi
explosive in entries and narrow places by two shot firers. Four men were emp
underground and one man aboveground. The tipple was of wood. The tota
duction was shipped as run of mine. Haulage was by pushers. One picker wa
ployed on the car. There was track capacity for six empty and six loaded ra
cars. The appearance of the lump coal on the cars was good. The capacity
mine was 150 tons a day and the average output 75 tons. In 1919 the min
developed to third left; thickness, 3 feet to 3 feet 6 inches. Mules were use
haulage in entries. Capacity, 300 tons; daily output, 150 tons.

HAILEYVILLE. BLUE CREEK NO. 7 MINE.

Analyses 30401 to 30403 (p. 59). Bituminous, McAlester field, from Blue Creek No. 7 mine, a slope mine 1½ miles south of Haileyville, in T. 5 N., R. 17 E., on the Chicago, Rock Island & Pacific R. R. Coal bed, Lower Hartshorne; Carboniferous (Allegheny) age, McAlester shale. Bed is 3 feet 6 inches to 6 feet thick; dip, 50° west. Thin bands of shale are occasionally encountered. Roof, gray shale on south side of mine, roof coal on north side; floor, 2 inches of fire clay, then hard shale; fairly smooth. The bed was sampled by W. H. McCoubrey and J. B. Hynal on April 12, 1918, as described below:

Sections of coal bed in Blue Creek No. 7 mine.

Section	A.		B.	
Laboratory No.	30401		30402	
Roof, section A, shale; section B, coal.	*Ft.*	*in.*	*Ft.*	*in.*
Bone		a 1		
Coal, clean		5½	1	6
Bone		½		½
Coal, clean		6	1	3
Coal, cannel		2		
Black "sulphur" band				⅛
Coal, clean	1	4	2	10
Bone		¼		a 2
Coal, clean	1	2		
Floor, hard shale.				
Thickness of bed	3	9¼	5	9⅝
Thickness of coal sampled	3	8¼	5	7⅝

a Not included in sample.

Section A (sample 30401) was cut at face of 1 south entry, main slope. Section B (sample 30402) was cut at face of 1 north entry, main slope.

The ultimate analysis of a composite sample made by combining face samples 30401 and 30402 is given under laboratory No. 30403.

System of mining, room and pillar. In 1918 it was shot down with black powder and permissible explosive by two shot firers. Men employed numbered 16 underground and 3 aboveground. The tipple was of wood. The total output was shipped as run of mine. Haulage was by mules and pushers. The coal was picked on the car by one picker. There were two loading tracks, with capacity for six empty and six loaded railroad cars. The appearance of the lump coal on the cars was good. The daily capacity was 150 tons, the average 75 tons, and the maximum day's run 101 tons.

KREBS. OSAGE NO. 5 MINE.

Analyses 69549, 69550, and 69556, average of mine-face samples; analyses 69551 and 69558, average of tipple samples of slack through ⅝-inch screen; analyses 69553 and 69557, of lump over 2½ inches; analyses 69555 and 69561, of nut through 2½-inch screen; and analyses 69559 and 69563, of pea through ⅞-inch screen (p. 59). Bituminous coal, McAlester field, from Osage No. 5 mine, a shaft mine 1½ miles northwest of Krebs, on the Missouri, Kansas & Texas R. R. Coal bed, McAlester; Carboniferous (Allegheny) age, McAlester shale. Average thickness of bed is 4 feet; dip, 9° to 12°; roof, hard shale; floor, hard, gray shale. Commercial samples were taken at the tipple by J. F. Davies and N. H. Snyder on June 21, 1918. The bed was sampled by W. H. McCoubrey on June 21, 1918, as described below:

Sections of coal bed in Osage No. 5 mine.

Section	A.		B.		C.
Laboratory No	69549		69550		6955
Roof, fairly strong, gray shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*
Coal		2¼		2¼	
Shale and "sulphur" band		1/16		1/16	
Coal		2		3	
Shale and "sulphur" band		1/16		1/16	
Coal		5		5¼	
Shale and "sulphur" band		1/16		1/16	
Coal		2		2¼	
Shale and "sulphur" band		1/16		1/16	
Coal		6		7½	
Shale and "sulphur" band		1/16		1/16	
Coal		7½		6	
Shale and "sulphur" band		1/16		1/16	
Coal		1	1	9	
Shale and "sulphur" band		½	....		
Coal	1	11½	....		2
Floor, smooth, hard shale.					
Thickness of bed	4	1½	4	0	4
Thickness of coal sampled	4	1½	4	0	4

Section A (sample 69549) was taken from the face of 8 west entry, east slope. Secti
B (sample 69550) was taken from the face of 2 west entry, west slope. Sectio
(sample 69556) was taken from the face of 6 east entry, east slope.

System of mining, room and pillar. In 1918 the coal was mined entirely by machi
and shot down with permissible explosive only. Men employed numbered 150
the mine and 22 on the surface. The coal was dumped from self-dumping cages a
passed over shaker screens. Sizes of coal: Domestic lump, 9 per cent; nut and pe
per cent; mine run, 32 per cent; pea and slack, 1 per cent; slack, 22 per cent.
1918, 60 per cent of the coal was taken out in advance work and represented ent
percentage of recovery, as pillars were drawn to some extent. Haulage was by mu
and by rope. The four loading tracks had capacity for 25 empty and 30 loaded r
road cars.

RIDGWAY. ROCK ISLAND NO. 10 MINE.

Analyses 30222 to 30227 (p. 60). Bituminous coal, McAlester field, from R
Island No. 10 mine, a shaft mine ½ mile east of Ridgway, in sec. 33, T. 5 N., R.
E., on the Chicago, Rock Island & Pacific R. R. Coal bed, Lower Hartshor
Carboniferous (Allegheny) age, McAlester shale. Bed is 2 to 5 feet thick, is lev
with cleat running north and south. Thin bands of black "sulphur" are encounter
usually near the center of coal. Roof, soft, gray shale, with frequent slips; flo
similar to roof, hard. The bed was sampled by W. H. McCoubrey and J. B. Hy
March 8, 1918, as described below:

Sections of coal bed in Rock Island No. 10 mine.

Section	A.		B.		C.		D.		E.
Laboratory No	30222		30223		30224		30225		302
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*
Coal, clean		10	1	0	1	6	2	4	2
Black "sulphur" band	....			1/32		1/32		1/32	
Coal, clean	1	6	1	0		11	2	0	2
Black "sulphur"		1/32		½		1/32	....		....
Coal, clean	1	6		6	1	5	....		....
Floor, shale.									
Thickness of bed	3	10	2	6	3	10	4	4	4
Thickness of coal sampled	3	10	2	6	3	10	4	4	4

Section A (sample 30222) was measured at the face of main east entry. Section B (sample 30223) was measured at the face of main west entry. Section C (sample 30224) was measured at the face of 27 room, main west entry. Section D (sample 30225) was measured at the face of east air course, main north entry. Section E (sample 30226) was measured at 6 east entry, main south.

The ultimate analysis of a composite sample made by combining face samples 30222, 30223, 30224, 30225, and 30226 is given under laboratory No. 30227 F.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down with permissible explosive by three shot firers. Men employed numbered 162 underground and 11 aboveground. The tipple was of steel. The total output was shipped as run of mine. Haulage was by one electric locomotive and by mules. The coal was picked on car by two pickers. There were three loading tracks, with capacity for 30 empty and 30 loaded railroad cars. The appearance of the lump coal on cars was good. The daily capacity of the mine was 1,000 tons, the average 650 tons, and the maximum day's run 730 tons.

SEQUOYAH COUNTY.

Hanson. Brewer Strip Pit.

Analysis 26800 (p. 60). Semibituminous coal, Cherokee field, from James Brewer et al. strip pit, 1 mile north of Hanson station, in sec. 6, T. 11, R. 25 E., on the Iron Mountain R. R. Coal bed, not named (?); Carboniferous age, McAlester shale. Roof, shale; floor, clay. The bed was sampled November 2, 1916, by R. V. L. Stratton, the sample representing 12 inches of coal, the thickness of the bed. The section was measured at north edge of pit.

WAGONER COUNTY.

Redbird. Kirk Strip Pit.

Analysis 26348 (p. 60). Bituminous coal, Cherokee field, from Ed. Kirk strip pit, 1½ miles northeast of Redbird. Coal bed, not named (?); Carboniferous age, Cherokee shale. Roof, blue shale, marine fossils; floor, clay. The bed was sampled October 20, 1916, by D. White, the samples representing 9½ inches of clear coal, with charcoal layer 2 inches below top; total thickness of the bed, 9½ inches. The section was measured in face of stripping.

OREGON.

COOS COUNTY.

Beaverhill. Beaverhill Mine.

Analysis 27951 (p. 60). Subbituminous coal, Coos Bay field, from Beaverhill mine, a slope mine at Beaverhill, in sec. 17, T. 27 S., R. 13 W., on a branch line of the Southern Pacific R. R. Coal bed, Newport; Eocene age, Coaledo (?) formation. Bed is 7 feet 11½ inches thick; dip, 26° to 40°; roof and floor, shale; cover at point of sampling, 1,500 feet; elevation above sea level, 60 feet. The bed was sampled by G. W. Evans on March 27, 1917, as described below:

Section of coal bed in Beaverhill mine.

Roof, shale.	Ft.	In.
Shale [a]		6
Coal [a]		2
Shale [a]		1½
Coal	3	0
Shale [a]		6

Roof, shale—Continued.	Ft
Coal	1
Coal, bony	
Bone [a]	1
Floor, shale.	
Thickness of bed	7
Thickness of coal sampled	5

The sample was taken at face of 8 gangway, north.

System of mining, in levels, 8-foot chutes being driven at about 50-foot cen Beaverhill has been developed at large expense, but because of excessive heavi the floor costs of operation are very high. The distance between levels is app mately 340 feet. In 1917 the coal was shot off the solid. At the time of samplin men were employed underground and 12 aboveground. The tipple was of w All coal was hand picked or washed and passed through 1½-inch screens. Two pic were employed. Haulage was by electric motor. Fifteen per cent of the was taken out in advance work. In 1917 the daily capacity was 200 tons and the c average output 40 tons; it was entirely used by the Southern Pacific R. R., w owns the property. In 1919 the coal was extracted on the retreating system; la decreasing the expense of maintenance from heaving. In addition to being used b Southern Pacific R. R., the coal was sold locally and the production was increased daily average of 60 tons. It was expected the demand could be increased to 200 daily by the autumn of 1919.

For description and analyses of other samples from this mine see Bureau of M Bull. 22, pp. 152, 684.

HENRYVILLE. HENRYVILLE MINE.

Analysis 27956 (p. 60). Subbituminous coal, Coos Bay field, from Henryville m a slope mine at Henryville, on a branch of the Southern Pacific R. R. Coal Newport; Eocene age, Coaledo formation. Bed is 6 feet 4 inches thick; dip, 26°; and floor, shale; cover at point of sampling, 300 feet. The bed was sampled by G Evans on March 24, 1917, as described below:

Section of coal bed in Henryville mine.

Roof, shale.	Ft.
Shale [a]	
Coal, bony	
Shale [a]	
Coal	
Shale [a]	
Coal	
Floor, black shale.	
Thickness of bed	
Thickness of coal sampled	

The sample was cut at 2 south gangway.

System of mining, breast and pillar. In 1917 it was cut by machine to a dept 7 feet. At time of sampling 4 men were employed aboveground and 21 undergrou The tipple was of wood; 30 per cent of the coal passed through bar screens 1-inch space; 50 per cent was lump coal and 20 per cent nut coal. Haulage wa mules. One picker was employed. There was track capacity for 5 empty an loaded cars. Fifty per cent was taken out in advance work, and the recovery about 60 per cent. The unmined area consisted of 2,000 acres. The estimated time of the mine was 50 years. The daily capacity in 1917 was 60 tons and the d average output 40 tons. This mine was closed down early in 1918 and will prob not be reopened.

[a] Not included in sample.

PENNSYLVANIA.

ALLEGHENY COUNTY.

CREIGHTON. CREIGHTON MINE.

Analyses 26932 to 26934, 26990 to 26992, and 27088 (p. 61). Bituminous coal, Beaver field, from Creighton mine, a drift mine in the Pittsburgh district, at Creighton, on the Conemaugh Division, Western Pennsylvania branch of the Pennsylvania R. R. Coal beds, Upper Freeport, or E, and Lower Freeport, or D; Carboniferous age, Allegheny formation. The two beds are practically one, being separated by a parting less than a foot thick. The thickness varies from 4½ to 7½ feet, averaging 5 feet; general dip, 2° north 60° west; thickness of the bone parting, 5 to 8 inches; roof, hard, smooth gray shale over thin coal; cannel coal 6 to 18 inches over thick coal; floor, hard, smooth underclay. The amount of cover over the coal varies; at some drill holes 150 to 170 feet. The bed was sampled by J. J. Rutledge on December 5, 8, and 12, 1916, as described below:

Sections of coal beds in Creighton mine.

Section. Laboratory No.	A. 26932	B. 26933	C. 26934	D. 26990	E. 26991
Roof, A, B, E, cannel coal; C, D, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal, hard, flinty			8½		
Coal	1 ½	1 7		10	5
"Sulphur" band	¼				
"Mother coal"					½
Coal	1 4				1 3½
"Mother coal"					¼
Coal					10½
Bony coal	a 8	a 6½	a 5½	a 6	a 7
Coal		9	1 11½	7	
"Mother coal"			½		
Hard coal		4			
Shale band				a 1	
Coal	3 0	2 11½	1 4	2 5	1 7
Shale band			a ½	a 1	a 1
Coal			4	3½	1 3
Floor, fire clay.					
Thickness of bed	6 ¾	6 2	4 10½	4 9½	6 1¾
Thickness of coal sampled	5 4¾	5 7½	4 4½	4 1½	5 5¾

a Not included in sample.

Section A (sample 26932) was taken on the rib of 1 room, 100 feet from the chute between 10 entry and the line air course, and 5,625 feet north 48° north, 48° west, from drift mouth. Section B (sample 26933) was taken on 1 crosscut of 10 room, 15 entry, 6,750 feet north, 35° west, from drift mouth. Section C (sample 26934) was taken on rib of 5 room, 19 entry off the main, 6,000 feet north, 15° west, from drift mouth. Section D (sample 26990) was taken at face of 2 room, 150 feet from 21 entry, 7,800 feet north, 24° west, from drift mouth. Section E (sample 26991) was taken 20 feet from face of 1 room, 10½ entry, 20 feet inby 1 crosscut, 3,325 feet north, 19° west, from drift mouth. A sample of cannel coal was obtained on C face, 300 feet inby old 8 right, for approximate analysis of which see laboratory No. 27088.

The results of an ultimate analysis of a composite sample made by combining samples 26932, 26933, 26934, 26990, and 26991 are given under laboratory No. 26992.

System of mining, double and triple entry, room and pillar. In 1916 cutting was done by machine and permissible explosive was used by shot firers at any time during the shift. Men numbered 135 employed underground and 25 aboveground. The coal was dumped over a tipple constructed of steel and wood. The coal was screened through bar screens 12 by 6 feet, with 1¼-inch spaces. Sizes of coal shipped run of mine, 1¼-inch lump, crushed coal, nut, and slack. After and before screening the coal was cleaned on pan by two pickers. There were two loading tracks, with capacity for 43 empty and 43 loaded railroad cars. The tonnage was derived mainly f advance work. The unmined area was 1,500 acres. The estimated lifetime of mine was 60 years. The daily capacity of the mine in 1916 was 1,400 tons, and actual daily average 750 to 800 tons.

For description and analyses of other samples of coal from this mine see Burea Mines Bull. 22, pp. 154, 694.

ARMSTRONG COUNTY.

APPLEWOLD. SNYDER MINE.

Analyses 28664 to 28666 (p. 61). Bituminous coal, Allegheny Valley field, f Snyder mine, Applewold, opposite Kittanning. Coal bed, Lower Kittanning; C boniferous age, Allegheny formation. Roof, gray shale; floor, clay. The coal sampled on June 13 and 14, 1917, by H. Bassler, as described below:

Sections of coal bed in Snyder mine.

Section	A.		B
Laboratory No.	28664		286
	Ft.	*in.*	*Ft.*
Roof, gray shale.			
Coal, perhaps slightly bony		2	....
Coal		11	
Shale, carbonaceous	....		
Shale binder		¼	....
Coal	2	8½	2
Floor, clay.			
Thickness of bed	3	10	3
Thickness of coal sampled	3	10	3

Section A (sample 28664) was measured 1,200 feet southwest of mine mouth, un Shawmut R. R. tracks. Section B (sample 28665) was measured 1,125 feet no northwest of mine mouth. The ultimate analysis of a composite sample made mixing samples 28664 and 28665 is given under laboratory No. 28666.

FORD CITY. CAMPBELL MINE.

Analyses 30289 to 30292 (p. 61). Bituminous coal from Campbell mine, a d mine in North Buffalo Township, about 1 mile southwest of Ford City, on the Pi burgh, Shawmut & Northern R. R. Coal bed, assumed to be Upper Kittanni Carboniferous age, Allegheny formation. Bed is 1 foot 6 inches to 2 feet 6 inc thick; dip, 1° southeast; roof, hard, gray shale; floor, hard shale. The bed lies ab 50 feet above low-water level. Cover at points of sampling, 200 feet. The bed sampled by G. S. McCaa on April 4, 1918, as described below:

Sections of coal bed in Campbell mine.

Section	A.		B.		C.
Laboratory No.	30289		30290		302
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*
Roof, hard shale.					
Bone		¼	....		
Coal		3½		1½	
Bone		¼		¼	....
"Mother coal" and bone		1½	....		
Coal and streaks of bone	1	4	....		1
Coal	....			1	....
Bone		¼		¼	
Coal		6½		10½	
Bone		¼		¼	
Coal	....			6½	....
Coal, bony	....			1½	....
Floor, hard shale.					
Thickness of bed	2	5	1	10	2
Thickness of coal sampled	2	5	1	10	2

Section A (sample 30289) was cut at 2 right, 50 feet from main entry. Section B (sample 30290) was cut at face of main entry, 250 feet from mouth. Section C (sample 30291) was cut at 3 right, 20 feet from main entry.

The ultimate analysis of a composite sample made by combining face samples 30289, 30290, and 30291 is given under laboratory No. 30292.

System of mining, room and pillar. In 1918 the mine was comparatively new and small. The coal was shot off the solid with FFF black powder, the only explosive used, and shots were fired at any time. Haulage was by man power. The tipple was of wood. The entire output was shipped as run of mine. The unmined area consisted of 40 acres. The estimated lifetime of the mine was 30 years. The daily capacity of the mine was about 40 tons, and the daily average production was equal to the capacity.

LOGANSPORT. RARIDAN MINE.

Analyses 28667 to 28669 (p. 61). Bituminous coal, Allegheny Valley field, from Raridan mine, Logansport P. O., at Glen station, on the Pennsylvania R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, "draw slate" 8 inches, then firm, gray shale; floor, clay. The coal was sampled on June 15, 1917, by H. Bassler, as described below:

Sections of coal bed in Raridan mine.

Section	A.		B.	
Laboratory No.	28667		28668	
	Ft.	in.	Ft.	in.
Roof, "draw slate," gray shale.				
Coal	2	4	2	4
Bone and shale		[a]1		[a]1
Coal		8		8
Bone and shale		½		½
Coal		6		5
Floor, clay.				
Thickness of bed	3	7½	3	6½
Thickness of coal sampled	3	6½	3	5½

[a] Not included in sample.

Section A (sample 28667) was measured east of main mouth 1,200 feet. Section B (sample 28668) was measured at face of main entry, 3,600 feet northeast of mine mouth.

The ultimate analysis of a composite sample made by mixing samples 28667 and 28668 is given under laboratory No. 28669.

MONTGOMERYVILLE. MONTGOMERYVILLE MINE.

Analyses 28774 to 28776 (p. 61). Cannel coal, Allegheny Valley field, from Montgomeryville mine, Montgomeryville, Adrian P. O. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, tough clay shale; floor, shale. The coal was sampled on June 21, 1917, by H. Bassler, as described below:

Section of coal bed in Montgomeryville mine.

Section	A.		B.	
Laboratory No.	28774		28775	
	Ft.	in.	Ft.	in.
Roof, tough clay shale.				
Coal (ash content may be rather high)		[a]4		
Coal	[a]1	2	[a]1	5
Pyrite streak				
"Sulphur" streak				[a]½
Coal	[a]1	5	[a]1	1
Shale		[a]1		
Shale binder				[a]1½
Coal		[a]4		[a]5
Coal, cannel	1	0		11
Floor, shale.				
Thickness of bed	4	4	4	0
Thickness of coal sampled	1	0		11

[a] Not included in sample.

Section A (sample 28774) was measured in 6 room, left entry, 250 feet from mouth. Section B (sample 28775) was measured in 2 left entry, face of crossove

The ultimate analysis of a composite sample made by combining samples 2877 28775 is given under laboratory No. 28776.

West Kittanning. Neal's Mine.

Analyses 28721 to 28723 (p. 62). Bituminous coal, Allegheny Valley field, Neal's mine, 1 mile north of West Kittanning. Coal bed, Lower Freeport; Ca iferous age, Allegheny formation. Roof, gray shale; floor, clay shale. The coa sampled on June 14, 1917, by H. Bassler, as described below:

Sections of coal bed in Neal's mine.

Section	A.
Laboratory No.	28721
	Ft. in.
Roof, gray shale.	
Coal	2 2¼
Bone	[illegible]
Coal	1 1[illegible]
Bone	[illegible]
Coal	3
Floor, clay shale.	
Thickness of bed	3 8
Thickness of coal sampled	3 8

Section A (sample 28721) was measured 330 feet from mine mouth, at end of entry, which branches off main entry 240 feet from mouth. Section B (sample 2 was measured at end of main entry, 330 feet from mine mouth at entry north 60°

The ultimate analysis of a composite sample made by mixing samples 28721 28722 is given under laboratory No. 28723.

Yatesboro. Cowanshannoc No. 2 Mine.

Analyses 28672 to 28674 (p. 62). Bituminous coal, Allegheny Valley field, No. 2 Cowanshannoc mine. Coal bed, Lower Freeport; Carboniferous age, gheny formation. Roof, shale; floor, clay. The coal was sampled on June 16. by H. Bassler, as described below:

Sections of coal bed in No. 2 Cowanshannoc mine.

Section	A.
Laboratory No.	28672
	Ft. in.
Roof, gray shale.	
Bone	[a] 5
Coal	4 2¼
Floor, clay.	
Thickness of bed	4 7¼
Thickness of coal sampled	4 2¼

[a] Not included in sample.

Section A (sample 28672) was measured at face of 1 left entry, 2,000 feet south of mouth of mine that opens out of upper bed. Section B (sample 28673) was m ured at face of 1 right entry, 2,000 feet south-southwest of mouth of mine in the u bed. Depth of cover, 125 feet.

The ultimate analysis of a composite sample made by mixing samples 28672 28673 is given under laboratory No. 28674.

BEAVER COUNTY.

SMITHS FERRY. ISLAND RUN MINE.

Analysis 25587 (p. 62). Bituminous coal, Beaver field, from Island Run mine, 2 miles north of Smiths Ferry, on Little Beaver. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Roof, bituminous shale 3½ inches, irregular bedded, massive sandstone; floor, clay. The bed was sampled on July 17, 1916, by J. H. Hance, as described below:

Section of coal bed in Island Run mine.

	Ft.	in.
Roof, bituminous shale and sandstone.		
Shale, black, coaly [a]		3½
Coal	3	3
"Mother coal" [a]		½
Coal		4½
Shale, black, coaly [a]		2
Floor, clay 4 feet 18 inches.		
Thickness of bed	4	1½
Thickness of coal sampled	3	7½

The section was measured ½ mile east of main entry.

BLAIR COUNTY.

GLEN WHITE. GLEN WHITE NO. 2 MINE.

Analyses 30830 to 30832 and composite 30833, face samples, and analysis 30834, tipple sample (p. 62.) Bituminous coal from Glen White No. 2 mine, a slope mine about 3 miles west of Kittanning Point and 1 mile from Glen White, Pa., on the Pennsylvania R. R. Coal bed, Upper Freeport, known in this field as the E or Lemon; Carboniferous age, Allegheny formation. Bed is 3 feet 6 inches to 4 feet 6 inches thick; dip, 5 per cent west; roof, shale, no "draw slate;" floor, hard, smooth shale. Commercial samples were taken at the tipple by B. W. Dyer on July 12, 1918. The bed was sampled by B. W. Dyer on July 12, 1918, as described below:

Sections of coal bed in Glen White No. 2 mine.

Section	A.		B.		C.	
Laboratory No.	30831		30830		30832	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, shale.						
Bone		[a] 1½		1		[a] 5½
Coal	1	4¾	1	8¾		10½
"Sulphur"		⅛		¼	Streak.	
Coal		3	1	½	1	8
"Sulphur"		⅛				
Coal		8½				
Shale		[a] 3		[a] 1½		[a] 2½
Coal		7	1		1	1½
"Sulphur"		$\frac{1}{16}$				
Coal		5				
Floor, shale.						
Thickness of bed	3	9$\frac{1}{16}$	4	½	4	4
Thickness of coal sampled	3	4¼	3	10½	3	8

[a] Not included in sample.

Section A (sample 30831) was cut from rib 40 feet inside 1 slant, 1 left. Secti (sample 30830) was cut from rib 10 feet from entry, room 65, 6 right. Secti (sample 30832) was cut from rib 70 feet from face, main slope, 6 right.

The ultimate analysis of a composite sample made by combining face sam 30831, 30830, and 30832 is given under laboratory No. 30833.

System of mining, room and pillar. The coal was cut by machine in the and shot down with black powder and squibs by the miners at any time during shift. Men employed numbered 85 underground and 35 above ground. All the was screened at a wooden tipple; about 40 per cent passed through screens openings ½ inch to 4 inches; the screenings were sent to coke ovens, the oversi railroad cars. The coal was cleaned by two pickers on the railroad cars. T was an inspector of coal at the tipple. In 1918, 65 per cent of the coal was take in advance work, and the total recovery claimed was 80 per cent. The unm area consisted of 200 acres. The estimated lifetime of the mine was 10 years. H age was by mule and rope. There were two loading tracks, with capacity for 7 en and 50 loaded railroad cars. The capacity of mine was 600 tons a day, and average daily production was 450 tons. The daily tonnage was only 75 per cent o capacity. The daily production of coke was about 95 tons, about 160 tons of being coked a day. The production of coal for the year 1917 was 111,180 tons.

BUTLER COUNTY.

Evans City. Young Mine.

Analysis 25823 (p. 63). Bituminous coal, Butler field, from Young mine, a s mine 6 miles north of Evans City, Connoquenessing Township, on the Baltimo Ohio R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny forma Roof, shale; floor, fire clay. The bed was sampled on August 18, 1916, by G Richardson, as described below:

Section of coal bed in Young mine.

Roof, shale.	F
Coal	1
Parting	
Coal	1
Floor, fire clay.	
Thickness of bed	3
Thickness of coal sampled	3

The section was measured 200 feet northwest of shaft.

Goff Station. Annandale No. 2 Mine.

Analyses 26241 to 26245 (p. 63). Bituminous coal, Butler field, from Annan No. 2 mine, a drift mine 1 mile east of Goff station, Bessemer, on the Bessemer & Erie R. R. Coal bed, Brookville; Carboniferous age, Allegheny formation. B 4 to 5 feet thick; dip, southeast, 40 feet to a mile, with cleat running south Occasional faults, but no rolls or horsebacks, are encountered in mining. gray, sandy shale; floor, hard and smooth, of sandy clay. The bed was sample E. H. Denny and W. B. Plank on October 9 and 10, 1916, as described below:

a Not included in sample.

Sections of coal bed in Annandale No. 2 mine.

Section	A.		B.		C.		D.	
Laboratory No.	26241		26242		26244		26243	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandy shale.								
Bony coal		a 2½		6				
Coal	1	9½	1	8	1	2		9
"Sulphur" band								a ¾
Coal								8½
Gray slate		a 5		a 4		a 6		a 7
Coal	1	1	1	1				
Bony coal						a 2½		a 2½
Coal						5		10
"Sulphur" and coal		½						
"Sulphur"				a 1				
Bony coal						a 1		
Coal						9½		
"Sulphur"						a 1		
"Sulphur" and bony coal band								a ½
Coal		8½	1	1½	1	0		11½
Floor, fire clay.								
Thickness of bed	4	3	4	9½	4	3	4	1¾
Thickness of coal sampled	3	7½	4	4½	3	4½	3	3

a Not included in sample.

Section A (sample 26241) was taken from face of 2 main entry. Section B (sample 26242) was taken from face of 3 room, 2 main, 150 feet from entry. Section C (sample 26244) was taken from face of 3 room, 3 right entry, 1 section. Section D (sample 26243) was taken from face of 5 left entry, about 20 feet inby 14 room, 39 section.

The ultimate analysis of a composite sample made by combining face samples 26241, 26242, 26243, and 26244 is given under laboratory No. 26245.

System of mining, room and pillar. In 1916 the coal was undercut by machine and shot down with black powder by the miners at any time during the shift. Men employed numbered 65 underground and 12 aboveground. Haulage was by one electric locomotive and mules. The tipple was of wood. The entire output was shipped as run of mine. There were two loading tracks, with capacity for 35 empty and 35 loaded railroad cars. The coal was picked on the car by two pickers. The tonnage came from advance work, no pillars being drawn. The unmined area consisted of 150 acres. The lifetime of the mine was approximately 10 years. The daily capacity in 1916 was estimated at 800 tons, the actual daily average being 350 tons.

HARMONY JUNCTION. NORTH PITTSBURGH REALTY MINE.

Analysis 25615 (p. 63). Bituminous coal, Beaver field, from North Pittsburgh Realty mine at Harmony Junction, on the Baltimore & Ohio R. R. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, shale; floor, fire clay. The bed was sampled on June 30, 1916, by G. B. Richardson. The sample represented 2 feet 9 inches of coal, the entire thickness of the bed except for 1 inch inch of shale at the middle, which was not included.

The section was measured in room 3, off second entry.

NEALEY. NEALEY MINE.

Analysis 25822 (p. 63). Bituminous coal, Beaver field, from Nealey drift mine at Nealey, Worth Township, on the Western Allegheny R. R. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, shale; floor, clay. The bed was sampled on August 18, 1916, by G. B. Richardson. The sample represented 2 feet 6 inches of coal, the thickness of the bed except a 1-inch "parting" 7 inches below the roof. The section was measured in main heading 700 feet north of mine mouth.

CAMBRIA COUNTY.

BAKERTON. STERLING NO. 1 MINE.

Analyses 69680 to 69682, average of mine-face samples, and analyses 69982 and 69
average of tipple samples run-of-mine coal (p. 64). Semibituminous coal, Win
field, from Sterling No. 1 mine, a drift mine ½ mile east of Bakerton, on the Penn
vania R. R. Coal bed, Lower Kittanning, known in this field as B, or Miller;
boniferous age, Allegheny formation. Bed is 3 feet to 4 feet 6 inches thick; dip, 4
cent west; roof, shale, with small amount of "draw slate" and 1 foot of bone; f
hard, smooth shale. Tipple samples were taken by J. J. Bourquin on August 23, 1
The bed was sampled by B. W. Dyer on July 2, 1918, as described below:

Section of coal bed in Sterling No. 1 mine.

Section	A.		B.		C
Laboratory No.	69680		69681		696
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*
Roof, shale and "draw slate."					
Bone	a 1	0		a 8	
Coal	a 0	7		5½	1
Bone		1		1	.....
"Sulphur"	....	....	....	....	
Coal	1	0	1	1	1
"Sulphur"		½		½	.....
Coal		10	1	4	.....
Bone		1	....	....	
Coal		8	....	....	
Floor, shale.					
Thickness of bed	4	3¼	3	7⅞	3
Thickness of coal sampled	3	3¾	2	11⅞	3

a Not included in sample.

Section A (sample 69680) was taken from room 1, inside 3 cross, 7 left, 3 dip.
tion B (sample 69681) was taken from 3 pillar, Gypsy crossheading, 2 dip. Secti
(sample 69682) was taken from face of 4 dip, main.

System of mining, room and pillar. In 1918 the coal was cut partly by machine
partly by hand and shot down with black powder and by dynamite, where the coal
wet, at any time during the shift. Sixty per cent of the coal was taken out in adv
work, and the total recovery claimed was 80 per cent. The unmined area consiste
800 acres. The probable lifetime of the mine was 25 years. Haulage was by four
tric locomotives. There was one loading track, with capacity for 40 empty and 40 lo
loaded railroad cars. Men employed numbered 65 underground and 22 abovegrou
The coal was dumped over a wooden tipple, all coal being loaded and shipped as r
mine. It was cleaned on railroad cars by one picker. There was an inspector of
at the tipple. In 1918 the coal was shipped to Pool No. 9 for domestic purposes
transportation. Prior to the war the coal was shipped to tidewater for steamship
and was used for domestic and smithing purposes. The capacity of the mine wa
tons a day, and the average daily output was 300 tons. The daily tonnage was
37½ per cent of the capacity of the mine, which could be increased to full capacit
additional labor.

For description and analyses of other samples from this mine see Bureau of M
Bull. 22, pp. 154, 696.

BAKERTON. STERLING NO. 3 AND NO. 5 MINES.

Analyses 69686 to 69688 and 69679, 69683, 69684 of Sterling No. 3 and Sterling N
mines, respectively, average of mine-face samples, and analyses 69984 and 69985 a
age of tipplesa mples (pp. 63, 64). Semibituminous coal, Windber field, from
mines located at Bakerton, on the Pennsylvania R. R. Coal bed, Lower Kittann

known in this field as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet 8 inches to 4 feet 8 inches thick; dip, 4 per cent northwest; roof, hard shale; floor, hard, rather rough shale. Commercial samples were taken at the tipple by J. J. Bourquin on August 23, 1918. The bed was sampled by J. J. Bourquin and B. W. Dyer on July 3, 1918, as shown below:

Sections of coal bed in Sterling No. 3 mine.

Section	A.		B.		C.	
Laboratory No.	69687		69688		69686	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Bone	a 1	5	a 1	4	a 1	3½
Coal		10½		11	1	10
"Sulphur"		¼		½	(Lens)	¼
Coal		9½		10½	1	1½
"Sulphur"		¼		½		
Coal	1	2		8½		
Floor, shale.						
Thickness of bed	4	3½	3	11	4	3¼
Thickness of coal sampled	2	10½	2	7	2	11¾

a Not included in sample.

Section A (sample 69687) was taken from face at Sharkey heading. Section B (sample 69688) was taken from face of 6 left. Section C (sample 69686) was taken from face of 40 room, off machine heading.

Sections of coal bed in Sterling No. 5 mine.

Section	A.		B.		C.	
Laboratory No.	69683		69679		69684	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale: C, 2 in. "draw slate."						
Bone	a 1	1	a 1	1	a 1	4
Coal		7½		6¼		
Bony coal		½				2
"Sulphur"				¼		
Coal	1	2	2	1	1	2
"Sulphur"		½				½
Coal		8½			1	3
"Sulphur"		½				
Bone		1		1		
Coal		8½		7		
Floor, shale.						
Thickness of bed	4	6	4	4½	3	11½
Thickness of coal sampled	3	5	3	3½	2	7½

a Not included in sample.

Section A (sample 69683) was taken from rib of 10 room, 5 left. Section B (sample 69679) was taken from main pillar, 1 left. Section C (sample 69684) was taken from face of 4 right, main off first.

System of mining, room and pillar. The coal was cut by machine and by hand in coal near the floor and shot down with black powder at any time during the shift by the miners. In 1918, 48 men were employed underground and 5 aboveground. The coal from both mines was dumped over the same wooden tipple with crossover dump, all coal being loaded and shipped as run of mine. In loading, the miner rejected bone near the roof. No pickers or inspectors were employed. At time of sampling 60 per cent of the coal was taken out in advance work, and the total recovery claimed was 85 per cent. The estimated lifetime of the mines was 5 years. Haulage was by two electric motors in each mine. There was one loading track, with capacity for 20 empty and 20 loaded railroad cars. The coal was being shipped to Pool No. 10 for use by transports. Prior to the war the coal was shipped to the United Fruit Co.

and was used also for domestic purposes and smithing. The combined capa the mines was 800 tons a day, and the combined average daily production a of sampling was 500 tons. The combined daily tonnage was 62½ per cent capacity.

For description and analyses of other samples from this mine see Bureau of Bull. 22, pp. 155, 697.

BAKERTON. STERLING NO. 6 MINE.

Analyses 69685 to 69691, average of mine-face samples (p. 64). Semibitu coal, Windber field, from Sterling No. 6 mine, a drift mine, ½ mile south of Ba on the Pennsylvania R. R. Coal bed, Lower Kittanning, known in this field or Miller Carboniferous age, Allegheny formation. Bed is 3 feet to 4 feet 6 thick; dip, 4 per cent west; roof, hard shale; floor, hard, smooth shale. T was sample by J. J. Bourquin on July 2, 1918, as shown below:

Sections of coal bed in Sterling No. 6 mine.

Section	A.		B.		C.	
Laboratory No.	69690		69691		69689	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Bone	a1	0	a1	1½	a1	0
Coal	1	10½	2	5	1	9
"Sulphur" (not regular)		[illegible]		[illegible]		[illegible]
Coal		[illegible]		5[illegible]	1	4
Shale		[illegible]				
Coal		9				
Floor, hard shale.						
Thickness of bed	4	[illegible]	4	[illegible]	4	1[illegible]
Thickness of coal sampled	3	[illegible]	2	11[illegible]	3	1[illegible]

a Not included in sample.

Section A (sample 69690) was taken from face of 12 right heading, 5,000 fee pit mouth. Section B (sample 69691) was taken from face of 2 right, off 8 left. S C (sample 69689) was taken 25 feet from face of 17 left heading, right rib. Sec (sample 69685) was taken 10 feet from face of 4 right main, left rib.

System of mining, room and pillar. The coal was cut by machine and sho with black powder at any time during the shift by the miners. Men em numbered 160 underground and 21 aboveground. The coal was dumped wooden tipple with crossover dump, all coal being loaded and shipped as run o The miners rejected 1 to 2 inches of bony coal on the top of the coal. In 1918, cent of the coal was taken out in the advance work, and a total recovery of from 8 per cent was claimed. The unmined area consisted of 2,000 acres. The proba time of the mine was 50 years. Haulage was by three main line and three ga electric locomotives. There was one loading track, with capacity for 60 emp 44 loaded railroad cars, and two storage tracks. The coal was shipped to Pool and used for transport service. Prior to the war the coal was used for domes smithing purposes and shipped to the United Fruit Co. The capacity of th was 1,200 tons a day and the average daily output at time of sampling was fr to 800 tons. The daily tonnage was 62½ per cent of capacity, but could be in by the employment of additional labor.

For description and analyses of other samples of coal from this mine see Bu Mines Bull. 22, pp. 155, 697.

BEAVERDALE. PENNSYLVANIA NO. 15 MINE.

Analyses 69505 to 69508, average of tipple samples (p. 64). Semibitumino taken from tipple, Windber field, from Pennsylvania No. 15 mine, a slop at Beaverdale, on the South Fork branch of the Pennsylvania R. R. Co

Lower Kittanning, known in this field as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet to 3 feet 8 inches thick; dip, 7 per cent north; roof, partly shale and partly sandstone, with 8 inches of "draw slate" and bony coal; floor, hard, smooth fire clay. Commercial samples were taken at the tipple by C. L. Colburn on June 20, 1918. The bed was sampled by E. G. Borden on May 1, 1911.

System of mining, room and pillar. In 1918 the coal was cut by pick and shot down with black powder at any time during the shift by the miners. Men employed numbered 97 underground and 56 aboveground. The coal was dumped over a steel and wooden tipple equipped with screens and picking conveyor, all coal being loaded and shipped as run of mine. The coal was cleaned on a conveyor by five or six pickers, and there was an inspector at the tipple. Miners were instructed to reject bone and slate in loading. The capacity of the mine was 750 tons a day, and the average daily production at the time samples were taken at the tipple was 375 tons.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 71, 266.

CASSANDRA. HUGHES NO. 2 MINE.

Analyses 69573 to 69575, average of mine-face samples (p. 65), and analyses 69576 to 69579, average of tipple samples (p. 65). Semibituminous coal, Windber field, from Hughes No. 2 mine, a slope mine 1 mile east of Cassandra, on the Bens Creek branch of the Pennsylvania R. R. Coal bed, Lower Kittanning, known in this field as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet to 4 feet 6 inches; dip, 8½ per cent northwest; roof, first layer, bony coal; second layer, 6 inches "draw slate;" third layer, sandstone and shale; floor, shale, then fire clay, is smooth except at rolls. Commercial samples were taken at the tipple on June 25, 1918, by C. L. Colburn who sampled the bed the next day, as described below:

Sections of coal bed in Hughes No. 2 mine.

Section	A.		B.		C.	
Laboratory No.	69573		69574		69575	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone and shale	5	0	2–5	0	6	0
Coal, bony		a 7		a 4		a 6
Coal	3	10	2	7	4	5
Shale		a 5	....	....		a 8
"Sulphur" streak	....	....		⅛	....	....
Coal	....	....	1	0	....	....
Carboniferous shale	....	....	1	0	....	....
Coal		a 3		a 2		a 3
Floor, shaley fire clay.						
Thickness of bed	5	1	5	1⅛	5	10
Thickness of coal sampled	3	10	3	7	4	5

a Not included in sample.

Section A (sample 69573) was taken from face of C heading, 2½ miles from entrance. Section B (sample 69574) was taken from S. 65 room, main slope. Section C (sample 69575) was taken from F heading, 2½ miles from entrance.

System of mining, room and pillar. The coal was undercut by pick and shot down by black powder by the miners at any time during the shift. In 1918, 180 men were employed underground and 16 aboveground. Twenty-five per cent of the coal was taken out in advance work, and the total recovery claimed was 90 per cent. The coal was dumped over a wooden tipple. Ninety per cent of the coal was shipped as run of mine; the rest was screened for smithing. Haulage was by four electric locomotives, by mules, and by rope. There were three loading tracks, with capacity for 42 empty and 33 loaded railroad cars. The coal was cleaned on railroad cars by two pickers. There was an inspector of coal at the tipple. The miner rejected bone in loading. At time of sampling 20 per cent of the coal was being shipped to commercial trade and 80 per cent to transports. Prior to the war 60 per cent of the coal was used for smithing and 40 per cent for steam. In June, 1918, the unmined area consisted of 2,800 acres, and the probable lifetime of the mine was 50 years. The daily capacity of the mine was 1,500 tons, and the average daily output was 750 tons. The daily tonnage could be increased by the employment of additional labor.

DUNLO. YELLOW RUN MINE.

Analyses 69439 to 69442, average of mine samples, and analyses 69443 to 69446, average of tipple samples (p. 65). Semibituminous coal, Windber field, from Yellow Run mine, a shaft mine, at Dunlo, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known in this field as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 to 4 feet thick; dip, 13 per cent northwest; roof, shale and sandstone; floor, hard, smooth fire clay. Commercial samples were taken at the tipple by J. J. Bourquin on June 15, 1918. The bed was sampled by J. J. Bourquin and C. L. Colburn on June 14, 1918, as described below:

Sections of coal bed in Yellow Run mine.

Section	A.	B.	C.	D.
Laboratory No.	69439	69440	69441	69442
Roof, sandstone.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Shale	....	8 0	8 0	2-12 0
"Draw slate"	....	[a] 2	[a] 2	....
"Sulphur"	....	....	[a] ½	....
Coal	3 11	3 5	3 4	3 9
Floor, fire clay.				
Thickness of bed	3 11	3 7	3 6½	3 9
Thickness of coal sampled	3 11	3 5	3 4	3 9

[a] Not included in sample.

Section A (sample 69439) was cut at face of 36½ room, 8 right heading. Section B (sample 69440) was cut at 53 stump, 4 right heading. Section C (sample 69441) was cut at face of 8 left entry, 8,500 feet from shaft bottom. Section D (sample 69442) was cut at face of 10 right entry, 6,500 feet from shaft bottom.

System of mining, room and pillar. In 1918 the coal was undercut by pick and shot down with black powder in the evening by the miners. Men employed numbered 135 underground and 12 aboveground. The coal was dumped over a wooden tipple by means of self-dumping cages, all coal being loaded and shipped as run of mine. There was one loading track, with capacity for 28 empty and 21 loaded railroad cars. The coal was cleaned on the railroad cars by two pickers. Haulage was by one electric motor and by mules. Forty per cent of the coal was taken out in advance work, and the total recovery claimed was 95 per cent. The unmined area consisted of 500 acres. At time of sampling the coal was being shipped to the New England States, to the Bethlehem Steel Co., and to Army transports. The capacity of the mine was 1,000 tons a day, and the average daily output was 500 tons.

GALLITZIN. GALLITZIN SHAFT.

Analyses 30824 to 30827 and composite 30828, face samples, and analysis 30829, tipple samples run of mine coal (p. 65). Bituminous coal, Windber field, from Gallitzin shaft, located in Gallitzin, on the Pennsylvania R. R. Coal bed, Upper Freeport, locally known as E, or Lemon; Carboniferous age, Allegheny formation. Bed is 3 feet 6 inches to 4 feet 8 inches thick; dip, 5 per cent west; roof, rather hard shale, very little "draw slate;" floor, rather smooth shale. Commercial samples were take at the tipple by J. J. Bourquin on July 11, 1918. The bed was sampled by B. W. Dyer on July 14, 1918, as described below:

Sections of coal bed in Gallitzin shaft.

Section	A.	B.	C.	D.
Laboratory No.	30827	30826	30825	30824
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, shale and bony coal.				
Coal, bony	*a* 3	*a* 2½	*a* 3	....
Coal	11¾	1 6½	1 4	1 7½
"Sulphur"			½	
Coal	6¼	4½	1 2	2½
"Sulphur"			....	
Coal	5¼	8¾	....	1 0
"Sulphur"		....	....	....
Coal	10½	....	....	....
Shale	*a* 1	*a* 1½	*a* 1½	*a* 1
Coal, bony	*a* 1	....	....	....
Coal	1 1	2	11	10
"Sulphur"	....	1/16	....	....
Coal	....	11	....	....
Floor, shale.				
Thickness of bed	4 5½	4 1 11/16	3 10	3 9⅝
Thickness of coal sampled	4 ½	3 9 11/16	3 5½	3 8⅝

a Not included in sample.

Section A (sample 30827) was cut from rib 20 feet from entry, 65 room, 9 right entry. Section B (sample 30826) was cut from rib 60 feet from entry, 5 room, 1 dip on motor road. Section C (sample 30825) was cut from rib 200 feet from entry, 55 room, 12 left entry. Section D (sample 30824) was cut from rib 70 feet from entry, 20 room, 10 right entry.

The ultimate analysis of a composite sample made by combining face samples 30824, 30825, 30826, and 30827 is given under laboratory No. 30828.

System of mining, room and pillar. In 1918 the coal was cut by machine and by pick near the bottom and shot down by the miners with black powder and squibs at any time during the shift. Men employed numbered 110 underground and 65 aboveground. The coal was dumped over a wooden tipple in a self-dumping cage. Eighty per cent of the coal passed through 4-inch bar screens and was loaded in railroad cars. The undersize was taken to coke ovens. The coal was cleaned by one picker on railroad cars and by two pickers in chutes. There was an inspector at the tipple.

Sixty-six per cent of the coal was taken out in the advance work, and a total recovery of 80 per cent was claimed. The unmined area consisted of 700 acres. The estimated lifetime of the mine was 17 years. Haulage was by one electric motor and by rope and mules. There were three loading tracks, with capacity for 25 empty and 20 loaded railroad cars. The capacity of the mine was 1,000 tons a day, and the average daily output was 550 tons. The daily tonnage was 55 per cent of the capacity, but could have been increased by the employment of additional labor. The daily production of coke was 270 tons from 450 tons of coal. The output of coal for the year 1917 was 179,844 tons.

LILLY. SONMAN NO. 2 MINE.

Analyses 69599 to 69601, average of tipple samples run-of-mine coal (p. 65). Semibituminous coal, Windber field, from Sonman No. 2 mine, a slope mine 1 mile east of Lilly, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known in this field as B, or Miller; Carboniferous age, Allegheny formation. Bed is 38 to 46 inches thick; dip, 7 per cent northwest; roof, good shale, no "draw slate;" floor, hard, smooth fire clay. Commercial samples were taken at the tipple by B. W. Dyer on June 26, 1918. The bed was sampled by A. J. Hazelwood on April 22, 1910.

System of mining, room and pillar. In 1918 the cutting was made in the b
and in the coal by hand and shot down with black powder and squibs by the m
at any time during the shift. Men employed numbered 85 underground a
above ground.

Sixty per cent of the coal was taken out in advance work, and a total recove
85 per cent was claimed. The unmined area consisted of 750 acres. The estin
lifetime of the mine was 20 years. Haulage was by rope and mules. There
three loading tracks, with capacity for 30 empty and 35 loaded railroad cars.
coal was dumped over a wooden tipple and was loaded and shipped as run of m
There were no impurities in the coal as loaded on the railroad cars. The b
smithing coal was being shipped west and the steam coal east. Before the wa
coal was used by blacksmiths and for steam making. The capacity of the
was 600 tons a day, and the average daily output was 350 tons. The output fo
year 1917 was 120,000 tons.

For description of coal bed and analyses of other samples, see Bureau of
Bull. 22, pp. 158, 707.

LLANFAIR. HENRIETTE No. 2 MINE.

Analyses 69435 and 69438, average of tipple samples (p. 66). Semibitum
coal, Windber field, from Henriette No. 2 mine, a shaft mine 1 mile south of Lla
on the South Fork branch of the Pennsylvania R. R. Coal bed, Lower Kittan
known in this field as B, or Miller; Carboniferous age, Allegheny formation. B
39 to 42 inches thick; dip, 7 per cent to 10 per cent northwest; roof, shale, very
"draw slate;" floor, smooth and, after being exposed, soft fire clay. Comm
samples were taken at the tipple by C. L. Colburn on June 12, 1918. The be
sampled by A. H. Fay on June 27, 1912.

System of mining, room and pillar. The coal was cut by pick and shot down
permissibles and black powder by the miners at the end of the day. Men emp
numbered 150 underground and 15 aboveground. Fifty per cent of the coa
taken out in advance work, and a total recovery of 92 per cent was claimed.
unmined area consisted of 213 acres. The estimated lifetime of the mine was 7
Haulage was by two electric locomotives, rope, and mules. There were two lo
tracks, with capacity for 35 empty and 60 loaded railroad cars. The coal was du
over a wooden tipple, all coal being loaded and shipped as run of mine. Th
was cleaned on railroad cars by one picker. There was an inspector of coal a
tipple. The miner rejected very little except slate in loading. The coal was
shipped to points without the State at the rate of 500 tons a day. Prior to th
the coal was used for custom trade only. The capacity of the mine was
tons a day, and the average daily output in 1918 was 500 tons. The output f
year 1917 was 132,620 tons.

NANTY GLO. CARDIFF No. 1 MINE.

Analyses 69696 to 69699, average of mine-face samples, and analyses 69931 to 6
average of tipple samples run of mine coal (p. 66). Semibituminous coal, Wi
field, from Cardiff No. 1 mine, a drift mine $2\frac{3}{16}$ miles north of Nanty Glo, on th
Pit Run branch of the Pennsylvania R. R. Coal bed, Lower Kittanning, kno
B, or Miller; Carboniferous age, Allegheny formation. Bed is $3\frac{1}{2}$ to 4 feet t
dip, 2 per cent south; roof, about 6 feet of hard, gray shale, above shale sands
very little "draw slate;" floor, smooth, hard fire clay. Commercial samples
taken at the tipple by J. J. Bourquin on August 20, 1918. The bed was sampl
C. L. Colburn on July 1, 1918, as shown below:

Sections of coal bed in Cardiff No. 1 mine.

Section	A.	B.	C.	D.
Laboratory No.	69699	69696	69698	69697
Roof, main, sandstone; immediate, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
"Draw slate"	a 6			
Coal	3 8	3 7	3 6	3 6
Floor, fire clay.				
Thickness of bed	4 2	3 7	3 6	3 6
Thickness of coal sampled	3 8	3 7	3 6	3 6

a Not included in sample.

Section A (sample 69699) was cut at face of 21 left entry, main entrance. Section B (sample 69696) was cut at face of 4 room, 12 right, main heading. Section C (sample 69698) was cut at face of 3 left entry, main heading. Section D (sample 69697) was cut at face of 11 left entry, 14 room, main entrance.

System of mining, room and pillar. In 1918 the coal was cut by machine and shot down by the miners with permissibles at any time during the shift. Men employed numbered 120 underground and 25 aboveground. The coal was dumped over a wooden tipple, all being loaded and shipped as run of mine; it was cleaned on railroad cars by two pickers. The miner rejected "sulphur" in loading. Fifty per cent of the coal was taken out in the advance work, and the total recovery claimed was 95 per cent. The unmined area was 1,000 acres. The probable lifetime of the mine was 25 or 30 years. Haulage was by four electric locomotives. There was one loading track, with capacity for 27 empty and 24 loaded railroad cars. At the time of sampling, the coal was being shipped to transports and to the trade for steam purposes. The capacity of the mine was 800 tons a day, and the average daily output was 600 tons. The output for the year 1917 was 127,000 tons.

For analyses of other samples of this coal see Bull. 22, Bureau of Mines, p. 159.

NANTY GLO. SPRINGFIELD NO. 1 MINE.

Analyses 69612, 69614, 69616, and 69618, average of mine-face samples, and analyses 69923 to 69926, average of tipple samples run-of-mine coal (p. 66). Semibituminous coal, Windber field, from Springfield No. 1 mine, a slope mine 1 mile east of Nanty Glo, on the New York Central and Pennsylvania Railroads. Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3½ to 4 feet thick; dip, 4 per cent northeast; roof, shale, from 2 to 5 feet thick, then sandstone; floor, hard, smooth fire clay. Commercial samples were taken at the tipple on August 19, 1918, by J. J. Bourquin and L. D. Tracy. The bed was sampled by C. L. Colburn on June 28, 1918, as shown below:

Sections of coal bed in Springfield No. 1 mine.

Section	A.	B.	C.	D.
Laboratory No.	69612	69614	69616	69618
Roof, main, sandstone; immediate, slate.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	3 6	3 8 {Little sulphur.}	3 7	3 7
Shale	a 5	a 6	a 6	a 6
Bottom coal	a 3	a 2	a 2	a 2
Floor, fire clay.				
Thickness of bed	4 2	4 4	4 3	4 3
Thickness of coal sampled	3 6	3 8	3 7	3 7

a Not included in sample.

Section A (sample 69612) was taken from face 7 left, ¼ mile from entrance. S
B (sample 69614) was taken from face in main dip, 1 mile from entrance. Sect
(sample 69616) was taken from face in main heading, 1½ miles from entrance. S
D (sample 69618) was taken from pillar 1 room, 4 heading.

System of mining, room and pillar. The coal was undercut by machine or p
coal and shot down with permissible explosive and with black powder, where
was no gas, at any time during the shift by the miners. About 66⅔ per cent was
out in advance work, and a total recovery of 95 per cent was claimed. The un
area consisted of about 1,500 acres. The estimated lifetime of the mine was 30
Haulage was by six electric locomotives and by rope. There was one loading
with capacity for 40 empty and 20 loaded railroad cars. Men employed num
175 underground and 15 aboveground. The coal was dumped over a wooden t
all being loaded and shipped as run of mine; it was cleaned on railroad cars b
picker. In loading the miner rejected slate. The capacity of the mine was
tons a day, and the average daily output in June, 1918, was 700 tons.

For description and analyses of other samples from this mine see Bureau of
Bull. 85, pp. 78, 276, and Bull. 123, pp. 75, 292.

NANTY GLO. SPRINGFIELD NO. 3 MINE.

Analyses 69625 and 69626, average of mine-face samples, and analyses 699
69930, average of tipple samples (p. 67). Semibituminous coal, Windber
from Springfield No. 3 mine, a drift mine ½ mile east of Nanty Glo, on the
York Central and the Pennsylvania Railroads. Coal bed, Lower Kittanning, k
as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3½ to 4 feet t
dip, 4 per cent northeast; roof, main, sandstone; immediate, shale, 2 to 5 feet t
floor, fire clay. Tipple samples were taken by L. D. Tracy on August 20, 1918.
bed was sampled by C. L. Colburn on June 30, 1918, as shown below:

Sections of coal bed in Springfield No. 3 mine.

Section	A.	
Laboratory No.	69625	6
Roof, main, sandstone; immediate, shale.	Ft. in.	F
Coal	3 0	
Shale	a 6	
Bottom coal	a 2½	
Floor, fire clay.		
Thickness of bed	3 8½	
Thickness of coal sampled	3 0	

a Not included in sample.

Section A (sample 69625) was taken from main B heading, 1 mile from entr
Section B (sample 69626) was taken from face C main heading, 1½ miles from entr

System of mining, room and pillar. In 1918 the coal was cut by machine and by
and shot down with black powder at any time during the shift by the miners.
66⅔ per cent of the coal was taken out in advance work, and a total recovery
per cent was claimed. Haulage was by five electric locomotives. There wer
loading tracks, with capacity for 40 empty and 30 loaded railroad cars. Men empl
numbered 125 underground and 15 aboveground. The coal was dumped o
wooden tipple, all being loaded and shipped as run of mine; it was cleaned on ra
cars by one picker The miner rejected slate in loading. The section of coal m
was practically free of impurities except "sulphur"; some slate was shipped wit
coal. The capacity of the mine was 900 tons a day, and the average daily ou
was 600 tons. The daily tonnage could be increased by the employment of addit
labor.

SONMAN. SONMAN SHAFT.

Analyses 69602 and 69604, average of tipple samples (p. 67). Semibituminous coal, Windber field, from Sonman shaft, 1 mile east of Portage, on the Sonman branch of the Pennsylvania R. R. Coal bed, Lower Kittanning, locally known as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet 3 inches to 4 feet 5 inches thick; dip, 9 per cent; roof, shale, with 6 inches of "draw slate;" floor, smooth, soft fire clay. Commercial samples were taken at the tipple by J. J. Bourquin on June 26, 1918. The bed was sampled by P. M. Riefkin on May 1, 1911.

System of mining, room and pillar. In 1918 the coal was undercut by pick and shot down with black powder and permissibles by the miners at any time during the shift. Men employed numbered 275 underground and 35 aboveground. The coal was dumped over a wooden tipple by a self-dumping cage, all being loaded and shipped as run of mine. In the B seam haulage was by four electric locomotives, mules, and hoist; in the E seam, also worked, haulage was by one electric locomotive, by mule, and by rope. The coal was cleaned on railroad cars by eight pickers at the shaft and six pickers at the slope. There was an inspector of coal at the tipple. The coal was unusually well picked and much "sulphur" band was removed. There were two loading tracks at the shaft and two at the slope, having a capacity for 80 empty and 97 loaded railroad cars. A total recovery of 80 per cent was claimed. There was a large territory of unmined area. The estimated lifetime of the mine was 25 years or longer. At time of sampling the capacity of the mine was 1,000 tons a day and the average daily production was about 600 tons. The coal was shipped to the Pennsylvania R. R., to the Du Pont Co., and to transports. Prior to the war it was used for commercial purposes and shipped to Philadelphia.

For description of coal bed and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 80, 279.

SONMAN. SONMAN SLOPE.

Analyses 26398 to 26404 (p. 67). Semibituminous coal, Windber field, from Sonman, a slope mine at Sonman, in Portage Township, on the Pennsylvania R. R. Coal bed, Upper Freeport, or E; Carboniferous age, Allegheny formation. Bed is 3 feet 6 inches to 4 feet 6 inches thick; dip, 8° west. A few faults and horsebacks are encountered. Immediate roof consists of impure coal from 4 to 15 inches in thickness, with shale above; floor, hard fire clay; cover at points of sampling, approximately 150 feet. The bed was sampled by E. H. Denny on October 18, 1916, as described below:

Sections of coal bed in Sonman slope.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	26398		26399		26400		26401		26402		26403	
Roof, main, shale; immediate, coal.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Bony coal										a ½		
Coal	2	2	2	4½	1	9	2	6	1	9½	1	4
"Mother coal" and "sulphur"						½				a ¾		½
Coal						8				10	1	1½
"Mother coal"						a ⅜						
Coal						1						
Shale parting		a 6		a 4½		a 3½		a 3½		a 2		a 3½
Coal		9	1	7	1	6	1	7	1	6½	1	3
"Mother coal" and "sulphur"		¼										
Coal		5										
Floor, hard fire clay.												
Thickness of coal bed	3	10½	4	4	4	4½	4	4½	4	5½	4	½
Thickness of coal sampled	3	4¾	3	11½	4	¼	4	1	4	2	3	8¾

a Not included in sample.

Section A (sample 26398) was measured near the face of 2 left entry, off the s dip and 3,500 feet south 45° west from the slope mouth. Section B (sample 2 was measured in 3 right air course at the intersection with the south dip, abou feet back from the face of the south dip and 2,900 feet south 70° west from the mouth. Section C (sample 26400) was measured 20 feet from the face of 2 right dip, 1,700 feet south 60° west from the slope mouth. Section D (sample 26401) measured at the face of 13 room, 1 right, north dip, 2,800 feet north 30° east fron slope mouth. Section E (sample 26402) was measured at the face of 1 cutthrough room, 2 left, north dip, 1,450 feet north 10° east from the slope mouth. Secti (sample 26403) was measured in the north dip, 20 feet from the face and 2,100 north from the slope mouth.

The ultimate analysis of a composite sample made by combining face san 26398, 26399, 26400, 26401, 26402, and 26403 is given under laboratory No. 264

System of mining, room and pillar. In 1916 the coal was undercut by Sullivan wall machines and shot down with permissible explosive. Men employed numb 130 underground and 12 aboveground. The tipple was of wood. The entire ou was shipped as run of mine. Haulage was by electric hoist, electric locomotive, mule. There was track capacity for 65 empty and 55 loaded railroad cars. probable lifetime of the mine was 25 years. In 1916 the daily capacity was 1,000 the daily average 800 tons, and the maximum day's run 1,000 tons. In 1919 the capacity was increased to 1,500 tons and the daily average to about 1,350 tons.

South Fork. Argyle No. 1 Mine.

Analyses 69453, 69455, and 69456, average of face samples; and analyses 699 69906, average of tipple samples run-of-mine coal (p. 67). Semibituminous Windber field, from Argyle No. 1 mine, a drift mine at South Fork, on the Pen vania R. R. Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous Allegheny formation. Bed is 3 feet to 4 feet 6 inches thick; roof, hard shale contai irregular streaks of "sulphur;" floor, fairly smooth, hard fire clay. Commercial ples were taken at the tipple by J. J. Bourquin and L. D. Tracy on August 16, The bed was sampled by J. J. Bourquin on June 10, 1919, as described below:

Sections of coal bed in Argyle No. 1 mine.

Section / Laboratory No.	A. 69453	B. 69455	C[illegible] 69[illegible]
Roof, main, sandstone; immediate, shale.	Ft. in.	Ft. in.	Ft
Coal	3 6	3 7	....
Bony coal	....	....	
Coal	....	....	
Floor, fire clay.			
Thickness of bed	3 6	3 7	
Thickness of coal sampled	3 6	3 7	

a Not included in sample.

Section A (sample 69453) was cut at 3 north entry, 6 entry, 5 feet from face. Sec B (sample 69455) was cut at split in pillar between 5 and 6 north entry. Secti (sample 69456) was cut at face of main heading, 1 mile from pit mouth.

System of mining, room and pillar, In 1918 the coal was undercut by pick and down at any time during the shift by three shot firers with permissible explo which was used in shooting up the bottom. Men employed numbered 38 undergr and 13 aboveground. The coal was dumped over a wooden tipple, all being lo and shipped as run of mine. Haulage was by tail rope. There was one loading t with capacity for 14 empty and 13 loaded railroad cars. The coal was cleaned on by one picker and one helper. As loaded on the railroad cars the coal showed " phur" in irregular streaks and balls. The work in the mine was confined to the removal of pillars, and a total recovery of 95 per cent was claimed. The estimated lifetime of the mine was 5 years. At time of sampling the capacity of the mine was 400 tons a day and the average daily production was 200 tons. The output for the year 1917 was 90,807 tons. About half the coal was being shipped to tidewater and half, for Government use, to Pools 9 and 10.

SOUTH FORK. ARGYLE NO. 2 MINE.

Analyses 69451, 69452, and 69454, average of mine samples; and analyses 69907 to 69910, average of tipple samples run of mine coal (p. 68). Semibituminous coal, Windber field, from Argyle No. 2 mine, a drift mine in South Fork Borough, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet 6 inches to 4 feet thick; dip, up to 10° northeast; roof, hard shale, no "draw slate"; floor, hard, rather smooth fire clay. Commercial samples were taken at the tipple by J. J. Bourquin and L. D. Tracy on August 15, 1918. The bed was sampled by J. J. Bourquin on June 11, 1918, as described below:

Sections of coal bed in Argyle No. 2 mine.

Section Laboratory No.	A. 69451	B. 69452	C. 69454
Roof, sandstone.	Ft. in.	Ft. in.	Ft. in.
Coal	6¼		
"Sulphur" band	¼		
Shale		[a] 1	
Coal	2 6¼	4	1 3
"Sulphur" band	¾	½	⅛
Coal	5¼	6	1 11
Shale		½	
Coal		1 8⅛	
"Sulphur"		⅛	⅝
Coal		1 0	9
Floor, fire clay.			
Thickness of bed	3 7¾	3 8¼	3 11⅝
Thickness of coal sampled	3 7¾	3 7¼	3 11⅝

[a] Not included in sample.

Section A (sample 69451) was cut 10 feet from face of 10 room, 7 right entry. Section B (sample 69452) was cut at face of 6 room, chain pillar, 5 left entry. Section C (sample 69454) was cut from 2 right entry, 9 entry, No. 1 rib.

System of mining, room and pillar. In 1918 the coal was undercut by pick and shot down with black powder and with permissible explosive in the safety-lamp sections, at any time during the shift, by miners and by shot firers. Men employed numbered 57 underground and 23 aboveground. The coal was dumped over a wooden tipple, all being loaded and shipped as run of mine. Haulage was by tail rope. There was one loading truck, with capacity for 12 empty and 14 loaded railroad cars. The coal was cleaned on railroad cars by one picker. The coal on the cars contained some material from roof and partings in seam, particularly "sulphur" bands. Sixty per cent of the coal was taken out in advance work, and a total recovery of 95 per cent was claimed. The estimated lifetime of the mine was 10 years. The capacity of the mine was 700 tons a day, and the average daily output at time of sampling was 450 tons. The output for the year 1917 was 137,934 tons.

SOUTH FORK. STINEMAN NO. 2 MINE.

Analyses 69391, 69394, to 69396, average of tipple samples, run of mine coal (p. 68). Semibituminous coal, Windber field, from Stineman No. 2 mine, a drift mine ¾ mile west of South Fork, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known as

B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet 8 inches to 6 inches thick; dip, 7½° northwest; roof, shale, no "draw slate"; floor, smooth and bottom coal. Commercial samples were taken at the tipple by J. J. Bou and C. L. Colburn on June 8, 1918. The bed was sampled by H. M. Wolfl September 7, 1909.

System of mining, room and pillar. In 1918 the coal was undercut with powder, a little permissible explosive being used for rock, at any time duri shift, by the miners. Men employed numbered 135 underground and 15 ground. The coal was dumped over a wooden tipple, all being loaded and sh as run of mine. The coal was cleaned on railroad cars by one picker. Haula by animal and by three electric locomotives. There was one loading track, capacity for 20 empty and 20 loaded railroad cars. The unmined area consis approximately 400 acres. At time of sampling 60 per cent of the coal was out in the advance work, and the recovery claimed was 90 per cent. The esti lifetime of the mine was from 15 to 20 years. The coal was shipped to the Du Co., at Carneys Point, N. J. The capacity of the mine was 700 tons a day, an average daily output at the time tipple samples were taken was 550 tons.

For description of coal bed and analyses of other samples see Bureau of Bull. 22, pp. 161, 716.

SOUTH FORK. STINEMAN NO. 4 MINE.

Analyses 69447 to 69450, average of tipple samples, run of mine coal (p. 68). bituminous coal, Windber field, from Stineman No. 4 mine, a slope mine ½ mil South Fork, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known or Miller; Carboniferous age, Allegheny formation. Bed is 2½ to 4½ feet thick 12° south 60° west; roof, gray shale, about 6 inches of which comes down as a " slate"; floor, hard, shaly clay, with a smooth surface. Commercial samples taken at the tipple by J. J. Bourquin and C. L. Colburn on June 8, 1918. Th was sampled by H. M. Wolflin on September 2 and 9, 1909.

System of mining, room and pillar. In 1918 the coal was undercut by han shot down with black powder at any time during the shift by the miners. employed numbered 120 underground and 20 aboveground. The coal was du over a wooden tipple, all being loaded and shipped as run of mine; it was c on the railroad cars by one picker. Haulage was by mule and by rope. The one loading track, with capacity for 30 empty and many loaded railroad cars. capacity of the mine at time of sampling was 500 tons a day, and the average dai put was 400 tons. The output for the year 1917 was 125,740 tons. The un area included 575 acres.

For description of coal bed and analyses of samples see Bureau of Mines Bu pp. 161, 717.

ST. MICHAEL. MARYLAND SHAFT MINE.

Analyses 25717 to 25722, 68185, 68187, 68193, 68219, 68220, 30152, and tipple s 30153 (p. 68). Semibituminous coal, Windber field, from Maryland shaft m mile west of St. Michael, on the Pennsylvania R. R. Coal bed, Lower Kittan Miller, or B; Carboniferous age, Allegheny formation. Average thickness o 3 feet 9 inches; dip, 6 per cent northeast; slight cleat; no faults. Rolls or backs are rather frequent. In places roof consists of 6 inches of "draw slate," comes down with the coal; the immediate roof falls in rooms, but not when n Floor, medium hard, rolling fire clay. Depth of shaft, 670 feet. The bed was sa by E. H. Denny and R. H. Seip on July 27 and 28, 1916, as described below:

Sections of coal bed in Maryland shaft mine, sampled in 1916.

Section	A.		B.		C.		D.		E.	
Laboratory No.	25717		25718		25719		25720		25722	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone.										
Coal, bony and "sulphury"		[a] 5½		[a] 5		[a] 6½		[a] 4		[b] 5
Bone										½
Coal	3	2½	3	4	3	1	3	6	2	4½
Floor, fire clay.										
Thickness of bed	3	8	3	9	3	7½	3	10	2	10
Thickness of coal sampled	3	2½	3	4	3	1	3	6	2	10

[a] Not included in sample.
[b] Five inches of top coal appeared to be good, and being low coal all of section was included in pillar sample.

Section A (sample 25717) was cut from the face of 7 left main entry. Section B (sample 25718) was cut from the face of 2 longwall. Section C (sample 25719) was cut from 2 left entry, south main entry, 15 feet from the face. Section D (sample 25720) was cut from the face of 7 left entry, south main entry. Section E (sample 25722) was cut from 19 pillar, 6 right north entry.

The ultimate analysis of a composite sample made by combining samples 25717, 25718, 25719, and 25720 is given under laboratory No. 25721. Commercial samples were taken at the tipple by E. T. Hancock on December 28, 1917. The bed was sampled by E. Stebinger on December 28, 1917, as described below:

Sections of coal bed in Maryland shaft mine, sampled in 1917.

Section	A.		B.		C.		D.		E.	
Laboratory No.	68220		68187		68193		68219		68185	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, bony coal and shale.										
Coal, "sulphurous"										[a] 6
Bony and "sulphurous" coal		[a] 4		[a] 4		[a] 2		[a] 2		3
Coal, fairly hard	1	0								
Coal, "dirty," bony, "sulphurous"				2		2		2		2
Coal, hard, dull			1	0	1	4				
Coal, soft and friable	1	11	2	5	1	8	3	7	2	10
Floor, fire clay.										
Total thickness of bed	3	3	3	11	3	4	3	11	3	9
Thickness of coal sampled	2	11	3	7	3	2	3	9	3	3

[a] Not included in sample.

Section A (sample 63220) was cut at face of south main. Section B (sample 68187) was cut at face of C heading on longwall. Section C (sample 68193) was cut on 6 longwall face. Section D (sample 68219) was cut at face of 2 right, 3 right. Section E (sample 68185) was cut at face of 3 right dip.

The ultimate analysis of a composite sample made by combining face samples 63220, 68187, 68193, 68219, and 68185 is given under laboratory No. 30152.

The ultimate analysis of a composite sample made by combining tipple samples of run of mine coal, 68201, 68202, 68210, and 68212, is given under laboratory No. 30153.

Systems of mining, longwall and room and pillar. Men employed numbered 325 underground. Mine had a steel tipple. Miners' electric lamps were used in pillar workings, carbide lamps in rooms and headings. There were no coal-cutting machines. Haulage was by electric motors. About half the coal was taken out in advance work, and the total recovery claimed was 85 per cent. The unmined area consisted of approximately 3,500 acres. The estimated lifetime of the mine was from 50 to 60 years. The coal was all shipped as run of mine; no screens were used. Three pickers were employed on the railroad cars. There were two loading tracks, with capacity for 50 empty and 40 loaded railroad cars. At time of sampling the capacity of the mine was 1,200 tons a day, and the maximum day's run was 1,900 tons. The output was to be increased to 3,000 tons a day.

VINTONDALE. VINTON No. 1 MINE.

Analyses 69729, 69730, 69733, and 69734, average of mine-face samples, and a
70030 to 70033, average of tipple samples (p. 69). Semibituminous coal, W
field, from Vinton No. 1 mine, ½ mile northwest of Vintondale, on the Pennsy
R. R. Coal bed, Lower Kittanning, locally known as B, or Miller; Carbon
age, Allegheny formation. Bed is 3 feet 4 inches to 4 feet thick; dip, 3½ p
northwest; roof, shale; floor, hard, smooth shale. Commercial samples were
at the tipple by L. D. Tracy on August 28, 1918. The bed was sampled b
Bourquin on July 9, 1918, as shown below:

Sections of coal bed in Vinton No. 1 mine.

Section	A.	B.	C.
Laboratory No.	69729	69734	69730
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	11½	3 6½	3 10
Bony coal	[a] ½	....	....
Coal	2 7¾	....	....
Shale; in sections C and D "sulphur" streaks	....	1	....
Floor, shale and coal.			
Thickness of bed	3 7¾	3 7½	3 10
Thickness of coal sampled	3 7¼	3 6½	3 10

[a] Not included in sample.

Section A (sample 69729) was taken from left rib 8 room, 1 left, 3 section,
from face. Section B (sample 69734) was taken from face of 9 room, 8 left, 2 s
Section C (sample 69730) was taken from face of 7 left, 5 butt, 2 section. Sec
(sample 69733) was taken from 1 breakthrough, 34 room, 9 left, 1 section.

System of mining, room and pillar. In 1918 the coal was cut by machine a
down with permissible explosive, at any time during the shift, by the miners
employed numbered 200 underground and 20 aboveground. About 65 per c
the coal was taken out in advance work, and a total recovery of 85 per cent was cl
The unmined area was 700 acres. The estimated lifetime of the mine was 20
Haulage was by seven electric locomotives. There were two loading track
capacity for 35 empty and 35 loaded railroad cars. The coal was dumped over
tipple with crossover dump, all coal being loaded and shipped as run of mine
coal was cleaned on picking tables by four pickers. There was an inspector of
the tipple. At time of sampling, the capacity of the mine was 1,200 tons
and the average daily output in June, 1916, was 900 tons. The output for th
1917 was 250,000 tons. The daily tonnage was 75 per cent of the capacity
mine.

For description and analyses of other samples from this mine see Bureau of
Bull. 22, pp. 162, 721.

VINTONDALE. VINTON No. 6 MINE.

Analyses 69731 and 69735 to 69738, average of mine-face samples (p. 69).
bituminous coal, Windber field, from Vinton No. 6, a drift mine at Vintond
the Pennsylvania R. R. Coal bed, Lower Kittanning, known locally as B, or
Carboniferous age, Allegheny formation. Bed is 3 to 4 feet thick; dip, 3 p
northwest; roof, good shale; floor, smooth, rather soft fire clay, above which i
and bony coal. The bed was sampled by B. W. Dyer on July 9, 1918, as shown

Section of coal bed in Vinton No. 6.

Section	A.	B.	C.	D.	E
Laboratory No.	69736	69735	69738	69737	69731
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, shale.					
Coal, bony	½				½
Coal	2	5½	6½	1	2 7
"Sulphur"	1/16	1/16	1/16	¼	¼
Coal	1 1½	1 8½	1 10	5	8½
Coal, bony	1½				
Coal	10				
"Sulphur"	¾	¼	¾	¼	
Coal	3¼	3½	2¼	2 10	
"Sulphur"	1/16	⅛	¼	½	
Coal	11½	8	4½	3½	
"Sulphur"		¼			
Coal, bony			1		
Coal		6½	9		
Floor, shale and bony coal under fire clay.					
Thickness of bed	3 7⅛	3 8 11/16	3 10 5/16	3 8½	3 4¼
Thickness of coal sampled	3 7⅛	3 8 11/16	3 10 5/16	3 8½	3 4¼

Section A (sample 69736) was taken from rib, 1 right butt, 13 right, off 2 slope. Section B (sample 69735) was taken from face of 13 right, off 3 slope. Section C (sample 69738) was taken from face of 4 right main, off 15 left, 2 slope. Section D (sample 69737) was taken from 1 left, off 1 slope, rib, 10 feet from face. Section E (sample 69731) was taken from rib, 100 feet from face, 15 right, 3 slope.

System of mining, room and pillar. At time of sampling the coal was cut by machine and shot down with permissible explosive at any time during the shift by shot firers. About 65 per cent of the coal was taken out in the advance work, and a total recovery of 85 per cent was claimed. The unmined area consisted of 2,500 acres. In 1918 the probable lifetime of the mine was 45 years. Haulage was by eight electric locomotives. There were two loading tracks, with capacity for 40 empty and 40 loaded railroad cars. There were 290 men employed underground and 35 aboveground. The coal was dumped over a steel tipple with chain haul dump; about 50 per cent of the coal went through a bar screen with 3 to 1½ inch openings, the oversize being recombined and loaded out, and the undersize being taken to washery; about one-third of the coal was loaded and shipped as run of mine. The coal was cleaned on railroad cars by three pickers. The coal as loaded on the railroad cars showed the presence of few impurities. The capacity of the mine in July, 1919, was 1,500 tons a day, and the average daily production was 1,200 tons. The output for the year 1917 was 450,000 tons. The daily tonnage was 80 per cent of the capacity. All coal passing through ½-inch screen was washed and coked; about 450 tons of coal a day was used for the coke oven. No washed coal was shipped.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 163, 722.

WINDBER. EUREKA NO. 40 MINE.

Analyses 68179, 68190, 68191, 68222, and 30173, and tipple samples 68204, 68206, 68207, 68208, and 30174 (p. 70). Semibituminous coal, Windber field, from Eureka No. 40 mine, a drift mine 1½ miles northwest of Windber, in Richland township, on a spur of the Pennsylvania R. R. Coal bed, Lower Kittanning or B seam; Carboniferous age, Allegheny formation. Average thickness of bed is 4 feet 2 inches; dip, 2° southwest; no cleat; few faults. Roof consists of "draw slate," 2 to 10 feet. Floor consists of fire clay and lower coal on top of fire clay. Particles of roof and floor did not become mixed with coal in loading. Vertical height to seam, 90 feet. The bed was sampled by E. Stebinger on December 26, 1917, as described below:

Sections of coal bed in Eureka No. 40 mine.

Section	A.		B.		C.	
Laboratory No.	68179		68190		68191	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, shale.						
Coal, "sulphury"		[a]3		[a]6		[a]5
Coal, "sulphury"		1				2
Coal, clean	1	0	3	4		
Coal, vertical slicken faces						10
Coal, bony		1				
Coal, clean		11¼				
Shale		¼				¼
Coal, soft, friable	2	0			2	5
Shale, 8 inches; "sulphury" coal, 8 inches; fireclay, 1 inch						
Floor, shale.						
Thickness of bed	4	4½	3	10	3	10¼
Thickness of coal sampled	4	1¼	3	4	3	5¼

[a] Not included in sample.

Section A (sample 68179) was cut in 25 room, left main. Section B (sampl
was cut in main heading, 600 feet inby 26 left. Section C (sample 68191) was
room, main, 14 right. Section D (sample 68222) was cut in 19 right main.

The ultimate analysis of a composite sample made by combining face sample
68190, 68191, and 68222 is given under laboratory No. 30173. The ultimate
of a composite sample made by combining tipple samples 68204, 68206, 682
68208 is given under laboratory No. 30174.

System of mining, room and pillar. In 1917 the coal was undercut by
and a punching machine; the haulage was by electric motor. The coal
shipped as run of mine and was picked on car and at tipple. The coal on
appeared to be very clean; the lumps were mostly small. There was track c
for 50 empty and 50 loaded railroad cars. About 50 per cent of the coal was ta
in the advance work, and a total recovery of 80 per cent was made. At time
pling the capacity of the mine was 4,000 tons a day, and the daily average sh
were 2,000 tons.

For descriptions and analyses of other samples of coal from this mine see B
Mines, Bull. 22, pp. 164, 725.

CLEARFIELD COUNTY.

MUNSON. GHEM MINE.

Analyses 26306 to 26312 (p. 70). Bituminous coal Windber field, from Ghe
a slope mine, at Munson, on the Beech Creek branch of the New York Centr
Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous age; Al
formation. Bed is 3 feet to 3 feet 4 inches thick and dips 4° southwest. M
impeded by rolls and by many faults. Roof, 14 to 16 inches of impure co
sandy shale above; floor, hard, firm underclay. The bed was sampled b
Denny on October 14, 1916, as described below:

Sections of coal bed in Ghem mine.

Section	A.		B.		C.	
Laboratory No.	26306		26307		26308	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, fine sandy shale.						
Roof coal	[a]1	2	[a]1	2½	[a]1	3½
Coal	1	2½	2	2	2	½
"Sulphur" band		¼		[a]2		½
Coal		11½	1	0	1	2
"Sulphur"		¼				
Coal	1	1				
Floor, fire clay.						
Thickness of bed	3	3½	3	4	3	3
Thickness of coal sampled	3	3½	3	2	3	3

[a] Not included in sample.

Section A (sample 26306) was measured at the face of 9 right heading, 3,425 feet south 75° west from the slope mouth. Section B (sample 26307) was measured 20 feet from face of 2 main and 2,275 feet north 89° west from the slope mouth. Section C (sample 26308) was measured in 2 room off 3 right back heading and 1,825 feet north 74° west from slope mouth. Section D (sample 26309) was measured 25 feet from face of 8 right heading and 3,475 feet south 75° west from slope mouth.

The ultimate analysis of a composite sample made by combining samples 26306 to 26309 is given under laboratory No. 26310. Two samples of roof coal were also taken. For the results of analyses see laboratory Nos. 26311 and 26312.

Sections of roof coal in Ghem mine.

Section	A.	B.
Laboratory No.	26311	26312
	Inches.	*Inches.*
Coal	5½	4½
"Sulphur" band	¼	⅜
Coal	4	3⅝
Dark dull binder	1½	....
Shale and coal	....	a 6½
Coal	1¾	....
Shale band	a 1	....
Total	13¾	15

a Not included in sample.

Section A (sample 26311) was taken from face 2 room off 3 right back heading. Section B (sample 26312) was taken 25 feet from face of 8 right.

System of mining, double and triple entry, room and pillar. At time of sampling the coal was either overcut or undercut by hand and shot down with FFFF black powder, 40 per cent dynamite being used in wet places and for blasting the rock in rolls and faults. The estimated lifetime of the mine was 15 years. In 1916 haulage was by two electric locomotives and by mule. There was one loading track, with capacity for 10 empty and 20 loaded railroad cars. The miners drilled, loaded, and shot their own holes whenever ready. Men employed numbered 64 underground and 10 aboveground. The coal was dumped over a wooden tipple, all coal being shipped as run of mine. The coal was cleaned by two pickers. The capacity of the mine in 1916 was estimated to be 400 to 500 tons a day, and the average production was 275 tons.

JEFFERSON COUNTY.

Punxsutawney. Eleanora Mine.

Analyses 26827 to 26832 (p. 71). Bituminous coal, Punxsutawney field, from Eleanora mine, a slope and a shaft mine 8½ miles north of Punxsutawney, accessible to a branch line of the Buffalo, Rochester & Pittsburgh R. R. Coal bed, Lower Freeport, or D; Carboniferous age; Allegheny formation. Bed is 4 to 7 feet thick and contains many minute seams of "sulphur" and bone; roof, 10 to 20 inch seam of soft shale, which makes mining difficult; there is a persistent 2 to 4 inch band of cannel coal about 3 feet from the roof, 3 inches below which lies an intermittent thin seam of bone. Floor, hard shale. Cover ranges from 200 to 350 feet. The bed was sampled by E. Steidle on November 27 to 28, 1916, as described below:

Sections of coal bed in Eleanora mine.

Section	A.		B.		C.		D.		E.	
Laboratory No	26827		26828		26829		26830		26831	
Roof, soft shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	0	3	2	2	10	3	2	1	7½
Bone		¼								
Coal		10								
Cannel		3		2½		4		3		
Coal		6		3		3	2	0		
Bone		½		¼		¼		¼		
Slate										½
Coal	3	0		3		6	2	6		3
Bone				¼		½				½
Coal			2	0	2	2			3	0
Floor, shale.										
Thickness of bed	6	7¾	5	11	6	1¾	6	11¼	4	11½
Thickness of coal sampled	6	7¾	5	11	6	1¾	6	11¼	4	11½

Section A (sample 26827) was taken from 12 left, 1,000 feet inby main slope. Section B (sample 26828) was taken from face 8 west, off 4 face entry. Section C (sample 26829) was taken from face 2 room, off 4 west butt, off 14 left. Section D (sample 26830) was taken from face 2, west butt, off 14 left. Section E (sample 26831) was taken from face of 1 left, off 12 south.

The ultimate analysis of a composite sample made by combining face samples 26827, 26828, 26829, 26830, and 26831 is given under laboratory No. 26832.

System of mining, room and pillar. In 1916 all coal was undercut with 3 chain machines and 15 punchers. Black powder was used in the nongaseous or open-light section by the miners, and permissible explosive in the gaseous or closed-light section, fired electrically by shot firers. Haulage was by eight trolley motors and by mules. The daily output in 1916 was 1,400 tons, and in 1918, 1,165 tons.

SOMERSET COUNTY.

CAIRNBROOK. LOYAL HANNA NO. 6 MINE.

Analyses 69564 and 69565, average of tipple samples (p. 71). Semibituminous coal, Somerset field, from Loyal Hanna No. 6 mine, a drift mine at Cairnbrook, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known locally as B, or Miller; Carboniferous age; Allegheny formation. The coal mined is about 4 feet in height, above which is from 5 to 6 inches of bone and above that from 0 to 20 inches of coal, but no coal above the bone is mined. The bed dips 1 to 2 per cent west. Roof, shale; floor, smooth shale. Commercial samples were taken at the tipple by J. J. Bourquin on June 24, 1918. The bed was sampled on September 18, 1914, by G. B. Richardson.

System of mining, room and pillar. In 1918 the coal was cut at the top and in the bony portion by machine and shot down with black powder in the room and with permissible explosives in the entries at any time by the miners. There were 170 men employed underground and 30 aboveground. The coal was dumped over a wooden tipple, all coal from the two benches being loaded and shipped as run of mine. There was an inspector on the railroad cars. The capacity of the mine was 2,600 tons a day, and the average daily output at the time samples were taken at the tipple was 800 to 900 tons.

For description of coal bed and analyses of samples see Bureau of Mines, Bull. 123, pp. 80, 308.

CAIRNBROOK. REITZ No. 2 MINE.

Analyses 69678 and 69591 to 69594, average of mine-face samples, and analyses 69566 to 69568, average of tipple samples (p. 71). Semibituminous coal, Somerset field, from Reitz No. 2 mine, a drift mine ½ mile west of Cairnbrook, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 to 4 feet thick and dips 2 per cent west; roof, good shale over about 5 inches of roof coal; floor, hard, smooth shale. Commercial samples were taken at the tipple by C. L. Colburn on June 22, 1918. The bed was sampled by B. W. Dyer on June 24, 1918, as described below:

Sections of coal bed in Reitz No. 2 mine.

Section Laboratory No.	A. 69591		B. 69593		C. 69594		D. 69678		E. 69592	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, main, shale; immediate, bone		5		5		5		2		....
"Draw slate"		....		....		....		....		4
Bone		1		2		....		....		....
Coal		6		4		3		4½		6
Shale		....		½		....		½		....
"Sulphur"		....		....		½		....		....
Bone		1		....		....		....		1
Coal	2	½		11	1	1	1	9	1	10½
"Sulphur"		½		⅛		½		1/16		½
Coal		3	2	5	1	1	1	3½		10
"Sulphur"		1/16		....		½		....		½
Shale		....		½		....		⅛		....
Coal		5½		3	1	2½		4		2½
"Sulphur"		½		....		....		....		....
Coal		2		....		....		....		....
Floor, shale.										
Thickness of bed	3	7 1/16	4	1⅝	3	8½	3	9 11/16	3	6½
Thickness of coal sampled	3	7 1/16	4	1⅝	3	8½	3	9 11/16	3	6½

Section A (sample 69591) was cut at face of 28 room, 8 left entry, 10 feet from entry. Section B (sample 69593) was cut at face of main heading. Section C (sample 69594) was cut at face of 18 room, 8 right entry, 15 feet from entry. Section D (sample 69678) was cut at face of 38 room, 6 left entry, 10 feet from entry. Section E (sample 69592) was cut at face of 31 room, 6 right entry, 150 feet from entry.

System of mining, room and pillar. In 1918 the coal was cut by machine in bottom coal and shot down with black powder and squibs by the miners at any time during the shift. Men employed numbered 180 underground and 25 aboveground. The coal was dumped over a wooden tipple, all being loaded and shipped as run of mine. Three pickers were employed on the railroad cars. The coal was shipped to Pennsylvania, New York, and the New England States and used for steam and domestic purposes. At time of sampling the capacity of the mine was 1,500 tons a day, and the average daily output was 1,200 tons. The output for the year 1917 was 360,000 tons. An increase in tonnage to 2,000 tons a day was anticipated.

CAIRNBROOK. SCALP LEVEL No. 3 MINE.

Analyses 69595 to 69598, average of mine-face samples (p. 71). Semibituminous coal, Somerset field, from Scalp Level No. 3 mine, a drift mine 2½ miles west of Cairnbrook, on the Pennsylvania R. R. Coal bed, Lower Kittanning, known as B, or Miller; Carboniferous age, Allegheny formation. Bed is 3 feet 2 inches to 3 feet 8 inches thick; dip, 3 per cent west; roof, shale, good above top coal; floor, smooth, hard fire clay. The bed was sampled by B. W. Dyer on June 25, 1918, as shown below:

Sections of coal bed in Scalp Level No. 3 mine.

Section	A.		B.		C.		D.	
Laboratory No.	69598		69597		69595		69596	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal and bone	a 1	2	a 2	0	a 1	7½	a 1	10
Coal	2	5	1	7	1	3		6½
"Sulphur"		¼		¼		¼		
Coal		1½	1	1	1	11		
"Sulphur"		¼						
Coal		6						
"Sulphur"		½						
Coal		4						
Slate		½		¼		¼		½
Coal		4		9		11	2	9
"Sulphur"								¼
Coal								7
Floor, shale.								
Thickness of bed	5	0	5	5½	5	9	5	9¼
Thickness of coal sampled	3	10	3	5½	4	1½	3	11¼

a Not included in sample.

Section A (sample 69598) was taken in 6 room, 4 left entry. Section B (sample 69597) was taken in 12 room, 3 right, 30 feet from entry. Section C (sample 69595) was taken in 5 room, 3 left entry. Section D (sample 69596) was taken in right main heading.

System of mining, room and pillar. In 1918 the coal was cut by machine in the bottom coal and shot down with black powder and squibs by the miners at any time during the shift. Men employed numbered 80 underground and 10 aboveground. The coal was dumped over a wooden tipple, all being loaded and shipped as run of mine. Haulage was by two electric locomotives. The coal was not usually cleaned after it was loaded in the mine. There was one loading track, with capacity for 20 empty and 20 loaded railroad cars. Sixty-five per cent of the coal was taken out in the advance work, and a total recovery of 85 per cent was claimed. The unmined area consisted of 1,000 acres. The estimated lifetime of the mine was 20 years. The capacity of the mine was 600 tons a day, and the average daily production was 600 tons. The coal was shipped to tidewater for New York and New England to be used for steam and fuel purposes.

ELK LICK. BOYNTON NO. 9 MINE.

Analyses 71065 and 71066, mine samples, and analyses 71103 to 71106, car samples, run-of-mine coal (p. 72.) Semibituminous coal, Somerset field, from Boynton No. 9 mine, a drift mine 1 mile south of Elk Lick, on the Baltimore & Ohio R. R. Coal bed, known as D, or Lower Freeport; Carboniferous age, Allegheny formation. Thickness of bed is about 3 feet. The immediate roof consists of bone 1 foot 6 inches and the main roof and floor of slate. The mine was sampled by N. H. Snyder and H. A. Goodman on June 13, 1919, as described below:

Sections of coal bed in Boynton No. 9 mine.

Section	A.		B.	
Laboratory No.	71065		71066	
Roof, main, shale; immediate, bone.	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	10	2	2½
"Sulphur"				Trace.
Shale		a ½		a 1
Coal		2		2
"Sulphur"		a ¼		
Shale				a ½
Coal		3½		6¼
Floor, shale.				
Thickness of bed	4	10	4	6¼
Thickness of coal sampled	3	4	3	[illegible]

a Not included in sample.

Section A (sample 71065) was cut from 3 right, off main, 500 feet from opening. Section B (sample 71066) was cut from face of main heading, 500 feet from opening.

System of mining, room and pillar. In 1919 the coal was undercut by hand and shot down with black powder. The mine was in course of development and had a capacity of 50 tons a day; it was expected to increase this to 150 tons a day. There were 16 men employed underground and 2 men on the surface. The mine was not operating on day visited. The seam was covered by 1 foot 6 inches of bone which was being removed from the headings. Coal was shipped as run of mine; it is cleaned in the mine, no pickers being employed on the cars.

Car was selected at the tipple and shipped by N. H. Snyder June 13, 1919, which was sampled at the Government fuel yard, Washington, D. C., June 20, 1919, by R. J. Swingle. A 1,000-pound sample was collected by taking successive large shovelfuls of coal at intervals under the car as it was being dumped. Sample was crushed and quartered by mechanical crusher at the Bureau of Mines laboratory, Washington, D. C.

ELK LICK. BOYNTON SMOKELESS MINE.

Analysis 71067 (p. 72). Semibituminous coal, Somerset field, from Boynton Smokeless mine, a drift mine 2½ miles east of Elk Lick, on the Baltimore & Ohio R. R. Coal bed, Upper Kittanning, or C′; Carboniferous age, Allegheny formation. Bed is about 3 feet; main roof, shale; immediate roof, bone; floor, shale. The mine was sampled by N. H. Snyder and H. A. Goodman on June 13, 1919, as described below:

Section of coal bed in Boynton Smokeless mine.

	Ft.	in.
Roof, main, shale; immediate, bone.		
Coal	2	7½
Shale[a]		2
Coal		6½
Floor, shale.		
Thickness of bed	4	10
Thickness of coal sampled	3	4

Section A was cut from face of main heading, 200 feet from opening.

In 1919 the Boynton Smokeless mine was a new mine not yet in operation. A drift had been driven in about 200 feet and a tipple constructed near the opening. It was expected that operations would begin soon and that about 50 tons a day would be the output. The property contained about 200 acres. The seam was covered by 1 foot 6 inches of bone, which was being removed from the headings. Mining was to be done by hand and haulage by mule.

ELK LICK. CHAPMAN NO. 3 MINE.

Analyses 71063 and 71064, mine samples, and analyses 71107 to 71110, car samples (p. 72). Semibituminous coal, Windber field, from Chapman No. 3 mine, a drift mine 1 mile north-northwest of Elk Lick, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh or Big Vein; Carboniferous age, Monongahela formation. Bed is 6 feet to 7 feet 6 inches thick. The roof and floor are shale, which readily parts from the coal. The mine was sampled by N. H. Snyder and H. A. Goodman on June 13, 1919, as described below:

[a] Not included in sample.

Sections of coal bed in Chapman No. 3 mine.

Section	A.		B.	
Laboratory No.	71063		71064	
	Ft.	*in.*	*Ft.*	*in.*
Roof, shale.				
Coal	2	1½	2	9½
Shale		a ¼		a ¼
Coal	2	¾	1	7
"Sulphur"		1/16	....	
Shale	....			½
Coal		11	2	2
Shale		½	....	
Coal	1	0	....	
Floor, shale.				
Thickness of bed	6	2 1/16	6	7½
Thickness of coal sampled	6	2 1/16	6	7½

a Not included in sample.

Section A (sample 71063) was cut in 2 right, off main entry, 450 feet from opening. Section B (sample 71064) was cut in face of main heading, 3,900 feet from opening.

System of mining, room and pillar. In 1919 coal was undercut by hand and shot down with black powder. The capacity of the mine was 100 tons a day. There were 17 men employed underground and 4 on the surface. The haulage was by mules. The tipple was about a half mile from opening and coal was hauled by mules and dumped over straight dump. The coal was shipped as run of mine. Coal was cleaned in mine, no pickers being employed on the cars.

A car sample (laboratory Nos. 71107 to 71110) of 1,000 pounds was also collected from one loaded car selected at the mine and shipped by N. H. Snyder on June 13, 1919. The car was sampled at the Government fuel yard, Washington, D. C., by R. J. Swingle on June 20, 1919. The sample was crushed and quartered by mechanical crusher at the Bureau of Mines laboratory, Washington, D. C.

SEANOR. EUREKA NO. 39 MINE.

Analyses 68200, 68205, 68214, and 30161; also average of tipple samples 68183, 68188, 68194, and 68223 (p. 72). Semibituminous coal, Windber field, from Eureka No. 39 mine, a drift mine ½ mile south of Seanor station, on the Pennsylvania R. R. Coal bed, known as the Upper Kittanning, or C′, seam; Carboniferous age, Allegheny series. Bed is 3½ to 5 feet thick; roof, 2 feet of brown shale or sandstone; floor, hard, smooth underclay; cover at points of sampling, about 100 feet. Commercial samples were taken at the tipple by E. Stebinger in December, 1917. The bed was sampled by E. T. Hancock on December 17, 1917, as described below:

Sections of coal bed in Eureka No. 39 mine.

Section	A.		B.		C.	
Laboratory No.	68200		68205		68214	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone.						
Coal	3	7	3	11	3	9
Shale		a 2	....		....	
Floor, brown shale.						
Thickness of bed	3	9	3	11	3	9
Thickness of coal sampled	3	7	3	11	3	9

a Not included in sample.

Section A (sample 68200) was cut at face of 6 left entry, 9 left main. Section B (sample 68205) was cut at face of 11 right entry, 9 left main. Section C (sample 68214) was cut at face of 9 right entry, 9 left main.

The ultimate analysis of a composite sample made by combining face samples 68200, 68205, and 68214 is given under laboratory No. 30161.

In 1917 the coal from this mine was all shipped as run of mine, and storage bins were used. The appearance of the coal on cars was good, and the lumps were large. At time of sampling the capacity of the mine was 1,200 tons a day. Men employed numbered 270 underground.

TENNESSEE.

MORGAN COUNTY.

CATOOSA. FLAT ROCK NO. 3 MINE.

Analyses 29556 to 29559 (p. 73). Bituminous coal from Flat Rock No. 3 mine, a drift mine, about 3 miles from Nemo, the junction point of the Morgan & Fentress R. R. with the Southern system. Coal bed is locally called the Catoosa seam; Carboniferous age, Lee (?) formation. Thickness of bed varies, the average workable thickness being about 33 inches; the seam is irregular, with no partings. The roof is shale of excellent quality and the floor hard fire clay. Cover at points of sampling, about 100 feet. The bed was sampled by J. M. Webb on January 7, 1918, the sample representing 2 feet to 2 feet 9 inches of coal, the total thickness of the bed.

Section A (sample 29556) was cut at face of 4 cross entry, 1 right main. Section B (sample 29557) was cut in 1 cross entry, 3 right main, 700 feet northeast. Section C (sample 29558) was cut at face of main north, 950 feet north.

The ultimate analysis of a composite sample made by combining face samples 29556, 29557, and 29558 is given under laboratory No. 29559.

System of mining, room and pillar. The mine is irregularly laid out, the maintenance of grade on entries and the avoidance of barren areas being the chief consideration. At the time of sampling the coal was shot with permissible explosives, which had just been introduced exclusively; black powder had been previously used. Men employed numbered 40 underground and 6 aboveground. The tipple was of wood. The entire output was shipped as run of mine. Haulage was by mules. There was one loading track, with capacity for 6 empty and 5 loaded railroad cars. The coal on the cars was bright. It was used mainly for steam purposes. In 1918 the estimated lifetime of the mine was 3 years. The daily output at time of sampling was 175 tons.

TEXAS.

WEBB COUNTY.

DOLORES. DOLORES MINE.

Analyses 29021, 29022 (p. 73). Cannel coal, Santo Tomas field, from Dolores mine at Dolores, 23 miles northwest of Laredo. Coal beds, Santo Tomas and San Pedro; Eocene age, Carrizo formation. Roof of Santo Tomas bed, clay and shale, very poor; floor, clay. Roof of San Pedro bed, joint clay; floor, poor, clay. The beds were sampled on August 7, 1917, by G. H. Ashley, as described below:

Section of Santo Tomas coal bed in Dolores mine.

	Ft.	in.
Roof, clay and shale.		
Sandstone		[a] 10
Shale [a]	1	0
Coal, bony [a]		6
Shale [a]	4	0
Coal	2	4
Bone		2

[a] Not included in sample.

	Ft.	in.
Floor, clay.		
Thickness of bed	2	6
Thickness of coal sampled	2	6

The section was measured in 20 room, north entry, 800 feet north 60° east from shaft (110 feet deep).

Section of San Pedro coal bed in Dolores mine.

	Ft.	in.
Roof, joint clay.		
Sandstone [a]	10	0
Sandstone and shale interbedded [a]	2	0
Clay jointed [a]	2	0
Coal	1	10
Floor, clay.		
Clay [a]	4	0
Coal, bony [a]	1	6
Thickness of bed	1	10
Thickness of coal sampled	1	10

The section was measured at face of I entry, 1,000 feet due west of shaft.

BETWEEN DOLORES AND DARWIN. HUNT MINE.

Analysis 29023 (p. 73). Cannel coal, Santo Tomas field, from Hunt mine, between Dolores and Darwin. Coal bed, Santo Tomas; Eocene age, Carrizo formation. Roof, sandstone 2 to 3 inches, over clay; floor, clay. The bed was sampled on August 7, 1917, by G. H. Ashley, as described below:

Section of coal bed in Hunt mine.

	Ft.	in.
Roof, sandstone.		
Coal [a]		10
Clay, shaly [a]	1	2
Coal	2	2
Floor, clay.		
Thickness of bed	4	2
Thickness of coal sampled	2	2

The section was measured 30 feet from mine mouth and the sample was taken to study the effect of weathering.

SANTO TOMAS. SANTO TOMAS MINE.

Analysis 29024 (p. 73). Cannel coal, Santo Tomas field, from Santo Tomas mine, 27½ miles northwest of Laredo. Coal bed, Santo Tomas; Eocene age, Carrizo formation. Roof, clay, very poor; floor, clay, poor. The bed was sampled on August 10, 1917, by G. H. Ashley, as described below:

Section of coal bed in Santo Tomas mine.

	Ft.	in.
Roof, clay.		
Coal	1	3
Bone		2
Coal	1	3
Bone [a]		5
Floor, clay.		
Thickness of bed	3	1
Thickness of coal sampled	2	8

The section was measured at breakthrough between rooms 118 and 119, 2,800 feet from shaft (165 feet deep).

[a] Not included in sample.

VIRGINIA.

LEE COUNTY.

Pockett. Reed Creek Mine.

Analyses 29684 to 29686 (p. 73). Bituminous coal, Black Mountain field, from Reed Creek mine, a drift mine, 2 miles east of Pockett, on the Southern R. R. Coal bed, not known; Carboniferous age, Pottsville group. Bed is about 3 feet thick; coal is very hard, with a 4-inch seam of hard, gray splint coal about 6 inches from the bottom; roof, very good, gray shale; floor, about 1 inch of soft "soapstone" overlying bottom coal; cover at point of sampling, 250 feet. The bed was sampled by J. Henson on January 14, 1918, as described below:

Sections of coal bed in Reed Creek mine.

Section	A.		B.	
Laboratory No.	29684		29685	
	Ft.	*in.*	*Ft.*	*in.*
Roof, gray shale.				
Coal, hard	2	0	2	0
Coal, gray splint		4½		4½
Coal, soft		6		6
Floor, soft "soapstone."				
Thickness of bed	2	10½	2	10½
Thickness of coal sampled	2	10½	2	10½

Section A (sample 29684) was taken from face of 1 slant, 560 feet north 25° east. Section B (sample 29685) was taken from face of 3 slant, north 85° east from opening.

An ultimate analysis of a composite sample made by combining face samples 29684 and 29685 is given under laboratory No. 29686.

The mine is rated as nongaseous by the State mine inspector and is worked on the room and pillar system. In 1918 the shooting was done on the solid by drilling six or seven holes across the face, loading with from 30 to 45 inches of FFF black blasting powder, tamping with "bug dust," and firing with fuse. No undercutting was done. Haulage was by mules. The daily output of the mine at the time of sampling was 50.

MONTGOMERY COUNTY.

Blacksburg. Slusser Mine.

Analyses 30689 to 30691 (p. 74). Semibituminous coal, Brushy Mountain field, from Slusser mine, a slope mine 3½ miles north of Blacksburg; no railroad connection. Coal bed, "Big"; Lower Carboniferous age, Price sandstone.

The bed was sampled on May 23, 1918, by M. R. Campbell and R. W. Howell, as follows:

Sections of coal bed in Slusser mine.

Section	A.		B.	
Laboratory No.	30689		30690	
	Ft.	*in.*	*Ft.*	*in.*
Roof, not noted.				
Coal	....	....	1	½
Bone	....	....		a 1½
Coal	....	....	1	½
Bone	....	....		a 1½
Coal		11¼		6½
Shale		a 8¾	a 1	2½
Coal		6½		9
Bone		a 2¼	....	....
Coal		11	....	....
Bone		a 3¼	....	....
Coal	1	1	....	....
Floor, not noted.				
Thickness of bed	4	8	4	10
Thickness sampled	3	5¾	3	4½

a Not included in sample.

Section A (sample 30689) was cut at point 220 feet down slope and 100 feet northeast of slope on level. Section B (sample 30690) was cut at point 225 feet down slope and 200 feet southwest of slope on level.

The ultimate analysis of a composite sample made by combining samples 30689 and 30690 is shown under laboratory No. 30691.

Merrimac Mines. Merrimac Mine.

Analyses and 30692 and 30797 (p. 74). Semianthracite coal from Merrimac mine of Merrimac Anthracite Coal Corporation, a slope mine at Merrimac Mines, a station on branch lines of both the Norfolk & Western and the Virginian Railroads. Coal bed, "Big"; Lower Carboniferous age, Price sandstone. The bed was sampled on May 13, 1918, by M. R. Campbell and R. W. Howell as follows:

Sections of coal bed in Merrimac mine.

	Ft.	in.
Roof, not noted.		
Coal		9½
Shale [a]		5
Coal	2	2
Shale [a]		2
Coal	2	0
Floor, not noted.		
Thickness of bed	5	6½
Thickness of coal sampled	4	11½

Section A (sample 30692) was cut on fourth level, 2,150 feet west of slope. This level is 600 feet from mine mouth on 20° dip. When sampled the mine had just been unwatered after having stood idle for 10 years. Section B (sample 30697) was a sample from railroad car of so-called "sand coal" from Merrimac mine.

Merrimac Mines. Prospect.

Analysis 30693 (p. 74). Semianthracite coal from prospect at Merrimac Mines. Coal bed known as "Little" bed; Carboniferous (Mississippian) age, Price sandstone. "Little" bed lies about 100 feet below "Big" bed. The bed was sampled on May 23, 1918, by M. R. Campbell and R. W. Howell. Sample represented coal bed 1 foot 9 inches thick, and was cut in prospect drift 20 feet from mouth of drift. Coal was weathered.

PULASKI COUNTY.

Gunton Park. Summit Mine.

Analysis 30696 (p. 74). Semianthracite coal from mine of Summit Coal & Iron Co., a slope mine at Gunton Park, on the Norfolk & Western Ry. Coal bed, "Upper"; Carboniferous (Mississippian) age; Price sandstone. Sampled on May 25, 1918, by M. R. Campbell and R. W. Howell, as described below:

Section of coal bed in Summit Coal & Iron Co. mine.

	Ft.	in.
Roof, not noted.		
Coal, bony [a]	2	2
Coal		5½
Shale [a]		3
Coal		5½
Shale [a]		1
Coal		6
Shale		2

[a] Not included in sample.

	Ft.	in.
Roof, not noted—Continued.		
Coal, sampled [a]	1	4
Shale [a]		½
Coal	1	6¼
Floor, not noted.		
Thickness of bed	6	11¾
Thickness of coal sampled	4	3¼

The sample was cut in room west of slope, 250 feet from mine mouth.

Parrott. Parrott Mine.

Analysis 30694 (p. 74). Semibituminous coal from Parrott mine of Pulaski Anthracite Coal Co., a slope mine at Parrott, on the Norfolk & Western R. R. Coal bed, "Big"; Carboniferous (Mississippian) age; Price sandstone. Bed dips about 20°. The bed was sampled on May 24, 1918, by M. R. Campbell and R. W. Howell, as described below:

Section of coal bed in Parrott mine.

	Ft.	in.
Roof, not noted.		
Coal	1	¾
Shale [a]		3¼
Coal		2¾
Bone [a]		2
Coal		3½
Bone [a]		2
Coal		7
Bone [a]		5¼
Coal	1	6½
Bone [a]		3¼
Coal		8¼
Bone [a]		1¼
Coal		5
Bone [a]		½
Coal		4¾
Floor, not noted.		
Thickness of bed	6	8
Thickness of coal sampled	5	2½

The sample was cut 150 feet west of slope and on level 2,750 feet from mine mouth.

Pulaski. Langhorne Mine.

Analysis 30695 (p. 74). Semianthracite coal from mine of D. G. Langhorne, 5 miles northeast of Pulaski, in Brushy Mountain field, a drift mine; no railroad connection. Coal bed, "Little"; Carboniferous (Mississippian) age; Price sandstone. The bed was sampled on May 25, 1918, by M. R. Campbell and R. W. Howell, as described below:

Section of coal bed in Langhorne mine.

	Ft.	in.
Coal	1	9
Shale [a]		1½
Coal	2	7
Coal, soft		10
Thickness of bed	5	3½
Thickness of coal sampled	5	2

The sample was cut at face of main left entry, 250 feet from tunnel, which is 25 feet long.

[a] Not included in sample.

RUSSELL COUNTY.

Dante. Clinchfield No. 2 Mine.

Analyses 32168 to 32172 (p. 75). Bituminous coal, Clinchfield (?) field, from Clinchfield No. 2 mine, at Dante, on the Carolina, Clinchfield & Ohio R. R. Coal bed, Upper Banner; Carboniferous age, Norton formation. Roof, shale; floor, clay or shale. The bed was sampled by A. W. Giles and C. K. Wentworth on June 16, 1919, as described below:

Sections of coal bed in Clinchfield Coal Corp. No. 2 mine.

Section	A.		B.		C.		D.	
Laboratory No.	32168		32169		32170		32171	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	7½		1½	1		1	6
Sandstone		[a] 1						[a] 1½
Shale				[a] 1		[a] 2		
Coal	1	6	1	5		2	1	4
Sandstone				[a] 2				
Shale		[a] 1				[a] 5		
Coal			1	5	1	4		
Sandstone						[a] 1-2		
Coal					1	2		
Clay						[a] 1		[a] 1
Coal						5		
Shale				[a] 1½		[a] 1-2		
Coal		3		3	1	8		
Shale		[a] 1		[a] 1		[a] 1		
Coal	2		2		1	9	2	5
Floor, clay and shale.								
Thickness of bed	5	7½	5	8	7	7	5	5½
Thickness of coal sampled	5	4½	5	2½	6	7	5	3

[a] Not included in sample.

Section A (sample 32168) was measured in 10 right entry, 200 feet off main entry. Section B (sample 32169) was measured in 4 left, near 20 room, off main entry. Section C (sample 32170) was measured in 3 left air course, near 15 room, off 7 right entry. Section D (sample 32171) was measured at 39 room, right cross 4.

The ultimate analysis of a composite sample made by combining free samples 32168, 32169, 32170, and 32171 is given under laboratory No. 32172. At time of sampling the output was 2,000 tons a day.

TAZEWELL COUNTY.

Bandy. Christian Mine.

Analysis 25913 (p. 75). Bituminous coal, southwest Virginia field, from Christian mine, 1 mile west of Bandy and Norfolk & Western R. R. Coal bed, Middle Seaboard; Carboniferous age, Lee formation. Roof, clay; floor, clay. The coal was sampled on August 28, 1916, by T. K. Harnsberger, as described below:

Section of coal bed in Christian mine.

	Ft.	in.
Roof, clay.		
Coal	1	1½
Clay [a]		1
Coal		9
"Rash" [a]		10
Coal	1	2
Floor, clay.		
Thickness of bed	3	11½
Thickness of coal sampled	3	½

The section was measured at face of main entry, 250 feet south, 25° west of mine mouth.

[a] Not included in sample.

Bandy. Patrick Mine.

Analysis 25912 (p. 75). Bituminous coal, southwest Virginia field, from Patrick mine, 1½ miles west of Bandy and Norfolk & Western R. R. Coal bed, Lower Seaboard; Carboniferous age, Lee formation. Roof, shale; floor, clay. The coal was sampled on August 28, 1916, by T. K. Harnsberger, as described below:

Section of coal bed in Patrick mine.

	Ft.	in.
Roof, shale.		
"Rash"[a]		8
Coal	1	0
"Mother coal"		¼
Coal		1½
Clay, hard[a]		2
Coal	1	5
"Mother coal"		¼
Coal		1
Clay, hard[a]		3
"Rash"[a]		1½
Floor, clay.		
Thickness of bed	3	10½
Thickness of coal sampled	2	8

The section was measured at face of main entry, 100 feet west of mine mouth.

Big Vein. Big Vein Nos. 1 and 2 Mines.

Analyses from No. 1 mine, 67886, 67889, 67902, 67934, 67951, 29908, and car sample 69458 and 69459, and analyses from No. 2 mine, 67927, 67964, 29909, and car samples 69326 and 69327 (p. 75). Semibituminous coal, Pocahontas field, from Big Vein Nos. 1 and 2 mines, slope and shaft mines at Big Vein, 1 mile south of Pocahontas, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville series. Bed is 8 to 16 feet, averaging 10 feet. Fault is encountered at eastern boundary of mine only; no rolls or horsebacks. Vertical depth to landing below entrance, about 60 and 20 feet, respectively. Roof, shale; floor, 2 feet of coal, then shale. Car samples from No. 1 mine were collected at tidewater by H. W. Jarrett on December 1, 1917, and June 17, 1918. Car samples from No. 2 mine were collected at tidewater by E. L. Wallace on April 10 to June 6, 1918. The mines were sampled at two points in No. 1 mine and four points in No. 2 mine by J. J. Bourquin and C. A. Allen on December 18, 1917, as described below:

Sections of coal bed in Big Vein Nos. 1 and 2 mines.

Mine	No. 1.		No. 1.		No. 2.		No. 2.		No. 1.		No. 2.	
Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	67889, 67902		67934, 67886		67964		67927		67951			
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	8½	1	5	1	0	1	9	[a]2	0	1	7
Gray coal with "sulphur"		1½		1½	....	....		[a]4	....	....	....	....
"Sulphur" band	....	....	....	....		2	....	....		1½		2
Coal		10½	1	11	2	5	1	1	2	0	2	3
Coal, gray and bony		1		1½		1½		[a]1		2		3
Coal		1	1	1		4	5	2		3	1	2
Bone		2		[a]3		2	....	....		2		3
Coal		1	3	0		2	....	....		4	4	0
Bony coal		2	....	....		2	[a]1	6		2		2
Coal		6	....	....	3	5	....	....		6	1	2
Bone		[a]2½	....	....		2½	....	....		4	....	....
Coal	3	0	....	....	1	6	....	....	3	2	....	....
Floor, shale.												
Thickness of bed	7	0	7	11	9	8	9	11	9	2½	11	0
Thickness of coal sampled	6	9½	7	8	9	8	8	0	7	2½	11	0

[a] Not included in sample.

Section A (samples 67886 and 67902) was cut in 1 room, Balls Hole entry. Section B (samples 67934 and 67889) was cut in 4 room, Cartersville entry. Section C (sample 67964) was cut in 1 room, 5 right, 75 feet from face. Section D (sample 67927) was cut at face of 2 right, main entry. Section E (sample 67951) was cut from split in pillar, dip heading, 60 feet from face. Section F was cut near 3 room, main, 8 left.

The ultimate analysis of a composite sample made by combining face samples 67886, 67889, 67902, 67951, and 67934 from Big Vein No. 1 mine is given under laboratory No. 29908. The ultimate analysis of a composite sample made by combining face samples 67927 and 67964 from Big Vein No. 2 mine is given under laboratory No. 29909.

System of mining, room and pillar. In December, 1917, the undercutting was done by blasting and the top coal was then shot down. Black powder was used. The capacity of No. 1 mine was about 150 tons a day and No. 2 mine, 350 tons; the average daily shipments were about the same. Both mines were working mostly on pillars. The estimated lifetime of the mines was 5 to 7 years. Haulage was by mules and electric motors; there were two 10-ton and four gathering motors. No. 1 mine shipped all its coal as run of mine. The tipple was only a chute, and the mine cars dumped directly into railroad cars. Top men picked out some of the bone. The mine was old and had been worked irregularly, but was producing good coal. No. 2 mine screened most of its coal with bar screens, having 3 by 6 inch holes and small screens having 1½ by 2½ and 1 by ½ inch holes. The lumps were large. There were four loading tracks at No. 2 mine and one at No. 1 mine, with capacity for 35 loaded and 40 empty cars. Mine No. 2 also has irregular workings. The cars were dumped by rotary dump into a steel conveyor. None of the bone was picked out. Considerable floor coal was left in order to get proper grade or to keep out of water.

Boissevain. (Boissevain Mine.)

Analyses 67887, 67888, 67892, 67899, 67900, 67901, 67903, 67904, 67922, 67923, 67925, 67957, 67960, 67971, and 29907, (p. 75). Semibituminous coal, Pocahontas field, from Boissevain mine, a shaft mine at Boissevain on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pocahontas formation, Pottsville group. Bed is 8 to 11 feet thick; dip, 1° to 6° north, 70° west, with a valley. There are a few faults near the shaft. Roof, shale; 12 to 24 inches of top coal is left up during advance work. There is a cap rock of sandstone. Floor, shaly clay, with a smooth surface. Depth of shaft 180 feet. The bed was sampled by J. W. Paul, C. A. Allen, and J. J. Bourquin on December 17, 1917, as described below:

Sections of coal bed in Boissevain mine.

Section	A.		B.		C.		D.		E.		F.		G.	
Laboratory No.	67888 67901		67903 67887		67899 67904		67900 67892		67960 67922		67923 67925		67957 67971	
Roof, shale and coal.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Shale		[a]1	...	...	...	...	...	...	...	...	...	...	...	...
Top coal	...	...	...	...	...	...	...	...	[a]2	0	[a]2	6	...	...
Coal	1	0	1	4		11		11		11		4½	2	0
"Sulphur" band		[a]2		[a]1½		[a]1		1	...	...	...	...	...	...
Bone	...	...	...	...	...	...	...	...		3		1		3
Coal	2	2	1	½	2	10	1	1½		7		5		7
Bone		2		1		[a]2		8½		2		2		7
Coal	1	8	1	9½	3	6		7	2	2		6	2	10
Bony coal		3		[a]3		[a]2		[a]3½		3		2		3
Coal	1	6	3	3	2	6	3	3	2	4	2	5	2	7
Bone		[a]3		[a]4	...	...		[a]3	...	...		5	...	...
Coal	2	2	2	1½	...	...	1	9	...	...	2	2½	...	...
Floor, fire clay.														
Thickness of bed	9	5	10	4	10	2	9	2½	8	8	9	3	9	1
Thickness of coal sampled	8	11	9	7½	9	10	8	7	6	8	6	9	9	1

[a] Not included in sample.

Section A (samples 67888 and 67901) was cut at face of 12 room, C-2 panel, off 5 east. Section B (samples 67903 and 67887) was cut at face of 9 room, A-1 panel, off 5 east. Section C (samples 67899 and 67904) was cut at face of 10 room, H-23, off C-4 entry. Section D (samples 67900 and 67892) was cut near face of main H-22 entry. Section E (samples 67960 and 67922) was cut 50 feet from face of 14 triple entry No. 1. Section F (samples 67923 and 67925) was cut 15 feet from face of 1 room, I-17 entry. Section G (samples 67957 and 67971) was cut on left rib 30 feet from face of J-3 air course.

The ultimate analysis of a composite sample, formed by combining face samples 67887, 67888, 67892, 67899, 67900, 67901, 67903, 67904, 67922, 67923, 67925, 67957, 67960, and 67971 is given under laboratory No. 29907.

System of mining, room and pillar, in panel. In 1917 the coal was undercut by machine in the coal just below the bone and was shot down by 6X black powder. Permissible explosives were used in brushing roof and floor. The shots were fired during shift by the miners. About 300 men were employed underground. Electric locomotives were used for haulage; 10-ton locomotives were used on the main entry and 6-ton cable locomotives for gathering. The steel tipple was provided with conveyor tables, shaking screens, a bone crusher, picking tables, and loading booms. The bone was crushed and reassembled with the other picked coal in the railroad car or loaded with the screenings. Minimum breakage of coal and high efficiency in cleaning should result from the use of the improved facilities of the tipple which had just been completed. About 25 per cent of the coal was mined in advance work. Room pillars were pulled as promptly as possible. They were cut through with 12-foot entries, leaving a 10-foot stump, which was then pulled. The capacity of the mine was about 2,500 tons a day, but at time of sampling the shipments averaged 1,200 to 1,500 tons a day.

For description and analyses of other samples of coal from this mine see Bureau of Mines Bull. 22, pp. 198, 824.

FARADAY. ALTIZER MINE.

Analysis 26101 (p. 76). Semibituminous coal, Pocahontas field, from Altizer mine, ½ mile north of Faraday, flag station on the Norfolk & Western R. R. Coal bed, Pocahontas No. 5; Carboniferous age, Lee formation. Roof, shale; floor, clay. The bed was sampled on September 16, 1916, by T. K. Harnsberger. The section was measured 110 feet north of mine mouth and represented 6 feet 7 inches of coal.

JEWELL. JEWELL RIDGE NO. 1 MINE.

Analyses 25651 to 25653 (p. 76). Bituminous coal, southwest Virginia field, from Jewell Ridge No. 1 mine, at Jewell, on the Norfolk & Western R. R. Coal bed, Raven; Carboniferous age, Norton formation. Roof, hard clay, floor, sandstone. The coal was sampled on July 22, 1916, by T. K. Harnsberger, as described below:

Section of coal bed in Jewell Ridge No. 1 mine.

Section	A.		B.	
Laboratory No.	25651		25652	
Roof, hard clay.	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	8	2	6
"Rash"		[a] 4		[a] 1
Clay, hard		[a] 2		
Coal		10		4
"Rash"				[a] 1
Clay, hard				[a] 2
"Rash"				[a] 2
Coal			1	½
Floor, sandstone.				
Thickness of bed	4	0	4	4½
Thickness of coal sampled	3	6	3	10½

[a] Not included in sample.

Section A (sample 25651) was measured in 2 right entry, off main entry, 1,900 feet north 60° east of mine mouth. Section B (sample 25652) was measured in 6 main entry, 3,700 feet northeast of mine mouth.

The ultimate analysis of a composite sample made by mixing samples 25651 and 25652 is given under laboratory No. 25653.

POCAHONTAS. WEST POCAHONTAS MINE.

Analyses 67910, 67954, 67958, 67953, and 29912, also car sample 30264 (p. 76). Semi-bituminous coal, Pocahontas field, from West Pocahontas mine, a drift mine at Pocahontas, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3, Carboniferous age, Pottsville group. No cleat, faults, rolls, or horsebacks. Bed is 8 to 11 feet thick, averaging 9 feet. The mine works a high bed of coal. The roof mixes but little with the coal. Roof, 1½ feet or more of shale; floor, soft shale, with smooth surface. Commercial samples were taken at tidewater by N. H. Snyder on February 20 and March 5, 1918. The bed was sampled by C. A. Allen on December 19, 1917, as described below:

Sections of coal bed in West Pocahontas mine.

Section	A.		B.		C.	
Laboratory No	67958		67953		67910, 67954	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal	[a]1	0	1	2	1	0
"Sulphur" band		[a]1		[a]1		[a]1
Coal	2	1	1	4	2	6
Bone		[a]2		2		[a]3
Coal		9		5		5
Bone		[a]3		2	....	
Coal		4		3	....	
Bone		[a]2		[a]4½		[a]3
Coal	2	5½	2	6	4	0
Bone		½		[a]1½	....	
Coal	2	3	2	5	....	
Floor, shale.						
Thickness of bed	9	7	9	0	8	6
Thickness of coal sampled	7	11	8	5	7	11

[a] Not included in sample. [b] Roof coal, to be mined later.

Section A (sample 67958) was cut at face of 7 room, 11 right, Norton district. Section B (sample 67953) was cut at face of 18 room, 34 heading, Newport News district. Section C (samples 67910 and 67954) was cut at face of 30 room, St. Paul entry, off 10 entry.

The ultimate analysis of a composite sample made by combining face samples 67958, 67953, 67910, and 67954 is given under laboratory No. 29912.

System of mining, room and pillar. In 1917 the coal was undercut by machine in the coal and shot down with black powder by the miners during shift. Very little brushing was required. Men employed undeground numbered 290. The haulage was by electric and steam locomotives. There were eleven 6-ton gathering motors, one 10-ton motor, and five 25-ton steam locomotives. About 30 per cent of the coal was taken out in advance work; the percentage of recovery was high. There were still several thousand acres to be mined, and the estimated lifetime of the mine was from 30 to 50 years. Most of the tonnage was to be derived from pillar work. The coal was all shipped as run of mine. By screening, 30 per cent lump may be obtained. There were three bar screens 9 by 8 feet with 4-inch spaces and one length with 5-inch spaces; the small screens had 1½ and ½ inch openings. The coal was picked on railroad cars by 12 pickers on two cars. The pickers remove 15 or 20 tons of refuse matter daily. The efficiency of the pickers was low, so that only a small part of the bone was removed from the coal. The impurity in the coal consisted of bony coal and gray coal with "sulphur." Storage bin capacity was small. There were three loading tracks for screened coal and two for run of mine, with capacity for 100 empty and 100 loaded railway cars. The lumps were large and had a good appearance. Capacity of mine, 2,000 tons a day; average daily shipments at time of sampling, 1,500 to 2,000 tons; maximum day's run, 4,800 tons.

The mine was sampled in 1909. For description of the bed and analyses of other samples see Bureau of Mines Bull. 22, pp. 200, 827.

POCAHONTAS. BABY MINE.

Analyses 67921, 67924, 67926, and 29906 (p. 77). Semibituminous coal, Pocahontas field, from Baby mine, a slope mine, ½ miles west of Pocahontas, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pocahontas formation. Thickness of seam is 9 to 11 feet, with a slight dip to the southwest; roof, hard, gray shale about 8 feet thick, above which is sandstone. In the greater part of the mine some coal is left up for roof. Floor, soft underclay with smooth surface. The coal separates readily from the roof and floor, but some particles of roof become mixed with the coal. The bed was sampled by J. W. Paul and J. J. Bourquin on December 13, 1917, as described below:

Sections of coal bed in Baby mine.

Section	A.		B.		C.	
Laboratory No.	67921		67924		67926	
Roof, shale and top coal.	Ft.	in.	Ft.	in.	Ft.	in.
Coal	[a] 4	1	2	4	[a] 3	9
Bone		1		3		2
Coal		3		9		4
Bone		3		4		2
Coal	3	1	5	10	5	6
Bone		3	......		......	
Coal	2	2	......		......	
Floor, shale.						
Thickness of bed	10	2	9	6	9	11
Thickness of coal	8	8	9	6	8	5

[a] Upper 1½ feet of coal left up temporarily as roof.

Section A (sample 67921) was cut at face of 19 room, 16 cross entry. Section B (sample 67924) was cut 75 feet from face of 7 room, 4 sump entry. Section C (sample 67926) was cut at face of 36 room, West Gurden entry.

The ultimate analysis of a composite sample made by combining face samples 67921, 67924, and 67926 is given under laboratory No. 29906.

System of mining, room and pillar. In 1917 the coal was undercut by breast machines and shot down by FFF black powder. Men employed numbered 100 underground and 14 on the surface. There were nine gathering electric motors and three main haulage motors. The tipple and bins were steel. Foundations were ready for a new steel tipple with picking tables and loading boom to handle the coal from Baby and West mines. The coal was coming half from advance work and half from pillars; it was screened through 5 and 2½ inch openings; all under 2½-inch size was sent to the bins. The screenings were coked, 900 tons of coke a day being produced in 150 ovens. The bins had storage capacity of 2,000 to 2,500 tons. The coal was picked as it was loaded into the railroad cars by four to six slate pickers. There were three loading tracks, with capacity for 100 empty and 100 loaded railroad cars. The capacity of the mine was 2,500 tons a day, and the average shipments were 1,200 to 1,500 tons a day. This mine is closely connected with the Boissevain and West Pocahontas mines.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 199, 825.

RED ASH. RAVEN RED ASH MINE.

Analyses 25630 to 25632 (p. 77). Bituminous coal, southwest Virginia field, from Raven Red Ash mine, at Red Ash, on the Norfolk & Western R. R. Coal bed, Raven; Carboniferous age, Pottsville group, Norton formation. Roof, hard clay; floor, hard clay. The coal was sampled on July 17, 1916, by T. K. Harnsberger, as described below:

Sections of coal bed in Raven Red Ash mine.

Section	A.	B.
Laboratory No.	25630	25631
	Ft. in.	*Ft. in.*
Roof, hard clay.		
"Rash"	a ½	....
Coal	1 10¼	3 1
"Mother coal"	¾	....
Coal	11½	....
Floor, hard clay.		
Thickness of bed	2 10½	3 1
Thickness of coal sampled	2 10½	3 1

a Not included in sample.

Section A (sample 25630) was measured at face of air course on 10 crossheading, 3,000 feet northeast of 1 drift mouth. Section B (sample 25631) was measured at face of air course to 3 main entry, 2,600 feet north of entrance to 3 drift.

The ultimate analysis of a composite sample made by mixing samples 25630 and 25631 is given under laboratory No. 25632.

RICHLANDS. EAST MINE.

Analyses 25763 to 25765 (p. 77). Bituminous coal, Russell Fork field, from East mine, 1½ miles west of Richlands, on a spur of the Norfolk & Western R. R. Coal bed, Tiller, known as "Little Town Hill;" Carboniferous age, Pottsville group, Norton formation. Roof, sandstone; floor, sandstone. The coal was sampled on August 4, 1916, by T. K. Harnsberger, as described below:

Sections of coal bed in East mine.

Section	A.	B.
Laboratory No.	25763	25764
	Ft. in.	*Ft. in.*
Roof, sandstone.		
Coal	4 4	11½
Bone	....	a 1½
Coal	....	2 10
Floor, sandstone.		
Thickness of bed	4 4	3 11
Thickness of coal sampled	4 4	3 9½

a Not included in sample.

Section A (sample 25763) was measured in 1 room, off main entry, 450 feet northeast of mine mouth. Section B (sample 25764) was measured at face of main entry, 400 feet north 30° east of mine mouth.

The ultimate analysis of a composite sample made by mixing samples 25763 and 25764 is given under laboratory No. 25765.

RICHLANDS. RICHLANDS NO. 2 MINE.

Analyses 31414 to 31416 (p. 77). Bituminous coal, Russell Fork field, from Richlands No. 2 mine, a small opening across the track from No. 4 mine. The drift opening was 5 feet wide at the bottom, 4 feet 7 inches wide at the top, and about 4 feet 10 inches high from the top of the rail. In 1919 only one entry was being driven, about 600 feet from the opening to the face of the entry. Four mine cars were used. Men employed numbered 10 inside the mine and 2 outside. Two men were employed to push the coal to the outside and dump it in a small bin with a capacity of about 10 tons. The coal is 22 inches high, and dips 40°. The bed was sampled by T. R. Williams on February 3, 1919, as described below:

Sections of coal bed in No. 2 mine.

	A.		B.	
Section	A.		B.	
Laboratory No.	31414		31415	
	Ft.	*in.*	*Ft.*	*in.*
Roof, shale.				
Roof brushing	[a] 2	0	[a] 2	6
Coal	2	3	1	11
Floor, shale.				
Thickness of bed	4	3	4	5
Thickness of coal sampled	2	3	1	11

[a] Not included in sample.

Section A (sample 31414) was cut 150 feet from face, 560 feet from drift opening. Section B (sample 31415) was cut at face, 600 feet from opening.

The ultimate analysis of a composite sample made by combining face samples 31414 and 31415 is given under laboratory No. 31416.

RICHLANDS. RICHLANDS NO. 4 MINE.

Analyses 31417 to 31419 (p. 77). Bituminous coal, Russell Fork field, from Richlands No. 4 mine, a drift mine, ½ mile northwest of Richlands, on the Big Creek branch of the Norfolk & Western R. R. Coal bed, Meadow; Carboniferous age, Pottsville group, Norton formation. Thickness of workable coal, 2 feet 10½ inches; dip, 40° north and south; impurities, a shell of shale overlying coal. Frequent rolls are encountered. From 1 to 2 feet of slate lies on top of the coal; above this is hard rock. Roof, rock, averaging about 2 feet in thickness; floor, sandstone; cover at point of sampling, 80 feet. The bed was sampled by T. R. Williams on Febraury 3, 1919, as described below:

Section of coal bed in Richlands No. 4 mine.

	Ft.	in.
Roof, rock.		
Shale [a]	1	½
Coal	2	0
Floor, sandstone.		
Thickness of bed	3	½
Thickness of coal sampled	2	0

Sample 31418 was cut 27 feet from face of main entry, 573 feet from drift opening.

A sample was taken by T. R. Williams on February 3, 1919, from a coal pile lying outside of the drift opening. The proximate analysis of this sample is given under laboratory No. 31417. The ultimate analysis of a composite sample made by combining samples 31417 and 31418 is given under laboratory No. 31419.

In February, 1919, the mine was being opened and only one entry, 600 feet long, had been driven. The coal was shot down with permissible explosive at any time by the miners. Three men were employed underground and eight aboveground. A tipple was being erected. The opening of the mine is 5 feet wide, 4½ feet high from the top of the rail; there was a 36-inch track gage, but no mine cars or hoisting or electric equipment had been installed. No coal was being loaded at time of sampling.

[a] Not included in sample.

Richlands. West Mine.

Analyses 25757 to 25759 (p. 77). Bituminous coal, southwest Virginia field, from West mine, 1½ miles west of Richlands, on a spur of the Norfolk & Western R. R. Coal bed, Jawbone, known as "Big Town Hill"; Carboniferous age, Norton formation. Roof, shale; floor, shale. The coal was sampled on August 4, 1916, T. K. Harnsberger, as described below:

Sections of coal bed in West mine.

Section	A.	B.
Laboratory No.	25757	25758
	Ft. in.	Ft. in.
Roof, shale.		
"Rash"	a1	a1
Coal	10	11
"Rash"	½	....
Bone	....	a1¼
Coal	5	1 9
Bone	a3½	a1
Coal	1 4½	4
Bone	a6	a3
Coal	1 4	8
Bone	a3½	....
Floor, shale.		
Thickness of bed	5 2	4 2¼
Thickness of coal sampled	4 0	3 8

a Not included in sample.

Section A (sample 25757) was measured at face of 9 entry, off 4 right entry, 1,700 feet north 45° west of mine mouth. Section B (sample 25758) was measured at face of 1 left entry, 1,400 feet west of mine mouth. The ultimate analysis of a composite sample made by mixing samples 25757 and 25758 is given under laboratory No. 25759.

Richlands. Wilson Mine.

Analyses 69806 to 69809 (p. 77). Bituminous coal, Pocahontas or Flat Top field, from Wilson mine, a drift mine 2 miles northwest of Richlands, near the Norfolk & Western R. R. Two coal beds lying almost flat, are worked; the upper, or Red Ash bed, is 5 feet 2 inches thick, without any noticeable partings or impurities, with sandstone top and fire-clay bottom, approximately 300 feet above the railroad track at the point where development was started the Town Hill bed, 225 feet below the Red Ash, is 4 feet 10 inches thick where sampled and is good coal, although not as clean as the Red Ash. Lenses of bony coal occur at about the middle of the seam, and near the bottom appears a band of soft dirty coal locally known as "rash." Cover at points of sampling, 50 to 100 feet. Each bed was sampled by C. A. Herbert, on July 26, 1919, as described below:

Sections of coal bed in Wilson mine.

Section	A.	B.
Laboratory No.	{ 69806 69807	69808 69809
	Ft. in.	Ft. in.
Roof, A, sandstone; B, shale and sandstone.		
Coal	5 2	1 5
Bony coal	....	3
Coal	....	2 2
Bone	....	a5
Coal	....	7
Floor, fire clay.		
Thickness of bed	5 2	4 10
Thickness of coal sampled	5 2	4 5

a Not included in sample.

Section A (samples 69806 and 69807) was cut at face of drift, 100 feet inby mouth drift. Section B (samples 69808 and 69809) was cut at face of drift, 500 feet from mouth of slope.

At the time of sampling the coal was shot off the solid with black powder. Considerable development was in progress in this field.

Richlands. Wysor Mine.

Analyses 69802 to 69805 (p. 78). Bituminous coal, Pocahontas or Flat Top field, from Wysor mine, a drift mine 1½ miles northeast of Richlands, on the Norfolk & Western R. R. There are two beds of coal, each about 3 feet in thickness; dip, 45° southeast. The beds crop out on the side of the mountain a short distance from the fault plane. In the upper bed at time of sampling a drift had been driven in approximately 500 feet; the coal was bright and fairly clean, with sandstone top and fire-clay bottom. In the lower bed a drift of approximately 800 feet had been driven; the bed was softer and more splinty and the coal clean except for the top 3 inches, which was soft and dirty, locally known as "rash"; above the coal was "draw slate" 7 to 12 inches, and above that sandstone; the bottom was fire clay; six thin "sulphur" streaks not over $\frac{1}{16}$ inch thick ran through the coal. The two seams were approximately 300 feet apart. Cover at points of sampling, 100 feet.

Each bed was sampled in a prospect drift by C. A. Herbert, on July 26, 1918, as described below:

Sections of coal bed in Wysor mine.

Section	A.		B.	
Laboratory No	69802, 69803		69808, 69809	
Roof, main, sandstone; immediate, "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*
"Rash"		3		
Coal	1	4	3	0
"Rash"		1		
Coal	1	8		
Floor, fire clay.				
Thickness of coal bed	3	4	3	0
Thickness of coal sampled	3	4	3	0

Section A (samples 69802 and 69803) and Section B (samples 69804 and 69805) were taken at face of heading.

Seaboard. Empire No. 6½ Mine.

Analyses 25760 to 25762 (p. 78). Bituminous coal, southwest Virginia field, from Empire No. 6½ mine, at Seaboard, on the Big C branch of the Norfolk & Western R. R. Coal bed, Upper Seaboard; Carboniferous age, Lee formation. Roof, shale; floor, shale. The coal was sampled on August 5, 1916, by T. K. Harnsberger, as described below:

Sections of coal bed in No. 6½ mine.

Section	A.		B.	
Laboratory No	25760		25761	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	5½	3	0
Bone		[a] 2½		
"Rash"				[a] ½
Floor, shale.				
Thickness of bed	2	8	3	½
Thickness of coal sampled	2	5½	3	0

[a] Not included in sample.

Section A (sample 25760) was measured at face of 3 right entry, 800 feet south of mine mouth. Section B (sample 25761) was measured at face of 2 left entry, 700 feet southeast of mine mouth.

The ultimate analysis of a composite sample made by mixing samples 25760 and 25761 is given under laboratory No. 25762.

WISE COUNTY.

JOSEPHINE. INTERMONT NO. 6 MINE.

Analyses 32067 to 32069 (p. 78). Bituminous coal, Black Mountain field, from Intermont No. 6 mine, opened by a drift at Josephine, 2½ miles west of Norton, on the Interstate R. R. Coal bed, Imboden; Carboniferous (Pottsville) age, Norton formation. Bed is 4 feet 8 inches thick; roof, shale and sandstone; floor, clay; cover at points of sampling, 200 feet. The bed was sampled by T. R. Williams on May 28, 1919, as described below:

Sections of Imboden coal bed in Intermont Coal and Iron Co. No. 6 mine.

Section	A.		B.	
Laboratory No.	32067		32068	
Roof, shale and sandstone.	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	6	1	3
Clay		2		2
Coal	3	0	3	1
Floor, clay.				
Thickness of bed	4	8	4	6
Thickness of coal sampled	4	8	4	6

Section A (sample 32067) was cut in 6 room, 50 feet from face, in the pillar between 5 and 6 rooms. Section B (sample 32068) was cut in 7 room, 20 feet through the pillar from fire, 1,700 feet from opening.

The ultimate analysis of a composite sample made by combining samples 32067 and 32068 is given under laboratory No. 32069.

System of mining, room and pillar. In 1919 the coal was shot down with 35 per cent dynamite. There were 20 men employed underground and 8 aboveground. The tipple was of wood. At the time of sampling 100 per cent of the output was derived from advance workings and all the output was shipped as run of mine. Haulage was by mules. There was one loading track, with capacity for five empty cars, and about ½ mile of switch track to main line. The appearance of the coal on the cars was very good. The estimated lifetime of the mine in 1919 was 4 years. The capacity of the mine was 80 tons a day, the maximum day's run being equal to the capacity.

WASHINGTON.

KITTITAS COUNTY.

ELLENSBURG. PROSPECT.

Analysis 26223 (p. 79). Bituminous coal from prospect of the North Manastash Coal Co., in NW. ¼ sec. 14, T. 18 N., R. 15 E., 25 miles northwest of Ellensburg. Coal bed, not named; Eocene age, Manashtash formation. The bed was sampled on September 29, 1916, by E. R. Lloyd, and at the point sampled was 3 feet 6 inches thick. The sample was cut 23 feet west of prospect mouth and represented entire thickness of the bed.

LEWIS COUNTY.

CENTRALIA. FORDS PRAIRIE MINE.

Analysis 29564 (p. 79). Subbituminous coal from Fords Prairie mine in NW. ¼ sec. 30, T. 15 N., R. 2 W., 3 miles north of Centralia. Coal bed, not named; Eocene age, Puget formation. The bed was sampled on September 12, 1917, by J. Daniels and H. E. Culver. The sample was cut in the main entry, near the last plane. The section was as follows:

Section of coal bed in Fords Prairie mine.

	Ft.	in.
Coal	2	7
Shale [a]		1
Coal	1	6½
Shale [a]		1½
Coal		9½
Shale [a]		¼
Coal	1	5
Shale [a]		¼
Coal		3½
Thickness of bed	6	10½
Thickness of coal sampled	6	7½

CENTRALIA. MONARCH MINE.

Analysis 29570 (p. 79). Subbituminous coal from Monarch mine, a slope mine, of Agnew Fuel Co., in NE. ¼ sec. 17, T. 14 N., R. 1 W., 6 miles east of Centralia. Coal bed, not named; Eocene age; Puget formation. The bed was sampled at face of slope on September 17, 1917, by J. Daniels and H. E. Culver. The sample represented 7 feet 6 inches of coal which was the thickness of the bed, excepting ¼ inch of shale about 1 foot below the top.

CHEHALIS. SUPERIOR MINE.

Analysis 29568 (p. 79). Subbituminous coal from Superior mine in W. ½ sec. 29, T. 14 N., R. 2 W., at Chehalis. Coal bed, Superior No. 2; Eocene age. Puget formation. Roof and floor not noted. The bed was sampled on September 14, 1917, by J. Daniels and H. E. Culver. Section at point of sampling was as follows:

Section of coal bed in Superior Coal Co. mine.

	Ft.	in.
Coal [a]	2	2
Coal	5	4
Shale [a]		1
Coal	1	4
Shale	1	1
Thickness of bed	10	0
Thickness of coal sampled	3	7

The sample was cut at face of entry, beyond chute 34.

CHEHALIS. SHELDON MINE.

Analysis 29569 (p. 79). Subbituminous coal from Sheldon mine in NE. ¼ sec. 33, T. 14 N., R. 2 W., 2 miles southeast of Chehalis. Coal bed, not named; Eocene age, Puget formation. Roof and floor not noted. The bed was sampled on September 14, 1917, by J. Daniels and H. E. Culver. The sample was cut at face of main entry and represented 5 feet 11 inches of coal. The section at point of sampling

[a] Not included in sample.

was 7 feet in thickness and carried 1 foot 1 inch of coal near the middle, that was not sampled.

Mendota. Mendota Mine.

Analysis 29565 (p. 79). Subbituminous coal from Mendota mine in E. ½ sec. 3, T. 14 N., R. 1 W., at Mendota. Coal bed, not named; Eocene age, Puget formation. The bed was sampled on September 12, 1917, by J. Daniels and H. E. Culver, as described below:

Sections of coal bed in Mendota Coal and Coke Co. mine.

	Ft.	in.
Roof, not noted.		
Coal	1	½
Shale		½
Coal	2	11½
Shale		½
Coal		2
Shale		½
Coal		7
Shale		¼
Coal	3	1
Floor, not noted.		
Thickness of bed	7	11¾
Thickness of coal sampled	7	10

Sample was cut at face of 5 north entry, 350 feet from mine mouth. The sample included the streaks of shale.

THURSTON COUNTY.

Tono. Hannaford Mine.

Analyses 29566 and 29567 (p. 79). Subbituminous coal from Hannaford mine, a slope mine in NW. ¼ sec. 21, T. 15 N., R. 1 W., at Tono. Coal bed, not named; Eocene age, Puget formation. Roof and floor not noted. Samples 29566 (upper bench) and 29567 (mining bench) were taken in 7 room, 2 entry, off 2 main slope, on September 13, 1917, by J. Daniels and H. E. Culver, as described below:

Section of coal bed in Hannaford mine.

	Ft.	in.
Upper bench.		
Coal		7½
Bone		½
Coal	1	10
Coal, bony	1	5
Mining bench.		
Coal	3	6
Shale [a]		1½
Coal	1	5
Shale [a]		2
Bone [a]		10
Shale [a]		1
Coal		11
Shale [a]		1
Coal	2	9
Shale [a]		½
Coal, sampled		8
Bone [a]		9
Thickness of bed	11	4
Thickness of coal sampled	9	3

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 222, 904.

WHATCOM COUNTY.

BELLINGHAM. BELLINGHAM MINE.

Analysis 32034 (p. 79). Bituminous coal from Bellingham mine, a shaft mine 1 mile from Bellingham, in sec. 13, T. 38 N., R. 2 E., on the Bellingham & Northern R. R. Coal bed, No. 1; Eocene age, Puget (?) formation. The bed dips 10°; roof, sandy shale; floor, concealed; cover at point of sampling, 290 feet. The bed was sampled near foot of rock slope by G. W. Evans on May 17, 1919, as described below:

Section of coal bed in Bellingham mine.

	Ft.	in.
Roof, sandy shale.		
Bone	1	0
Shale [a]		2
Coal	1	0
Coal and siliceous shale		4
Coal	1	10
Bone		2
Coal	1	9
Shale, variable [a]		½
Coal		5
Shale, hard [a]		1½
Coal		5
Shale [a]		4
Bone [a]	1	1
Bone [a]	2	0
Floor, bone.		
Thickness of bed	10	8
Thickness of coal sampled	6	11

System of mining, room and pillar. At time of sampling the daily output was 100 tons.

WEST VIRGINIA.

BROOKE COUNTY.

COLLIER. LOCUST GROVE NOS. 1 AND 2 MINES.

Analyses 31627 to 31632 (p. 80). Bituminous coal, Wheeling field, from Locust Grove Nos. 1 and 2 mines, drift mines, 1½ miles west of Collier, on the Pennsylvania Lines west. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. The average thickness of workable coal is 4 feet 6 inches. The bed dips slightly to the southeast. A few rolls and clay veins are encountered. Roof, 12 inches "draw slate;" floor, smooth fire clay, which becomes soft, with limestone below. Bed contains shale, "sulphur" stone, and "sulphur" streaks. The bed was sampled by P. D. Browning on March 21, 1919, as described below:

[a] Not included in sample.

Sections of coal bed in Locust Grove Nos. 1 and 2 mines.

Section	A.	B.	C.	D.	E.
Laboratory No.	31627	31628	31629	31630	31631
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, "draw slate."					
Coal	1 10½	1 1	7½	2¼	1 3½
"Mother coal"	....	....	¼	¼	....
Coal	....	....	7½	2¼	....
"Sulphur" streak	....	⅛	....	⅛	....
Coal	....	3	....	1 0	....
"Mother coal"	....	½	½	....	....
"Sulphur"	....	....	....	a ½	a ½
Coal	....	8	7½	8¼	10
Shale	a ¼	a ½	¼	a ¼	a ½
Coal	2¾	3	3	3	3
Shale	a 1	a 1½	a 1	1	a 1½
Coal	4	1 3½	....	....	....
"Mother coal"	¼	....	....	....	....
Coal	8¾	....	....	....	....
Soft shale	¼	....	....	....	....
"Sulphur" streak	....	⅛	....	....	....
Coal	11½	6⅜	1 11½	1 10⅝	1 8
Floor, fire clay.					
Thickness of bed	4 3¼	4 3½	4 3¼	4 6	4 3½
Thickness of coal sampled	4 1¾	4 1½	4 2¼	4 4¾	4 0½

a Not included in sample.

Section A (sample 31627) was cut at right rib, at face of main entry. Section B (sample 31628) was cut at slant, at face of 4 face entry. Section C (sample 31629) was cut at right rib, at face of 1 face entry. Section D (sample 31630) was cut at left rib, at face of 5 face entry. Section E (sample 31631) was cut at left rib, at face of 6 left butt.

The ultimate analysis of a composite made by combining face samples 31627, 31628, 31629, 31630, and 31631 is given under laboratory No. 31632.

System of mining, room and pillar with butt entries. In 1919 the coal was undercut by machine in bottom of coal and shot down with black powder by the miners at any time during the shift. There were 250 men employed underground and 45 aboveground. The tipple was constructed chiefly of steel. The coal was screened through bar screens 12 feet long by 6 feet wide, with 1½-inch spaces. About 25 per cent of the coal passed through the screens. Haulage was by six electric locomotives and by mule. Six pickers were employed on car. There were three loading tracks, with capacity for 45 empty and 35 loaded railway cars. The lump coal, medium size, presented a good appearance on cars. There was a recovery of 85 per cent. The unmined area consisted of about 2,500 acres. The estimated lifetime of the mine was 15 years. At the time of sampling the capacity of the mine was 2,500 tons a day, the daily average output 1,200 tons, and the maximum day's run 1,800 tons. The daily output was to be increased to 3,000 tons.

SHORT CREEK. BEECH BOTTOM MINE.

Analyses 31597, 31598, 31599, 31600, 31601, and 31602 (p. 80). Bituminous coal, Wheeling field, from Beech Bottom mine, a drift mine, at Short Creek, 5 miles south of Wellsburg, on the Pennsylvania Lines West. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. The thickness of workable coal is 4 feet 5 inches to 5 feet 3 inches. A few rolls and clay veins are encountered. Streaks of shale and "sulphur," in coal, the former persistent. Roof, 3 to 18 inches "draw slate"; up to 18 inches roof coal; shale above; floor, smooth, soft fire clay; elevation of entrance above sea, 913.30 feet. The bed was sampled by P. D. Browning on March 15, 1919, as described below:

Sections of coal bed in Beech Bottom mine.

Section	A.	B.	C.	D.	E.
Laboratory No	31597	31598	31599	31600	31601
Roof, "draw slate."	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	1 6	1 8	2 2½	2 1	1 5
"Mother coal"	½	¼	....	....	½
Coal	2	4½	....	....	4
"Mother coal"	½	½	....	....	¾
Coal	7	9½	....	....	8
Shale	[a]1	[a]1	....	½	[a]½
Bone coal	....	....	½	....	....
Coal	3	9	3	3	1
"Sulphur" streak	....	....	....	....	[a]½
Shale	....	....	[a]1	[a]1	....
"Mother coal"	½	¾	....	....	....
Coal	2 ½	1 5½	2 2	2 1½	1 9
Floor, fire clay.					
Thickness of bed	4 9	5 3	4 9	4 7	4 5
Thickness of coal sampled	4 8	5 2	4 8	4 6	4 4½

[a] Not included in sample.

Section A (sample 31597) was cut on left rib, 75 feet in 17 room, 6 west, 4 north. Section B (sample 31598) was cut on left rib, at face of 3 entry, 4 north. Section C (sample 31599) was cut at face of 3 east butt, 4 north face. Section D (sample 31600) was cut on left rib, at face of main east. Section E (sample 31601) was cut at neck of 3 east butt, 4 south face.

The ultimate analysis of a composite sample made by combining face samples 31597, 31598, 32599, 31600, and 31601 is given under laboratory No. 31602.

System of mining, double and triple entry, room and pillar, in panels. In 1919 the coal was undercut by machine in bottom of coal and shot down with black powder and a little permissible explosive by miners at any time during the shift. There were 235 men employed underground and 34 aboveground. The tipple was constructed of steel chiefly and of wood. The entire output was crushed. Haulage was by incline and by nine electric locomotives. About 60 per cent of the coal was taken out in advance work, and a total recovery of over 70 per cent was claimed. The unmined area was approximately 3,900 acres. The estimated lifetime of the mine was about 40 years. At the time of sampling, the daily capacity of the mine was 1,400 tons, the actual daily average being 1,200 tons.

FAYETTE COUNTY.

LAYLAND. LAYLAND NOS. 1, 2, 3, AND 4 MINES.

Analyses 68180, 68186, 68196, 68224, 68225, and 30147; also car samples 69233 and 69234 (p. 80). Semibituminous coal, New River field, from Layland mine, which has four drift openings, called Nos. 1, 2, 3, and 4. The mine is 2 miles north of Layland station, on the Quinnemont branch of the Chesapeake & Ohio R. R. Coal bed, Fire Creek; Carboniferous age, Pottsville group, Quinnemont formation. Bed is 3½ to 4½ feet thick; dip 2 or 3 per cent, generally northeast. There are no general faults; rolls or horsebacks are frequent. Elevation of entrance above sea level, 2,493 feet; roof, thick, brown shale, which does not stick to coal; floor, smooth shale. Commercial samples were taken at tidewater by N. H. Snyder on May 10 to 16, 1918. The bed was sampled by E. T. Hancock and E. Stebinger on January 3, 1918, as described below:

Sections of coal bed in Layland Nos. 1, 2, 3, and 4 mines.

Section	A.		B.		C.		D.		E.	
Laboratory No	68180		68186		68196		68224		68225	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		11½	4	2						
Coal, with impure streaks		2						9		[a]4
Shale								[a]1		
Coal, soft, lustrous						10				10
Coal, hard, with splinty fracture	2	9			2	7	2	10	2	6
Floor, shale.										
Thickness of bed	3	10½	4	2	3	5	3	8	3	8
Thickness of coal sampled	3	10½	4	2	3	5	3	7	3	4

[a] Not included in sample.

Section A (sample 68180) was cut from face of 8 left, 4 main. Section B (sample 68186) was cut from face of 11 left, 3 main. Section C (sample 68196) was cut from face of 1 room, 26 left, 2 main. Section D (sample 68224) was cut from face of 7 left, main tunnel. Section E (sample 68225) was cut from face of 8 room, 17 left, 1 main.

The ultimate analysis of a composite sample made by combining face samples 68180, 68186, 68196, 68224, and 68225 is given under laboratory No. 30147.

System of mining, room and pillar. There are four main entries, each one constituting a separate mine. In 1918 the coal was undercut by pick and one shortwall machine, and shot down by means of black powder and permissible explosives. There were 200 men working underground and 55 aboveground. Half of the coal was taken out in advance work, and there was a total recovery claimed of 95 per cent. The tipple was of steel. Haulage was by electric motor; 21 locomotives were employed. The coal was all shipped as run of mine and was picked on cars. The lump coal had a good appearance on cars. There were two loading tracks, with capacity for 30 empty and 30 loaded cars. The capacity of the mine was 1,400 tons a day, and the actual average shipments at time of sampling were 750 tons.

For other analyses of this coal see Bureau of Mines Bull. 22, p. 227.

MINDEN. MINDEN NOS. 2, 3, 4, AND 5 MINES.

Analyses 68113, 68127, 68133, and 30149 from No. 2 mine; 30046 from No. 3; 68124, 68125, 68131, and 30150 from No. 4; 68116, 68119, 68120, 68121, and 30151 from No. 5; 69231 and 69232, car samples (p. 81). Bituminous coal, New River field, from Minden mines, drift mines at Minden, on the Minden branch of the Chesapeake & Ohio R. R. Coal bed, Sewell seam; Carboniferous age, Pottsville group, Sewell formation. Bed is 3 to 5 feet thick; dip, 2½ per cent northwest; roof, clayey shale overlain by sandstone; in parts of mine, roof is sandstone; floor hard, smooth shale. Car samples were taken at tidewater by N. H. Snyder on May 10 to 15, 1918. The bed was sampled at three points in No. 2 mine, one point in No. 3 mine, three points in No. 4 mine, and four points in No. 5 mine by G. H. Ashley on January 1 to 4, 1918, as described below:

Sections of coal bed in Minden Nos. 2, 3, 4, and 5 Mines.

Section	A.		B.		C.		D.		E.		F.		G.		H.		I.		J.		K.	
Laboratory No.	68113		68127		68133		68117		68131		68125		68124		68116		68119		68120		68121	
Roof, shale; floor, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	4	5	5	1	4	9	5	2	3	1	4	3	3	7	4	1	4	8	4	4	3	0

Section A (sample 68113) was cut at face of 15 room, 1 crosscut, off 10 left, 2 main, No. 2 mine. Section B (sample 68127) was cut in 12 room, 2 main, No. 2 mine. Section C (sample 68133) was cut in 1 crosscut, off 13 left, 1 main, No. 2 mine. Section D (sample 68117) was cut in 20 room, 10 right, 2 main, No. 3 mine. Section E (sample

68131) was cut at head of straight main, No. 4 mine. Section F (sample 68125) was cut at face of 21 room, 9 left, 2 main, No. 4 mine. Section G (sample 68124) was cut in breakthrough off 11 left, 3 main north, No. 4 mine. Section H (sample 68116) was cut in 19 right, 1 main, No. 5 mine. Section I (sample 68119) was cut in 10 right, 3 main, No. 5 mine. Section J (sample 68120) was cut in 15 room, 1 right, 2 main, No. 5 mine. Section K (sample 68121) was cut at face of 1 main, No. 5 mine.

The ultimate analysis of a composite sample made by combining face samples 68113, 68127, and 68125 from No. 2 mine is given under laboratory No. 30149. The ultimate analysis of a composite sample made by combining face samples 68124, 68125, and 68131 from No. 4 mine is given under laboratory No. 30150. The ultimate analysis of a composite sample made by combining face samples 68116, 68119, 68120, and 68121 from No. 5 mine is given under laboratory No. 30151.

System of mining, room and pillar. In 1918 the coal was undercut by machine and shot down by black powder. The total capacity of the group of mines was 2,300 to 2,500 tons a day. Nos. 3 and 4 mines were the largest producers, but No. 5, a newer mine, was doing advance work, and was to be a larger producer. About thirty 6 to 13 ton electric locomotives were used for haulage. Nos. 3, 4, and 5 mines had a large territory to work, but No. 2 mine was becoming exhausted. The coal was all shipped as run of mine.

For description and analyses of other samples from these mines see Bureau of Mines Bull. 22, pp. 234–235, 932–934.

MINDEN. ROCK LICK NO. 4 MINE.

Analyses 68114, 68126, 68132, and 30157; also analyses of tipple samples 70120 and 70123 and car samples 69293 and 69294 (p. 81). Bituminous coal, New River field, from Rock Lick No. 4 mine, 1½ miles northeast of Minden station, on the Minden branch of the Chesapeake & Ohio R. R. Coal bed, Sewell; Carboniferous age, Pottsville group, Sewell formation. Bed is 3 feet 10 inches to 4 feet 2 inches thick; roof, clay shale; floor, hard, smooth clay; dip of bed, 1½° west of north. The bed was sampled by G. H. Ashley on January 4, 1918, as described below. Car samples were taken at tidewater by N. H. Snyder on May 17 to 28, 1918. Tipple samples were taken on September 13, 1918, by J. J. Bourquin and S. S. Shirkey.

Sections of coal bed in Rock Lick No. 4 mine.

Section	A.		B.		C.	
Laboratory No.	68126		68132		68114	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	3	7	3	3	3	6
Coal						[a] 4
Floor, clay.						
Thickness of bed	3	7	3	3	3	10
Thickness of coal sampled	3	7	3	3	3	6

[a] Not included in sample, on account of the cutting being done in this portion of the coal.

Section A (sample 68126) was cut in face of 2 main. Section B (sample 68132) was cut in face of straight main. Section C (sample 68114) was cut in face of 4 main.

The ultimate analysis of a composite sample made by combining face samples 68114, 68126, and 68132 is given under laboratory No. 30157.

System of mining, room and pillar. In 1918 the capacity of the mine was 600 tons a day, the actual average shipments at time of sampling being 450 tons. Tonnage was to be increased. There were 105 men employed underground and 12 on the surface. Haulage was by electric motors, gathering by small motors and by mules. In advance work 40 per cent of the coal was extracted, and a total recovery of 90 per cent was made. There were over 1,000 acres still to be mined. All coal was shipped run of mine. It was picked on car by one picker.

THURMOND. ROCK LICK NO. 2 MINE.

Analyses 68128, 68129, 68130, and 30158; also tipple samples 70127 to 70130 and car samples 69293 and 69294 (p. 82.) Semibituminous coal, New River field, from Rock Lick No. 2 mine, a drift mine 1 mile north of Thurmond, on the South Side branch of the Chesapeake & Ohio R. R. Coal bed, Fire Creek; Carboniferous (Pottsville) age, Quinnemont formation. Bed is 3 to 6 feet thick; dip, 5 per cent northwest. Faults and rolls or horsebacks are frequent. Roof, blue carbonaceous shale; floor, hard, smooth clay. The bed was sampled by G. H. Ashley on January 5, 1918. Tipple samples were taken on September 14, 1918, by J. J. Bourquin and S. S. Shirkey. Car samples were collected at tidewater by N. H. Snyder on May 17 to 28, 1918.

Section A (sample 68128) was cut at face of 2 left heading. Section B (sample 68129) was cut at face of 2 room, off 2 left. Section C (sample 68130) was cut at face of parting, being cut on 2 left.

The ultimate analysis of a composite sample made by combining face samples 68128, 68129, and 68130 is given under laboratory No. 30158.

System of mining, room and pillar. In 1918 the coal was undercut by machine and shot down with black powder. There were 25 men employed underground and 3 on the surface. Haulage was by a 6-ton motor and by mules. The mouth of the mine is 600 to 800 feet above the railroad track. The coal was dumped from mine cars into a bin, fed into a 7-ton monitor, and lowered to tipple. A 90 per cent recovery was claimed. The estimated lifetime of the mine was 15 to 20 years. The coal was all shipped as run of mine. There were several loading tracks, with capacity for 25 or 30 cars. The capacity of the mine was 200 tons a day, and the average daily shipments at time of sampling were 150 tons.

GRANT COUNTY.

BISMARCK. COSNER MINE.

Analysis 69068 (p. 82). Semibituminous coal, Abram Creek-Stony River field, from Cosner mine, an outcrop mine, ¾ mile east of Bismarck. Coal bed, Thomas; Carboniferous age. Thickness and dip not noted. Roof, shale, drab, over 1 foot of black shale; floor, clay. The bed was sampled by G. H. Ashley on April 27, 1918, and consisted at point of sampling of 9 inches of bone, not sampled, at the top, and 2 feet 5 inches of coal. The section was measured at face of entry.

BISMARCK. HAMLINE MINE.

Analysis 69069 (p. 82). Semibituminous coal, Abram Creek-Stony River field, from Hamline mine, 1¾ miles east of Bismarck. Coal bed, Davis; Carboniferous age, Allegheny formation. Roof, black shale 2 feet under brown sandstone; floor, clay. The bed was sampled by G. H. Ashley on April 25, 1918, as described below:

Section of coal bed in Hamline mine.

	Ft.	in.
Roof, black shale.		
Coal		3½
Clay [a]		3
Coal		11
"Clay rock" [a]		4
Coal		10
"Clay rock" [a]		3
Coal	1	6
Floor, clay.		
Thickness of bed	4	4½
Thickness of coal sampled	3	6½

The section was measured at face of room being driven to west.

[a] Not included in sample.

BISMARCK. OUTCROP.

Analysis 69073 (p. 82). Semibituminous coal, Abram Creek-Stony River field, from an outcrop at the falls of Stony River ¼ mile west of Bismarck. Coal bed, Falls. Carboniferous age, Allegheny formation. Roof, black shale 4 feet thick; floor, clay. The bed was sampled at outcrop at water's edge by G. H. Ashley on April 27, 1918. The sample represented 2 feet 10 inches of coal, or the entire thickness of bed, except 2 inches of shale near the middle.

BISMARCK. OUTCROP.

Analysis 69066 (p. 82). Semibituminous coal, Abram Creek-Stony River field, from an outcrop ½ mile above the Falls of Stony River, ¼ mile west of Bismarck. Coal bed, Davis; Carboniferous age, Allegheny formation. Roof, black shale 2 feet 4 inches; with sandstone above; floor, clay, with flint clay. The bed was sampled by G. H. Ashley on April 27, 1918. The sample was taken from stock pile dug from bed of river [illegible] previous winter and was probably weathered.

HARTMONSVILLE. KITZMILLER MINE.

Analysis 69065 (p. 82). Semibituminous coal, Abram Creek-Stony River field, from Kitzmiller mine, 2 miles southwest of Hartmonsville. Coal bed, Barton; Carboniferous age, Conemaugh formation. The bed is persistent, but is generally less than 4 feet thick; roof, carbonaceous brown shale; floor, clay; cover at point of sampling, 25 to 50 feet. The bed was sampled by G. H. Ashley on April 27, 1918, as described below:

Section of coal bed in Kitzmiller mine.

	Ft.	in.
Roof, shale.		
Coal, bony [a]	1	8
Coal		9
Parting		½
Coal	1	0
Parting		½
Coal		11
Shale [a]		1
Coal [a]		6
Floor, clay.		
Thickness of bed	5	0
Thickness of coal sampled	2	9

The section was measured at face of main entry.

HENRY. HENRY OR NO. 22 MINE.

Analysis 26579 (p. 82). Semibituminous coal from Henry or No. 22 mine, at Henry, on the Western Maryland R. R. Coal bed, Upper Freeport; Carboniferous age, Allegheny formation. Bed is 6 feet 5½ inches to 6 feet 7½ inches thick; roof, massive sandstone and shale; floor, shale and fire clay; cover at point of sampling, about 200 feet. The bed was sampled by the Maryland Geological Survey on October 30, 1916, as described below:

Section of coal bed in Henry or No. 22 mine.

	Ft.	in.
Roof, massive sandstone and shale.		
Shale [a]		2–4
Bony coal [a]	1	9
Coal	4	6
Shale [a]		½
Fire clay [a]		

[a] Not included in sample.

	Ft.	in.
Floor, shale and fire clay.		
Thickness of bed	6	5¼–7¼
Thickness of coal sampled	4	6

This sample was measured in 3 left butt heading, off Webster heading, about 4,800 feet from shaft bottom. The daily output of the mine in 1916 was 590 tons.

MOUNT STORM. KOONTZ MINE.

Analyses 69064 and 69070 (p. 83). Semibituminous coal and bone, Abram Creek-Stony River field, from Koontz mine, 1 mile north of Mount Storm, on Stony River. Coal bed, Thomas; Carboniferous age, Allegheny formation. Roof, brown shale; floor, clay, hard; cover at point of sampling, 50 feet. The bed was sampled by G. H. Ashley on April 24, 1918, as described below:

Section of coal bed in Koontz mine.

	Ft.	in.
Roof, brown shale.		
Coal, bony [a]	1	4
Coal	2	6
Floor, hard clay.		
Thickness of bed	3	10
Thickness of coal sampled	2	6

The section was measured at breakthrough from 1 right-hand entry.

HANCOCK COUNTY.

CHESTER. ALLISON COAL BANK.

Analysis 25633 (p. 83). Bituminous coal, Panhandle field, from Allison coal bank, 2 miles south of Chester, in Middle Run Township. Coal bed, Mahoning (Groff); Carboniferous age, Conemaugh formation. Roof, shaly sandstone to sandy shale; floor, clay. The bed was sampled on July 23, 1916, by J. H. Hance and contains 2 feet 1½ inches of coal, overlain by 2 inches of bituminous clay and bone. The section was measured 60 feet south of mine mouth.

CHESTER. JONES'S COAL BANK.

Analysis 25635 (p. 83). Bituminous coal, Panhandle field, from Jones's coal bank, ½ mile south of Chester, in Middle Run Township. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, shale; floor, clay. The bed was sampled on July 18, 1916, by J. H. Hance, as described below:

Section of coal bed in Jones's coal bank.

	Ft.	in.
Roof, shale.		
Shale, bituminous [a]		1½
Coal		11½
"Mother coal"		⅛
Coal		2
"Mother coal"		⅛
Coal		7
Shale, bituminous, and clay [a]		½
Floor, clay.		
Thickness of bed	1	10¾
Thickness of coal sampled	1	8¾

The section was measured 65 feet south of west of mine mouth.

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[a] Not included in sample.

CHESTER. LINE ISLAND COAL BANK.

Analysis 25591 (p. 83). Bituminous coal, Panhandle field, from Line Island coal bank, 2 miles northeast of Chester, opposite east end, Ohio, Grant Township. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Roof, massive sandstone, with 3 inches coaly shale; floor, clay, 15 to 16 feet thick. The coal was sampled on July 15, 1916, by J. H. Hance, as described below

Section of coal bed in Line Island coal bank.

	Ft.	in.
Roof, massive sandstone and shale.		
Coal		9
Clay [a]		1/8
Coal		2 1/2
Coal, bony, pyrite [a]		1/8
Coal		5 3/4
Clay, pyrite band [a]		1 1/2
Coal		6
Clay, pyrite band [a]		1
Coal	1	7
Floor, clay.		
Thickness of bed	3	9
Thickness of coal sampled	3	6 1/4

The section was measured in small entry, 70 feet south of mouth of mine and 15 feet from main entry.

CHESTER. SPROUT'S COAL BANK.

Analysis 25634 (p. 83). Bituminous coal, from Sprout's coal bank, 1 1/4 miles south of Chester, in Middle Run Township. Coal bed, Lower Freeport; Carboniferous age' Allegheny formation. Roof, shaly sandstone; floor, clay. The bed was sampled on July 18, 1916, by J. H. Hance, as described below:

Section of coal bed in Sprout's coal bank.

	Ft.	in.
Roof, shaly sandstone.		
Clay shale [a]		3
Clay, bituminous shale, and bone [a]		1 3/8
Coal		7 1/2
"Mother coal" and clay		1/4
Coal		10
Coal, bony [a]		2 1/4
Sandy-pyrite band [a]		1
Coal		10 1/2
Floor, clay.		
Thickness of bed	2	11 7/8
Thickness of coal sampled	2	4 1/4

The section was measured about 15 feet southwest from mine mouth.

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[a] Not included in sample.

NEW CUMBERLAND. MCNEIL-HERRON MINE.

Analysis 25715 (p. 83). Bituminous coal, Panhandle field, from McNeil-Herron mine, 1 mile north of New Cumberland. Coal bed, Groff (Mahoning); Carboniferous age, Conemaugh formation. Roof, shale and sandstone; floor, clay. The bed was sampled on July 28, 1916, by J. H. Hance, as described below:

Section of coal bed in McNeil-Herron mine.

	Ft.	in.
Roof, shale and sandstone.		
Coal	2	2½
Clay		¼
Coal	1	0
Clay and bone [a]		2
Coal		2½
Floor, clay.		
Thickness of bed	3	7¼
Thickness of coal sampled	3	5¼

The section was measured 200 feet north 22° west from mine mouth.

NEW CUMBERLAND. CRESCENT CLAY MINE.

Analysis 25716 (p. 83). Bituminous coal, Panhandle field, from Cresent clay mine, New Cumberland. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Roof, sandstone; floor, clay. The bed was sampled on July 28, 1916, by J. H. Hance, as described below:

Section of coal bed in Crescent clay mine.

	Ft.	in.
Roof, sandstone.		
Coal		5¾
Pyrite band		¾
Coal	1	7
Floor, clay.		
Thickness of bed	2	1½
Thickness of coal sampled	2	1½

The section was measured 2,500 feet north 80° east from mine mouth.

NEW CUMBERLAND. MARTIN COAL BANK.

Analysis 25714 (p. 83). Bituminous coal, Panhandle field, from Martin coal bank, 2 miles northeast of New Cumberland. Coal bed, Groff (Mahoning); Carboniferous age, Conemaugh formation. Roof, shale and shaly sandstone; floor, clay. The bed was sampled on July 28, 1916, by J. H. Hance, 160 feet south 70° east from mine mouth. The sample represented 3 feet 11 inches of coal and 3 inches of bony coal at the bottom, the entire thickness of the bed.

PUGHTOWN. WERN'S COAL BANK.

Analysis 25713 (p. 83). Bituminous coal, Panhandle field, from Wern's coal bank, Pughtown, 2½ miles northeast of New Cumberland. Coal bed, Groff (Mahoning); Carboniferous age, Conemaugh formation. Roof, shale and shaly sandstone; floor, clay. The bed was sampled on July 29, 1916, by J. H. Hance, as described below:

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[a] Not included in sample.

Section of coal bed in Wern's coal bank.

	Ft.	in.
Roof, shale and shaly sandstone.		
Shale, brown sandy [a]		9−
Clay, coaly [a]		½
Coal	2	5
Clay, coaly [a]		1¼
Floor, clay.		
Thickness of bed	3	3¾+
Thickness of coal sampled	2	5

The section was measured 110 feet north 35° east of mine mouth.

McDOWELL COUNTY.

ARLINGTON. ARLINGTON MINE.

Analyses 68026, 68031, 68032, and 29993; also car sample 30253 (p. 83). Semibituminous coal, Pocahontas field, from Arlington mine, a drift mine at Arlington, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 4¾ to 6½ feet thick; roof, 1 to 4 inches fine shale or clay, 8 to 12 inches hard shale, then shale and sandstone; floor, hard, smooth shale. There are two bone streaks; one is hard and has some "sulphur;" the lower one is softer and plays out in places. Cover at points of sampling, 300 to 500 feet. Car samples were taken at tidewater by N. H. Snyder on December 19 and 20, 1918. The bed was sampled by C. A. Allen on December 27, 1917, as described below:

Sections of coal bed in Arlington mine.

Section	A.		B.		C.	
Laboratory No.	68032		68026		68031	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate."						
Coal				½	1	0
"Mother coal"				a ¾		
Bone						a 3
Coal and "mother coal"		3		1¾		
Coal		10		10	1	11
Bone		a 3				a 3
Bone and "sulphur"				a 2		
Coal, slightly bony						3
Coal	2	1	1	6½		5¾
"Mother coal"						½
Coal, bony		a 2½		a 2½		
Coal	1	8½	1	10		3½
"Mother coal"						a ½
Coal						9
Floor, shale.						
Thickness of bed	5	4	4	10	5	3
Thickness of coal sampled	4	10½	4	4¾	4	8¾

[a] Not included in sample.

Section A (sample 68032) was cut at face of 10 room, 12 entry. Section B (sample 68026) was cut at face of 10 room, 6 entry. Section C (sample 68031) was cut from 7 pillar, 16 left.

The ultimate analysis of a composite sample made by combining face samples 68026, 68031, and 68032 is given under laboratory No. 29993.

System of mining, room and pillar. In 1917 the coal was undercut by hand and shot down by black powder by the miners during the shift. Men employed numbered 85 underground and 6 aboveground. Haulage was by two 10-ton electric motors, one 3-ton and one 5-ton motor, also by mules. About 35 per cent of the coal was

[a] Not included in sample.

taken out in advance work; the percentage of recovery was high. The future tonnage will be derived more largely from pillars than from advance work. There were two loading tracks, with capacity for 37 empty and 50 loaded cars. The coal was screened over 16 by 8 foot bars spaced 4 inches apart; egg, nut, and slack were produced over screens having 2-inch, 1½-inch, and ¾-inch openings. The coal was picked on belt by 10 pickers. The screenings were coked. There was storage bin capacity for 200 tons. The coal was dumped 15 feet into a chute to plunger feeder, which fed it to a retarding conveyor that took it down the hill. From this conveyor the coal slid into a short conveyor 3 feet wide and was elevated to a shaking screen 5 by 8 feet, with ¾-inch holes, which took out part of the slack. The coal then passed to a picking conveyor, where it was picked; it was then dumped over the stationary screens having 4-inch, 2-inch, and 1½-inch spaced bars, and thence down to the cars. Additional lip screens took out remaining slack. All run of mine coal shipped passed over first slack screen to take out slack for coking. Arlington mine was laid out square, had good trackage, and was well maintained. From 1 to 4 inches of clay and "draw slate" came down with the coal. The tipple arrangements were good for getting out good run of mine coal, but there was no chance to pick egg and nut coal. The mine seemed to produce good coal. The capacity of the mine was 800 tons a day, and the average shipments at time of sampling 500 tons a day, according to labor conditions, and were to be increased, if possible. The maximum day's run was 1,500 tons. This mine was sampled in 1909.

For description and analyses of other samples from these mines see Bureau of Mines Bull. 22, pp. 248, 967.

BEAR WALLOW. ROANOKE MINE.

Analyses 67990, 67991, 67993, and 29917 and car sample 30232 (p. 84.) Semibituminous coal, Pocahontas field, from Roanoke mine, a drift mine ½ mile east (?) of Bear Wallow station, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 4½ to 5½ feet thick; roof, good "draw slate" 10 inches thick; floor, hard, smooth clay; dip, slight, irregular in direction, but generally northwest. There is no cleat. Commercial samples were taken at tidewater by N. H. Snyder on February 13 to 16, 1918. The bed was sampled by E. W. Shaw on December 27, 1917, as described below:

Sections of coal bed in Roanoke mine.

Section	A.		B.		C.	
Laboratory No.	67990		67991		67993	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate."						
Coal		10		9		10
Bony, "sulphurous" coal		[a] 3				
Bone				[a] 3		[a] 3
Coal	3	10½	3	10	4	10
Floor, hard, sandy clay.						
Thickness of bed	4	11½	4	10	5	11
Thickness of coal sampled	4	8½	4	7	5	8

[a] Not included in sample.

Section A (sample 67990) was cut at face of 20 room, 13 entry. Section B (sample 67991) was cut at face of 28 room, 2 diagonal. Section C (sample 67993) was cut at face of 27 room, 15 entry.

The ultimate analysis of a composite sample made by combining face samples 67990, 67991, and 67993 is given under laboratory No. 29917.

System of mining, room and pillar. In 1917 the coal was undercut by machine and shot down by black powder fired by the miners during shift. About 80 men were employed underground. Two-thirds of the product was shipped as run of mine. The bar screens had 2½-inch openings; the small coal screens had 2-inch and ¾-inch openings. There were 24 coke ovens, and about 60 tons of coke were made per day. Sizes of coal, lump, egg, nut, and slack. Haulage was by four electric locomotives and by mule. There were eight pickers on table and belt; the miners endeavored to reject some of the bone, but most of the picking was done outside. The mine was nearly worked out, there being but 4 or 5 acres still to be mined, and the work was mostly pillar-robbing. There was storage capacity for 300 tons of slack. The capacity of the mine was 800 tons a day, the actual average at time of sampling 400 tons, and the maximum day's run 1,000 tons.

For description and analyses of other samples of coal from this mine see Bureau of Mines Bull. 22, pp. 250, 970.

BERWIND. BERWIND NO. 1 MINE.

Analyses 68085, 68091, 68092, and 30171 and tipple samples 70263 to 70266 (p. 84). Semibituminous coal, Pocahontas field; from Berwind No. 1 mine, a drift mine 1½ miles northeast of Berwind, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 4 to 5 feet thick; roof, sandstone with "draw slate" in parts of mine; floor hard, smooth shale. The bed dips 3½ per cent north 45° west. The bed contains frequent faults. Commercial samples were taken at car loadings by J. J. Bourquin on September 24, 1918. The mine was sampled by S. P. Holt on January 1, 1918, as described below:

Sections of coal bed in Berwind No. 1 mine.

Section	A.		B.		C.	
Laboratory No.	68091		68085		68092	
Roof, sandstone.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	11¾		7¾	3	1⅜
"Sulphur"				a ¼		
Coal			2	1¾		
Bone		a 2¾		a 1¼		a 1¼
Coal	1	1	1	1	1	4⅝
Floor, shale.						
Thickness of bed	4	3½	4	0	4	7¼
Thickness of coal sampled	4	¾	3	10½	4	6

a Not included in sample.

Section A (sample 68091) was cut at face of main heading in No. 1¾ mine. Section B (sample 68085) was cut at face of 3 left in No. 1½ mine; Section C (sample 68092) was cut from 1 pillar, 2 left, 3 right.

The ultimate analysis of a composite sample made by combining samples 68085, 68091, and 68092 is given under laboratory No. 30171.

System of mining, room and pillar. In 1918 it was undercut by mining machines and shot down by FFF black powder. Men employed numbered 40 underground and 9 on the surface. The haulage was done by six electric motors. In advance work 66 per cent of the coal was taken out, and a total recovery of 95 per cent was made. The estimated lifetime of mine was 15 years. There were three loading trucks, with capacity for 20 empty and 20 loaded railroad cars. The coal was all screened. There were 1½-inch, 2-inch, and 3-inch openings in the screens. The coal was picked on cars by three pickers. There was a jig washery, with capacity for 500 tons. The screenings were coked. The capacity of the mine was 200 tons a day, and that amount was shipped daily at time of sampling. The tonnage was to be increased to 250 or 300 tons a day.

BERWIND. BERWIND No. 2 MINE.

Analyses 68081, 68087, 68082, and 29978 and car samples 69133 and 69134 (p. 84). Semibituminous coal, Pocahontas field, from Berwind No. 2 mine, a drift mine at Berwind, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 3 to 5 feet thick; average, 4 feet; dip, 4° northwest. Faults are frequent. Elevation above sea level, 1,488 feet. Commercial samples were taken at tidewater by N. H. Snyder on March 9 to May 3, 1918. The bed was sampled by R. H. Seip on January 1, 1918, as described below:

Sections of coal bed in Berwind No. 2 mine.

Section Laboratory No.	A. 68081	B. 68087	C. 68082
Roof, "draw slate."	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	2 10½	1 4	2 7¼
"Mother coal"		½	
Coal		11½	
Bone	a 3¼	a 3½	a 2
Coal, high in ash	1 10½	1 0	1 6¾
Floor, shale and fire clay.			
Thickness of bed	5 0¼	3 7½	4 4
Thickness of coal sampled	4 9	3 4	4 2

a Not included in sample.

Section A (sample 68081) was cut at face of 1 left, off 1 right, off 4 left. Section B (sample 68087) was cut at face of 9 left. Section C (sample 68082) was cut in 8 pillar, 3 right.

The ultimate analysis of a composite sample made by combining samples 68081, 68087, and 68082 is given under laboratory No. 29978.

System of mining, room and pillar. In 1918 the coal was undercut in bottom coal by machines and shot down by means of permissible explosive by the miners during shift. Men employed numbered 40 underground and 8 aboveground. The mine had a steel tipple. The haulage was by means of one 13-ton motor and four gathering motors. Impurities were 2 to 5 inches of bone, and 10 to 14 inches of coal high in ash at bottom of seam, which was sent to washery. Pieces of the roof and floor did not tend to become mixed with the coal in shipping. About 60 per cent of the coal was taken out in advance work; a total recovery of 95 per cent was attained. There were about 5,000 acres yet to be mined from this opening. The estimated lifetime of the mine was 20 years. Future tonnage was to be derived, 60 per cent from advance work and 35 per cent from pillars. The coal was all shipped as run of mine. The bottom coal was loaded out separately and sent to washery and used for coking. There were two loading tracks, with capacity for 20 empty and 20 loaded railroad cars. The capacity of the mine in 1918 was 500 tons a day and the average production 250 tons.

BERWIND. BERWIND No. 3 MINE.

Analyses 68070, 68073, 68077, and 29982, and car sample 30234 (p. 85). Semibituminous coal, Pocahontas field, from Berwind No. 3 mine, a drift mine 1½ miles east of Berwind, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 3 to 5½ feet thick, dips 3° to 4° northwest, and is free from faults; roof, mainly hard sandstone, a little draw slate; floor, ½ to 2 inches soft fire clay, with shale or sandstone below. Surface is smooth. Commercial samples were collected at tidewater by N. H. Snyder on January 28 to February 28, 1918. The bed was sampled by R. H. Seip on January 2, 1918, as described below:

Sections of coal bed in Berwind No. 3 mine.

Section	A.	B.	C.
Laboratory No.	68070	68073	68077
	Ft. in.	Ft. in.	Ft. in.
Roof, sandstone.			
Coal	2 8½	2 6	3 5
Bone	a4	a4	a4½
Coal	9½	1 8	1 5
Floor, fire clay and sandstone.			
Thickness of bed	3 10	4 6	5 2½
Thickness of coal sampled	3 6	4 2	4 10

a Not included in sample.

Section A (sample 68070) was cut on 4 pillar, 5 left, off main. Section B (sample 68073) was cut at face of main heading. Section C (sample 68077) was cut at face of 22 room, 5 left, off main.

The ultimate analysis of a composite sample made by combining face samples 68070, 68073, and 68077 is given under laboratory No. 29982.

System of mining, room and pillar. In 1918 it was undercut by shortwall machine in the coal and shot down by black powder by the miners during the shift. Permissible explosive was used for brushing roof or floor. Men employed numbered 62 underground and 10 on the surface. There is a streak of bone of varying thickness through the middle of seam. In mining, 60 per cent of the coal was taken out in advance work, and the total recovery was about 93 per cent. The estimated lifetime of the mine was 10 years. Future tonnage was to be derived 60 per cent from advance work and 30 per cent from pillars. The coal was all shipped as run of mine; it was picked on railroad car by two pickers. There were two loading tracks, with capacity for 14 empty cars and 6 loaded. The bone was separated from the coal by the miner as far as practicable. The capacity of the mine was 500 tons a day, and the average production at time of sampling was 400 tons.

BERWIND. BERWIND No. 4 MINE.

Analyses 68068, 68067, 68074, and 29979, and car samples 68907 and 68908 (p. 85). Semibituminous coal, Pocahontas field, from Berwind No. 4 mine, a drift mine at Berwind, just above Canebrake, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. Bed is 4 to 5½ feet thick, averaging 4½ feet. Dip of bed is 4° northwest. A persistent streak of bone lies 12 to 16 inches above floor; about 6 inches from the top is a persistent streak of gray or harder coal. Near or at the bottom the coal is harder and higher in ash. Where the clay was soft it mixed with coal in loading. In most parts of mine there is an excellent sandstone roof; floor, hard and smooth clay, except in a few places, where it is soft. Elevation of entrance above sea level, 1,800 feet. Commercial samples were taken at tidewater by N. H. Snyder on February 21 and April 3, 1918. The bed was sampled by C. A. Allen on January 2, 1918, as described below:

Sections of coal bed in Berwind No. 4 mine.

Section	A.	B.	C.
Laboratory No.	68068	68067	68074
	Ft. in.	Ft. in.	Ft. in.
Roof, sandstone.			
Coal	5½	6¼	5
Gray coal	1½	1	1
Coal	7½	2 8	2 4
"Mother coal"	¼		
Coal	1 10½		
Bone	a4	a4½	a4½
Coal	11	1 4	1 4½
Floor, clay and shale.			
Thickness of bed	4 4	5 0	4 7
Thickness of coal sampled	4 0	4 7½	4 2½

a Not included in sample.

Section A (sample 68068) was cut at face of 5 room, 3 right; depth below surface, 100 feet. Section B (sample 68067) was cut at face of 2 room, 8 left; depth below surface, 600 feet. Section C (sample 68074) was cut from 4 pillar, 3 left; depth below surface, 600 feet.

The ultimate analysis of a composite sample made by combining face samples 68068, 68067, and 68074 is given under laboratory No. 29979.

System of mining, room and pillar. In 1918 the coal was shot down by black powder, except near the outcrop, where permissible explosives were used. The coal was undercut. The haulage was by one 13-ton motor and four 6½-ton gathering motors. Men employed numbered 44 underground and 11 on the surface. About 65 per cent of the coal was taken out in advance work; there was a total recovery of 95 per cent. The future production will be about 60 per cent from pillars. The coal was all shipped as run of mine, except cuttings, and was picked on car by two pickers. The cuttings were sent to washery and then coked; machine cuttings were loaded out separately and sent to No. 1 washery. About 45 tons of coke were produced a day. The lumps were rather small and presented only a fair appearance on cars. There were two loading tracks, with capacity for 20 loaded and 20 empty railroad cars. The daily capacity of the mine was 500 tons, and the average production at time of sampling was 250 tons.

Big Sandy. Big Sandy Mine.

Analyses 68018, 68021, and 29976, and tipple samples 70267 to 70270 (p. 85). Semibituminous coal, Pocahontas field, from Big Sandy mine, a drift mine, at Big Sandy, on the main line of the Norfolk & Western R. R. Coal bed, Sewell; Carboniferous age, Pottsville group, Sewell formation. The bed varies in thickness from 2½ to 4½ feet, averaging about 3½ feet. Roof is hard shale, which does not fall with the coal; floor, hard shale, with a smooth surface. The cover over the coal is 100 to 800 feet. Commercial samples were taken at the tipple by S. S. Shirkey on September 24, 1918. The bed was sampled by W. T. Lee on December 29, 1917. The samples represented 3 feet 6 inches and 3 feet 9 inches of coal, respectively, which was the entire thickness of the bed where measured.

Section A (sample 68018) was measured at face of 3 crosscut, 17 left entry. Section B (sample 68021) was measured at face of 1 crosscut, 8 right entry.

The ultimate analysis of a composite sample made by combining face samples 68018 and 68021 is given under laboratory No. 29976.

System of mining, room and pillar. In 1917 the coal was shot down with permissible explosive and fired by the miners at any time of the day. Open carbide lamps were in use. The haulage system was electric. The coal is naturally dry, but no sprinkling was done. The property embraced 834 acres. The estimated lifetime of the mine was 18 years. The coal was shipped as run of mine and was picked on a table. About 50 per cent of the coal was lump.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 250, 971.

Coalwood. Olga Mine.

Analyses 68094, 68097, 68098, and 30155; also car samples 69404, 69405, 68800, and 68801 (p. 85). Semibituminous coal, Pocahontas field, from Olga mine, a shaft mine, 1½ miles southeast of Coalwood, on the Coalwood branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 4; Carboniferous (Pottsville) age, Pocahontas formation. Average thickness of bed is about 6 feet; roof, sandstone underlain by shale and locally by shaly fire clay; floor, shale underlain by sandstone. Car samples were taken at tidewater by N. H. Snyder on February 1 to March 8, 1918, and by H. W. Jarrett on

April 25 to June 12, 1918. The bed was sampled by J. W. Paul on December 31, 1917, as described below:

Sections of coal bed in Olga mine.

Section	A.	B.	C.
Laboratory No.	68094	68097	68098
	Ft. in.	Ft. in.	Ft. in.
Roof, shaly fire clay.			
Coal	10¾	8¾	10½
Shale	[a] 1½	....	[a] 1½
"Sulphur" lens, local	....	[a] ½	....
Coal	9	10¾	....
Coal, gray	7½	3½	3
Coal	1 3¾	4 0	8½
Coal, gray	....		8½
Shale, localized	[a] ½	....	....
Coal	2 5	....	3 6
Floor, hard fire clay.			
Thickness of bed	6 1½	5 11½	6 2
Thickness of coal sampled	5 11¾	5 11	6 ½

[a] Not included in sample.

Section A (sample 68094) was cut at face of No. 2 development, 2,000 feet from shaft; total depth of cover at point of sampling about 1,200 feet. At this point the miners rejected the 1½-inch band of shale. Section B (sample 68097) was cut at face of 2 left entry, 2 main, 1,500 feet from shaft, at which point the vertical depth from surface was about 1,000 feet. Section C (sample 68098) was cut at face of 1 right entry, No. 2 development, 2,000 feet from shaft, at which point the vertical depth from surface was about 1,000 feet.

The ultimate analysis of a composite sample made by combining face samples 68094, 68097, and 68098 is given under laboratory No. 30155.

System of mining, room and pillar, in panels. In 1917 the mine was about four years old. The tonnage had been increased from two to seven cars daily. There were 74 men employed underground and 20 aboveground. The tipple was steel, with a single cage hoist; the cage was of the platform type. An electric hoisting engine was in use, and the mine purchased its electric power. Electric safety lamps were employed. The haulage was by mule and one 5-ton electric motor. The mine was sprinkled once a week. The coal was undercut by pick in floor and roof and was brought down with permissible explosive by shot firers at any time during the shift. Pieces of the roof had a tendency to become mixed with the coal in mining. From 5 to 10 per cent of the coal was taken out in advance work. The property embraced 17,000 acres of which about 5,000 were yet to be mined from this opening. The estimated lifetime of the mine was about 100 years. The coal was all shipped as run of mine. There were no screens, the coal being picked on the railroad cars by two pickers. There was no storage-bin capacity. The appearance of the coal on cars was similar to that of Pocahontas No. 3 coal; the lumps were of medium size. There was one loading track and track capacity for 25 empty cars and 12 loaded cars. The surface equipment of the mine at time of sampling was only temporary. The coal was being shipped to Portsmouth, Ohio. The capacity of the mine was 500 tons a day in 1917, and the average production was 350 tons. It was expected that the production would be increased to 1,000 tons a day within 10 months.

COOPER. TUG RIVER MINE.

Analyses 67933, 67896, 67898, and 29913; also car samples 69053 and 69054 (p. 86). Semibituminous coal, Pocahontas field, from Tug River mine, a drift mine 5 miles west of Cooper on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 8½ to 11 feet thick and dips slightly to the west; roof, "draw slate," with sandstone above; floor, medium hard, smooth shale. Car samples were collected by N. H. Synder on April 5 to 25, 1918. The bed was sampled by R. H. Seip on December 18, 1917, as described below:

Sections of coal bed in Tug River mine.

Section	A.		B.		C.	
Laboratory No.	67933		67896		67898	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate."						
Coal	2	10	1	7	3	8¼
Bone		ᵃ3				
Coal, gray				8		ᵃ7¼
Coal	2	8½		5½	2	8½
Bone		ᵃ1		ᵃ1¼		ᵃ1½
Coal	2	7	5	6	2	1
Floor, shale.						
Thickness of bed	8	5½	7	10¾	9	3
Thickness of coal sampled	8	1½	7	9½	8	6

ᵃ Not included in sample.

Section A (sample 67933) was cut at face of main heading, 1½ miles west of drift mouth. Section B (sample 67896) was cut at face of 4 room, 2 crosscut, 2,000 feet north of drift mouth. Section C (sample 67898) was cut at face of 46 room, off 1 slant, 2,500 feet northwest of drift mouth.

The ultimate analysis of a composite sample made by combining samples 67933, 67896, and 67898 is given under laboratory No. 29913.

System of mining, room and pillar. In 1917 the coal was undercut in the coal. The coal was shot down by the use of permissible explosive and FFF black powder by the miners in pillar work and by shot firers in other portions of the work. About 100 men were employed underground. Impurities were bone and "sulphur." Pieces of roof and floor occasionally became mixed with coal. Half of the coal was shipped as run of mine and balance was screened through bar screens, producing egg, nut, pea, and slack sizes. There were six pickers on railroad cars. Ninety tons were coked a day. The storage bin had capacity for 600 tons. Track capacity was 35 empty and 35 loaded cars. The capacity of the mine was 800 tons a day, the average output was 600 tons, and the maximum day's run, 1,200 tons. There were about 400 acres or more to be taken out from present opening. In advance work 25 per cent of the tonnage was taken out. Of the future output of the mine 25 per cent was to be derived from advance work and 70 per cent from pillars. The daily output will probably be increased when new territory is opened up.

DAVY. BLACKSTONE MINE.

Analysis 29889 (p. 86). Semibituminous coal, Pocahontas field, from Blackstone mine, a drift mine ½ mile southeast of station at Davy, on the Norfolk & Western R. R. Coal bed, Sewell or Davy; Carboniferous age, Pottsville group, Sewell formation. Bed is 2½ to 4 feet thick; dip, slight and irregular; roof, massive shale; floor, hard, smooth shale; no cleat or faults occur; low rolls are frequent. The mine was sampled on December 29, 1917, by E. W. Shaw, as described below:

Section of coal bed in Blackstone mine.

	Ft.	in.
Roof, massive shale.		
Coal	1	1
Coal with bony streaks		2
Coal	2	3
Floor, shale.		
Thickness of bed	3	6
Thickness of coal sampled	3	6

The sample was cut at a point in break through between main entry and air course, 1,000 feet southeast of mine mouth.

System of mining, room and pillar. In 1917 the coal remaining in the mine was all in pillars, and the lifetime of the mine was only about 2 years. The coal was brought down by black powder and pick. There were 8 men underground and 2 or 3 on the surface. The haulage was by mule. A bony streak 1 to 3 inches thick occurs above the middle of the coal. Most of the bone was rejected before shipping. The coal was all shipped as run of mine and was picked on car by two or three pickers. There were two loading tracks, with capacity for 15 empty and 15 loaded railroad cars. The capacity of the mine was 75 tons a day, and the average in 1917 was 50 tons daily.

For description and analyses of other samples of coal from this mine, see Bureau of Mines Bull. 22, pp. 252, 976.

DAVY. CLETUS MINE.

Analyses 29892 and car samples 69496 and 69497 (p. 86). Semibituminous coal, Tug River field, from Cletus mine, a drift mine 1½ miles southeast of the station at Davy, on the Norfolk & Western R. R. Coal bed, Davy or Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 2½ to 4 feet thick; roof, about 6 inches of "draw slate," over which is cap of sandstone; floor, hard, smooth underclay. Depth of cover, about 150 feet. Car samples were taken at tidewater by H. W. Jarrett on June 6 to 18, 1918. The bed was sampled by E. W. Shaw on December 29, 1917, as described below:

Section of coal bed in Cletus mine.

	Ft.	in.
Roof, "draw slate."		
Coal	1	0
Bone [a]		1½
Coal with a little "sulphur"	1	7
Floor, hard shale.		
Thickness of bed	2	8½
Thickness of coal sampled	2	7

This sample was cut at head of 1 crosscut, off 3 main.

In 1917 the capacity of the Clotus mine was 300 tons a day; actual average at time of sampling, 200 tons. There were about 1,000 acres to be mined, and the estimated lifetime of the mine was 20 to 25 years. Haulage was by five electric locomotives. The impurity in the coal consisted of bone and occasional streaks of "sulphur" and "mother coal." The coal was all shipped as run of mine and was picked on belt at top of incline and on table below by five pickers. The tracks will take care of 11 empty and 20 or 30 loaded cars.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 254, 979.

DAVY. DAVY CROCKETT NO. 2 MINE.

Analysis 29891, average of tipple samples 70215 to 70218, and car samples 69328 and 69348 (p. 86). Semibituminous coal, Pocahontas field, from Davy Crockett No. 2 mine, a drift mine ½ (?) mile north of Davy station, on the Norfolk & Western R. R. Coal bed, Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 2 to 4 feet thick and dips slightly and irregularly. No cleat occurs, and few small rolls or horsebacks are encountered. Roof and floor, hard shale. Commercial samples were taken at the tipple by J. J. Bourquin and S. S. Shirkey on September 18, 1918. The bed was sampled by E. W. Shaw on December 28, 1917, as described below:

[a] Not included in sample.

Section of coal bed in Davy Crockett No. 2 mine.

	Ft.	in.
Roof, shale.		
Coal	1	0
Bone [a]		2
Coal	1	10
Floor, shale.		
Thickness of bed	3	0
Thickness of coal sampled	2	10

The sample was cut in the 11 cross entry of old hallway, 4,000 feet southeast of opening.

System of mining, room and pillar. In 1917 the coal was undercut by machine and shot down with black powder. Haulage was by means of two electric motors and by mules. The coal was clean, with the exception of a small band of bone; occasional lenses of bone and "mother coal" occur. The bone parting is excluded from sample. Half of the coal was shipped as lump, 10 per cent passed over 2½-inch screen, and 40 per cent was shipped as "smithing" coal, having passed through a 2½-inch screen. Screenings were not coked. There were three loading tracks, used by Davy Crockett and Helena mines, with capacity for 25 empty and 25 loaded cars. There were seven pickers on belt. The capacity of the mine was 200 tons a day, and the actual average 150 tons a day at time of sampling. There were still about 100 acres to be mined from this opening.

DAVY. HELENA, OR SUPERIOR NO. 3, MINE.

Analysis 29886 (p. 87). Semibituminous coal, Pocahontas field, from Helena mine, a drift mine ½ mile from Davy station, on the Norfolk & Western R. R. Coal bed, Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 2 feet 5 inches to 3½ feet thick; roof, massive clayey shale, 8 feet over coal, 4 feet of which is taken down in main entry; floor, hard smooth shale. Dip of bed is upward to 3° and irregular, generally northwest. No cleat occurs and no faults; few rolls or horsebacks are encountered. The bed was sampled by E. W. Shaw on December 28, 1917, as described below:

Section of coal bed in Helena mine.

	Ft.	in.
Roof, shale.		
Bone		2
Coal		2
Bone and "mother coal"		½
Coal	2	3
Floor, slate.		
Thickness of bed	2	7½
Thickness of coal sampled	2	7½

The sample was cut from the head of 23 entry, 4,000 feet north of opening.

System of mining, room and pillar. In 1917 the coal was undercut by pick and shot down with black powder. Two electric motors and 11 mules were used for haulage. Helena and Davy Crockett mines used the same screens and shipping facilities. Half of the coal was shipped as lump, 10 per cent passed over 2½-inch screen, and 40 per cent through 2½-inch screen, the latter being shipped as "smithing" coal. The production of Helena mine at time of sampling was 300 tons a day; capacity, 500 tons a day. There were 400 to 500 acres still unmined. Future shipments were dependent on supply of labor and cars.

[a] Not included in sample.

Analyses 70212 to 70214, average of face samples, and analyses 70219 to 70222, average of tipple samples (p. 87). The bed was sampled by J. J. Bourquin and S. S. Shirkey on September 18, 1918, as described below:

Sections of coal bed in Superior No. 3 mine.

Section	A.		B.		C.	
Laboratory No.	70213		70214		70212	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal		12		10½		11
Black shale		[a] 1½		[a] ½		[a] 2½
Coal	2	½	1	7½	1	5½
Floor, shale.						
Thickness of bed	3	2	2	6½	2	7
Thickness of coal sampled	3	½	2	6	2	4

[a] Not included in sample.

Section A (sample 70213) was cut from 15 cross, 3 left, 1½ miles from opening. Section B (sample 70214) was cut from face of 23 left entry of main entry, 1½ miles from main opening. Section C (sample 70212) was cut from 5 heading, 1½ miles from main opening.

System of mining, room and pillar. In 1918 the coal was cut by hand and shot down with black powder at any time during the shift by the miners, powder and dynamite being used for brushing the roof or floor. Men employed numbered 55 underground and 8 aboveground. Sixty per cent of the coal was taken out in advance work, and the total recovery claimed was 95 per cent. The unmined area consisted of 350 acres. The estimated lifetime of the mine was 15 years. Haulage was by electric motors and by mule. There were three loading tracks, with capacity for 26 empty and 26 loaded railroad cars. The coal from this mine and from Superior No. 2 mine was dumped over the same wooden tipple, all being loaded and shipped as run of mine. The coal was cleaned on the belt by two pickers, and there was no inspector at the tipple. The coal as loaded on the railroad cars showed the presence of small pieces of the roof. In loading the miner was instructed to reject the black shale at partings. The coal was being shipped to the tidewater coal exchange for steam use. The capacity of the mine was 600 tons a day, and the average daily output in September, 1918, was 250 tons. The daily tonnage was about 40 per cent of the capacity of the mine.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 253, 978.

Eckman. Pulaski No. 2 Mine.

Analyses 26615 to 26623, and analyses 69014 and 69015, car samples of loaded run of mine coal (p. 87). Semibituminous coal, from Pulaski No. 2 mine, a drift mine at Keystone, 1 mile east of Eckman, on the main line of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Pottsville group, Pocahontas formation. The average thickness of the coal is about 6 feet 3 inches; dip, about 2° north 45° west. The immediate roof is a "draw slate" about 1 foot 6 inches thick, with sandstone above. The floor is a hard, firm underclay. Material from the roof and floor did not tend to become mixed with the coal in mining, as the "draw slate" was easily kept separate from the coal. The bed was sampled by E. H. Denny and W. B. Plank on November 12, 1916, as described below:

Sections of coal bed in Pulaski No. 2 mine.

Sections	A.	B.	C.	D.	E.	F.	G.
Laboratory No	26615	26616	26618	26619	26620	26621	26622
	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Roof, "draw slate."							
Coal, impure, soft							a ½
Coal	8½	3	6½	6	6½	7½	4½
Bony coal	a 2½	a 4½	a 3½	a 2½	a 3	a 3	a 3
Coal	1 9	1 8½	1 8½	2 0	1 8½	1 9½	1 9½
Bony coal	a 2½	a 3	a 1½	a 2	a 3½	a 4	a 7½
Coal			1 10½	2	1 9½		
"Mother coal"				½	1½		
Coal, hard			2				
Coal	3 7	3 7	2 3	2	1 1	3 6	3 6
"Mother coal"				½			
Coal				1			
"Mother coal"				½			
Coal				3 2			
Floor, underclay.							
Thickness of bed	6 5½	6 2	6 11½	6 7½	5 9½	6 6	6 7
Thickness of coal sampled	6 ½	5 6½	6 6½	6 3	5 2½	5 11	5 8

a Not included in sample.

Section A (sample 26615) was measured on the pillar on 3 left, off 34 cross entry, 400 feet from 34 cross entry and 5,600 feet south 40° east from drift mouth. Section B (sample 26616) was measured on the pillar of 4 room, off 1 dip, 1,350 feet south 87° east from drift mouth. Section C (sample 26618) was measured between 10 and 11 rooms, on left inby rib of the third cross entry, off 36 cross entry, 6,450 feet south 70° east from drift mouth. Section D (sample 26619) was measured opposite the first breakthrough in 1 room, off the milk-dairy entry, and 4,650 feet south 22° east from drift mouth. Section E (sample 26620) was measured in the neck of 23 room, off 2 cross entry, off 36 cross entry, and 6,600 feet south 80° east from drift mouth. Section F (sample 26621) was measured at the face of 12 room 20 feet from 1 left entry, off 34 cross entry, and 4,680 feet south 46° east from drift mouth. Section G (sample 26622) was measured at the face of 5 room, 90 feet from the slant, off 5 cross entry, off 36 left entry, and 5,175 feet south 80° east from drift mouth.

Two composite samples were made by combining samples 26615 and 26616 (pillar samples) and samples 26618, 26619, 26620, 26621, and 26622. The results of an ultimate analysis of each of these composite samples are given, respectively, under laboratory Nos. 26617 and 26623. The same coal bed was later sampled by J. J. Bourquin on December 24, 1917, as described below. A commercial sample was taken at tidewater by N. H. Snyder on February 11 to April 10, 1918.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 255, 983.

Later analysis of sections of coal bed in Pulaski No. 2 mine.

Section	A.	B.	C.
Laboratory No	68011	67929	67956
	Ft. in.	Ft. in.	Ft. in.
Roof, hard shale.			
Coal	6½	6½	5½
Bone	a 1½	a 2	
"Sulphur" band			a 1½
Coal	1 7	1 8½	1 11½
Bone	a 3	a 2	a 2
Coal	4 0	3 9½	4 1
Floor, hard shale.			
Thickness of bed	6 6	6 4½	6 9½
Thickness of coal sampled	6 1½	6 ½	6 6

a Not included in sample.

Section A (sample 68011) was cut at face of 12 room, 37 entry, 2 main. Section B (sample 67929) was cut at face of 1 room, 3 crosscut, 36 left. Section C (sample 67956) was cut at face of 8 room, 2 crosscut, 34 entry.

The ultimate analysis of a composite sample made by combining face samples 68011, 67929, and 67956 is given under laboratory No. 29987.

System of mining, entry, room, and pillar. In 1917 the coal was undercut by machine in coal at bottom and shot down by the use of black powder by the miners during shift. Permissible explosive was used in brushing the roof. From 200 to 215 men were employed underground and 25 on the surface. Haulage was by eight electric motors. The coal was screened through shaking screens having 1-inch, 2-inch, and 3½-inch openings. It was picked on a picking table by five pickers. The screenings were coked. The lumps, which were large, had a good appearance. There were two loading tracks, with capacity for 60 empty and 75 loaded cars. In October, 1917, a typical period, this mine produced 28,080 tons, coking 17,482 tons and shipping 10,598 tons of coal. The maximum day's run was 1,500 tons, and the daily average was 900 tons. The estimated lifetime of the mine was about 20 years. The recovery claimed was 95 per cent of the coal. The company operated 390 coke ovens, each producing 2.7 tons of coke daily. The output of coke went to the furnaces of the Pulaski Iron Co., at Pulaski, Va., for the production of iron. The pig iron was used in Government contracts, and the shipments of coal were a secondary matter and varied greatly in tonnage. This mine was sampled also in 1916.

ECKMAN. PULASKI NO. 3 MINE.

Analyses 26610 to 26614 (p. 88). Semibituminous coal, Pocahontas field, from Pulaski No. 3 mine, a drift mine, at Eckman, on the main line of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3, Carboniferous age, Pottsville group, Pocahontas formation. The average thickness of bed is about 7 feet 3 inches; general dip, about 2 per cent northwest. The immediate roof is a "draw slate" 1½ to 3 feet thick, with sandstone above. The floor is a hard, firm, underclay. Material from roof and floor does not tend to become mixed with the coal in mining. The bed was sampled by E. H. Denny and W. B. Plank on November 11, 1916, as described below:

Sections of coal bed in Pulaski No. 3 mine.

Section	A.		B.		C.		D.	
Laboratory No.	26610		26611		26612		26613	
Roof, "draw slate."	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Coal		7		7		7		9
"Sulphur"				1/16				[a] ⅜
Bony coal		[a] 2½				[a] 3		
Coal	2	1	1	2½	1	11½	3	9⅜
"Mother coal"				¼		1		¾
Coal				9½		2½		
Bony coal		[a] 2½		[a] 3		[a] 3		
Coal	1	7		11½		4		
"Mother coal"				¼		½		
Coal				2	1	3		
"Mother coal"				¼				
Splint coal		2½				1		
Coal				2½				
"Mother coal"				¼				
Coal	2	3	2	9	2	1½	3	2½
Floor, underclay.								
Thickness of bed	7	1½	7	1/16	7	2	7	10
Thickness of coal sampled	6	8½	6	9 1/16	6	8	7	9⅝

[a] Not included in sample.

Section A (sample 26610) was measured on the rib of 1 left entry, 1,350 feet from the main entry and 1,500 feet south 85° east from the drift mouth. Section B (sample 26611) was measured at the face of 19 room, 80 feet from 4 left cross entry and 2,475 feet south 51° east from the drift mouth. Section C (sample 26612) was measured on the rib of 3 left entry, 1,800 feet from the main and 2,450 feet south 68° east from the drift mouth. Section D (sample 26613) was measured on the main entry, about halfway between 4 and 5 cross entries and 2,025 feet south 21° east from the drift mouth.

The ultimate analysis of a composite sample made by combining samples 26610, 26611, 26612, and 26613 are given under laboratory No. 26614.

System of mining, room and pillar retreat. In 1916 the coal was undercut by electric machine and shot down by FFFF black powder. Permissible explosive was used for brushing roof and floor when necessary. Mine haulage was by electric locomotive. Carbide miners' lamps were used. The coal passed through the same tipple as that from Pulaski No. 2 mine and was screened into lump, egg, nut, and slack. Some coal was shipped as run of mine. The coal was picked over a picking table after the slack was removed. At time of sampling the output was about 250 tons a day; capacity, 300 tons a day. The future output was to come entirely from advance work, the mining having consisted only in driving the entries and narrow work. The estimated lifetime of the two mines was 16 years, there being about 150 acres of solid coal.

ECKMAN. SHAWNEE MINE.

Analyses 67937, 67938, 67935, and 29915 and car samples 68839 and 68840 (p. 88). Semibituminous coal, Pocahontas field, from Shawnee mine, a drift mine at Eckman, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 6 to 7½ feet thick; roof, 2 feet of shale, over which is sandstone; floor, hard, smooth shale; dip, about 1° west; no cleat; no faults. Commercial samples were taken at tidewater by N. H. Snyder on February 6 to March 23, 1918. The bed was sampled by C. A. Allen on December 24, 1917, as described below:

Sections of coal bed in Shawnee mine.

Section	A.		B.		C.	
Laboratory No.	67937		67938		67935	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		2½		3		3¼
"Sulphur" band		[a] ¾		[a] 1		[a] ¾
Coal		10	2	4	2	3
Coal, gray		1	......		......	
Coal	1	4	......		......	
Bone		[a] 1		[a] 1		[a] 4
Coal	1	9	3	6	1	½
"Mother coal"		1	......			½
Coal	2	2	......		3	3
Floor, shale.						
Thickness of bed	6	7	6	3	7	3
Thickness of coal sampled	6	5½	6	1	6	10¼

[a] Not included in sample.

Section A (sample 67937) was cut at face of 8 room, 2 main; depth from surface, 550 feet. Section B (sample 67938) was cut on 24 pillar, 2 right; depth from surface, 500 feet. Section C (sample 67935) was cut on 31 pillar, 4 right; depth from surface, 350 feet.

The ultimate analysis of a composite sample made by combining face samples 67937, 67938, and 67935 is given under laboratory No. 29915.

System of mining, room and pillar. In 1917 the coal was undercut by pick and shot down with black powder and permissible explosive by the miners during shift.

About 100 men were employed underground and 25 on the surface. There was a steel tipple. Haulage was by two 10-ton locomotives and by mules. The mine made a large amount of dust, and salt was used for humidifying the dust in places where the sprinkler did not reach. Impurity consisted of gray shale in the roof, which tended to scale off and break into fine pieces. There were two loading tracks, with capacity for 30 empty and 35 loaded cars. Over 90 per cent of the coal was shipped as run of mine, of which 22 per cent was lump over 3½-inch bar screens; the egg size was screened over 1½-inch bars and the nut over ⅝-inch bars. Of the total production 55 per cent was slack, passing through ⅝-inch screens. The picking was done in railroad car by 8 to 10 pickers, in charge of an inspector. The pickers took out 2 or 3 tons of slate and 5 or 6 tons of bone and "sulphur" daily. The capacity of the mine was 600 tons a day; average production, 400 tons. The probable lifetime of the mine was about 20 years, there being about 500 acres to be mined. Most of the future tonnage was to be from pillars.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 255, 981.

ELKHORN. HOUSTON NOS. 1 AND 2 MINES.

Analyses 67955, 67959, and 29989 from No. 1 mine and 67962, 67969, 67970, and 29990 from No. 2 mine; also car samples 68802 and 68803 (p. 88). Semibituminous coal, Pocahontas field, from Houston Nos. 1 and 2 mines, drift mines at Elkhorn, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 6 to 9 feet thick; roof, "draw slate;" floor, hard shale. Commercial samples were taken at tidewater by N. H. Snyder on February 23 to March 11, 1918. The beds were sampled by R. H. Seip and S. P. Holt on December 28, 1917, as described below:

Sections of coal bed in Houston Nos. 1 and 2 mines.

Section	A.		B.		C.		D.		E.	
Laboratory No	67959		67955		67970		67962		67969	
Roof, "draw slate"	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
"Mother coal" and coal								3		
Coal	1	1½	1	4	1	3½	1	2	1	4
Bone		[a] 3		[a] 2		[a] 2½		[a] ½		[a] 4
Coal	4	1½	4	6½	4	5	4	4	3	8
Floor, shale.										
Thickness of bed	5	6	6	½	5	11	5	9½	5	4
Thickness of coal sampled	5	3	5	10½	5	8½	5	9	5	

[a] Not included in sample.

Section A (sample 67959) was cut on 16 pillar, 39 entry, mine No. 1. Section B (sample 67955) was cut on 21 pillar, 40 cross entry, mine No. 1. Section C (sample 67970) was cut on 5 pillar, 38 cross entry, mine No. 2. Section D (sample 67962) was cut at face of 3 room, 44 cross entry, mine No. 2. Section E (sample 67969) was cut on 6 pillar, 24 cross entry, mine No. 2.

The ultimate analysis of a composite sample made by combining samples 67955 and 67959 is given under laboratory No. 29989. The ultimate analysis of a composite sample made by combining samples 67962, 67969, and 67970 is given under laboratory No. 29990.

System of mining, room and pillar. In 1917 the coal was undercut by pick and shot down with FFFF black powder and permissible explosives by the miners during shift. About 60 per cent of the output was shipped as run of mine, the balance going through bar screens with 4-inch openings and through revolving screens with ¾ and 1¼-inch openings. The screenings were crushed and coked, there being 300 tons of coke produced daily. The coal was picked on the car by nine pickers. The track capacity could take care of 50 empty and 50 loaded cars. The daily capacity of No. 1 mine was 450 tons and of No. 2 mine 1,000 tons; the actual daily average shipments at time of sampling were 250 and 750 tons, respectively. There were 45 and 165 men, respectively, employed underground and 87 on the surface for the two mines. Haulage was by mule and motor, there being a total of six motors used. In advance work 35 per cent of the coal was taken out; a total of 95 per cent recovery was made. There were still from 100 to 200 acres to be mined from these two openings, which had a probable lifetime of 15 years. The coal was shipped to Lambert's Point, Va., and to Sandusky, Ohio, docks (the latter going to lake ports) and to Youngstown, Canton, Toledo, and other points in Ohio and Indiana. The coke was shipped to Roanoke, Va., and Wellston, Ohio.

FARADAY. PRESSLY MINE.

Analysis 26159 (p. 89). Semibituminous coal, Pocahontas field, from Pressly mine, 4 miles east of Faraday, flag stop on the Norfolk & Western R. R. Coal bed, Pocahontas No. 5; Carboniferous (Pottsville) age, Pocahontas formation. Roof, shale; floor, clay. The bed was sampled on September 20, 1916, by T. K. Harnsberger. The sample represented 3 feet 9½ inches of coal; 3 inches of "rash" was not included in the sample. The section was measured in 3 room, on right of main entry, 200 feet west of mine mouth.

GILLIAM. GILLIAM MINE.

Analyses 68000, 68023, 68022, and 29992; also car sample 30238 (p. 89). Semibituminous coal, Pocahontas field, from Gilliam mine, a drift mine at Gilliam, on the North Fork branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3 seam; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4½ to 6 feet thick; roof, strong, dark shale underlain with 3 inches of "draw slate." It is stated that a 16-inch seam of coal lies 15 feet above this bed. Floor, hard shale with smooth surface. Commercial samples were taken at tidewater by N. H. Snyder on January 28 to February 13, 1918. The bed was sampled by W. T. Lee on December 27, 1917, as described below:

Sections of coal bed in Gilliam mine.

Section	A.		B.		C.	
Laboratory No.	68023		68022		68000	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	3	1	3	1	3
Coal, bony		[a] 1½		[a] ¾		[a] 3
Coal	3	4	3	10	3	10
Floor, shale.						
Thickness of bed	4	8½	5	1¾	5	4
Thickness of coal sampled	4	7	5	1	5	1

[a] Not included in sample.

Section A (sample 68023) was cut in 3 crosscut, at face of 2 main. Section B (sample 68022) was cut in 3 crosscut, at face of 6 room. Section C (sample 68000) was cut in 6 crosscut, at face of 28 room.

The ultimate analysis of a composite sample made by combining face samples 68000, 68022, and 68023 is given under laboratory No. 29992.

System of mining, room and pillar. In 1916 the coal was undercut by machine, the cutting being done in the coal. The coal was shot down with black powder by the miners during the shift. Permissible explosive was used in brushing roof and floor. The capacity of the mine at time of sampling was 900 tons a day, although the actual average shipments were only about 700 tons. Open carbide lamps were used. The haulage was by mules and electric motor. There were two loading tracks, with a total capacity of about 20 empty railroad cars.

For descriptions and analyses of other samples of coal from this mine see Bureau of Mines Bull. 22, pp. 260, 991.

HARTWELL. BERWIND NO. 5 MINE.

Analyses 68069, 68072, 68076, and 29980 and car sample 30263 (p. 89). Semi-bituminous coal, Pocahontas field, from Berwind No. 5 mine, a drift mine ¾ mile southwest of Hartwell, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 3 to 5 feet thick; roof, sandstone; floor, soft, smooth shale. The bed dips 6 per cent west and contains three faults and horsebacks. Commercial samples were taken at tidewater by N. H. Snyder on February 11 to March 6, 1918. The bed was sampled by S. P. Holt on January 2, 1918, as described below:

Sections of coal bed in Berwind No. 5 mine.

Section	A.		B.		C.	
Laboratory No.	68069		68072		68076	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone.						
"Rash"		a 5				
Bone				a 2¼		
Coal, cube						a 1½
Coal	2	5	2	5½	2	7
Bone		a 4¾		a 2		a 2¼
Coal		7	1	0		2¼
Bone		a 2				a ¾
Coal	1	0				10½
Bone						a 1½
Coal						7
Floor, shale.						
Total thickness of bed	4	11¾	3	9¾	4	8¾
Thickness of coal sampled	4	0	3	5½	4	2¾

a Not included in sample.

Section A (sample 68069) was cut at face of main heading. Section B (sample 68072) was cut from chain pillar between 3 and 4 room, 3 left. Section C (sample 68076) was cut at face of 2 right.

The ultimate analysis of a composite sample made by combining face samples 68069, 68072, and 68076 is given under laboratory No. 29980.

System of mining, room and pillar. In 1918 the coal was undercut by machine and shot down by FFF black powder. There were 55 men employed underground and 9 on the surface. Haulage was by four gathering electric locomotives and one larger locomotive. The tonnage in the future will be derived largely from pillars. The output could have been increased to 375 tons by additional labor and cars. The coal was all shipped as run of mine and was picked on cars by three pickers. There was storage-bin capacity for 100 tons. There was loading track capacity for 30 empty and 30 loaded cars. The capacity of the mine was 325 tons a day, and the average shipments at time of sampling were 275 tons daily.

HAVACO. HAVACO (FORMERLY JED) MINE.

Analyses 67996, 68019, 68020, and 29991; also car samples from eight cars, analysis 30237 (p. 89). Semibituminous coking coal, Pocahontas field, from the Havaco (formerly Jed) mine, a shaft mine at Havaco, on the Tug Fork branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. The bed varies in thickness from 4 feet 8 inches to 5 feet 5 inches, with an average of 5 feet, and has a dip of about 1½ to 2½° north 45° west; roof, strong bedded sandstone underlain in places with 12 to 15 inches of treacherous slate that does not fall regularly with the coal, but is brushed in the entries; floor, 12 to 18 inches of hard clay with smooth surface. Commercial samples were taken at tidewater by N. H. Snyder on January 14 to February 13, 1918. The bed was sampled by W. T. Lee on December 28, 1917, as described below:

Sections of coal bed in Havaco mine.

Section	A.	B.	C.
Laboratory No.	67996	68019	68020
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	2 2	1 11½	2 0
Bony coal	a 3	a 3	a 3½
Coal	2 11½	2 11½	2 11
Floor, shale.			
Thickness of bed	5 4½	5 2	5 2½
Thickness of coal sampled	5 1½	4 11	4 11

a Not included in sample.

Section A (sample 67996) was cut at face of 1 main. Section B (sample 68019) was cut at face of 8 right main. Section C (sample 68020) was cut at face of 15 right, 1 left main.

The ultimate analysis of a composite sample made by combining face samples 67996, 68019, and 68020 is given under laboratory No. 29991.

System of mining, room and pillar. In 1917 the coal was undercut by electric chain machines and shot down with permissible explosive at any time of the day by shot firers. Steel tipples with self-dumping cages were in use. Electric safety lamps were used by miners, and electric lighting on the main roads. Haulage was by electric motor. The mine was sprinkled regularly. A large area of coal remained to be mined, and most of the future tonnage was to be from advance work. The coal was picked in the cars by four pickers and shipped as run of mine. There were four loading tracks, with a total capacity for 75 empty railroad cars. The production capacity was 1,200 tons a day, although at time of sampling, owing to railroad conditions, the production only averaged about 500 tons.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 261, 993, and Bull. 85, pp. 116 and 355.

HEMPHILL. WELCH MINE.

Analyses 26582 to 26587 (p. 89). Semibituminous coal, Pocahontas field, from Welch mine, a drift mine, at Hemphill, ½ mile west of Welch, on a short spur from the main line of the Norfolk & Western R. R. Coal bed, Welch; Carboniferous (Pottsville) age, New River series. The bed lies practically flat; average thickness, about 3 feet 9 inches; roof, hard, firm shale; floor, called sandstone, but probably sandy shale. Material from roof and floor did not become mixed with the coal when mined. The bed was sampled by E. H. Denny and W. B. Plank on November 10, 1916, as described below:

Sections of coal bed in Welch mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	26582	26583	26584	26585	26587
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal, soft	11	11¾	11½	11	....
"Sulphur" band	....	1/16	....	....	....
Coal, hard	2¾	2¾	3½	1 4½	....
Coal	2 4¼	1 11	1 11	1 1	4 9
Coal and "sulphur" band	....	½	....	....	....
Coal	....	5	....	....	....
Floor, hard, sandy shale.					
Thickness of bed	3 6	3 7 1/16	3 2	3 4½	4 9
Thickness of coal sampled	3 6	3 7 1/16	3 2	3 4½	4 9

Section A (sample 26582) was cut at face of 14 left entry, main entry, just in by 35 room and 6,750 feet south 20° west from the drift mouth. Section B (sample 26583) was cut in the last cutthrough to the air course in 25 room, 200 feet off 15 left air course and 6,850 feet south 25° west from drift mouth. Section C (sample 26584) was cut in the face of 1 right entry, tunnel entry, and 2,250 feet south 2° east from the drift mouth. Section D (sample 26585) was cut from face of main entry, 400 feet inby 16 entry and 6,900 feet south 36° west from drift mouth. Section E (sample 26587) was cut from 14 room pillar of 13 entry, 150 feet from 13 entry and 5,900 feet south 24° west from drift mouth.

The ultimate analysis of a composite sample made by combining face samples 26582, 26583, 26584, and 26585 is given under laboratory No. 26586.

System of mining, room and pillar. In 1916 the coal was undercut by machine, and FFF black powder was used in shooting down the coal, also in brushing the roof or floor. Haulage underground was by electric locomotive and by mule. Carbide miner's lamps were used. At the time of sampling the output was 500 tons a day, of which the greater part was to be derived from advance workings. The actual daily capacity of the mine was said to be 800 tons. All of the coal was shipped as run of mine. Two pickers were employed on the cars. There was one loading track, with a capacity of 15 loaded and 25 to 30 empty cars. About 150 acres were still to be mined. The estimated lifetime of the mine was 12 to 15 years at the 1916 rate of output.

Jenkinjones. Jenkinjones No. 6 Mine.

Analyses 68096, 68090, 68083, and 30160; also car sample 30256 (p. 90). Semibituminous coal, Pocahontas field, from Jenkinjones No. 6 mine, a drift mine at Jenkinjones at the terminus of the Tug River branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 7 to 14 feet thick; roof, 1 to 6 inches "draw slate," then smooth black shale; floor, hard, gray shale. There is one persistent bone-coal parting 2 to 4 inches thick, which is partly picked out in the mine or on railroad cars. Commercial samples were taken at tidewater by N. H. Snyder on December 19 to 22, 1917. The bed was sampled by C. A. Allen on December 31, 1917, as described below:

Sections of coal bed in Jenkinjones No. 6 mine.

Section	A.		B.		C.	
Laboratory No.	68083		68096		68090	
	Ft.	in.	Ft.	in.	Ft.	in.
Roof, shale.						
Coal		9½		10	2	3
Coal, gray		1½		6		6
Coal		8½		8½		3
"Mother coal"		½	.....		.....	
Bony coal	.....			½		¾
Coal	1	5		9½		2¼
Bony coal		a 1		½		a 2
Coal		2	2	0	2	9
Bony coal		a 3		a 4		a 2½
Coal		5		8½	2	7½
Coal, gray		2	.....		.....	
"Mother coal"	.....			½	.....	
Coal	1	10½	1	10	.....	
Bony coal		a ½	.....		.....	
Coal, gray	.....			1½	.....	
Coal	2	9	3	3½	.....	
Floor, shale.						
Thickness of bed	8	10	11	3	9	0
Thickness of coal sampled	8	5½	10	11	8	7½

a Not included in sample.

Section A (sample 68083) was cut in 29 room, 14 double entry. Section B (sample 68096) was cut on 19 pillar, M-13 entry. Section C (sample 68090) was cut at face of 3 room, H-10 entry. The ultimate analysis of a composite sample made by combining samples 68096, 68090, and 68083 is given under laboratory No. 30160.

This mine has three openings, with tracks leading to one tipple. The openings are called 6–1, 6–4, and 6–8.

System of mining, room and pillar, in panels. In 1917 the men employed numbered 125 underground and 15 on surface. The coal was cut by machine in coal above the floor and shot down with permissible explosives at any time during the shift by the miners. The miners used a pocket battery for firing the holes. The haulage was by two 15-ton electric motors and 11 gathering motors. Some pieces of roof and floor became mixed with the coal in shipping. There was a wooden tipple, with no cage. Electric power was bought from the railroad company. Impurities in the bed comprised bone streaks and "mother coal." About 45 per cent of the coal was taken in advance work, and a high recovery was made. All of the coal was shipped as run of mine and was picked on belt by seven pickers. There were no storage bins. The appearance of lump coal on cars was fair. There was one loading track, which had capacity for a large number of cars. The coal was dumped onto a plunger feeder, then onto a retarding conveyor, which took it down the hill, and then over bars about 4 inches apart, which took out sizes from egg to slack; these sizes were conveyed to the car by one conveyor. The oversize, or lump, passed over the screens to a second picking conveyor, on which seven pickers worked. From the picking belt the lumps joined the first coal just as it fell into the car. About 1,500 acres remained unmined, insuring long life to the mine. About three-quarters of the tonnage was from solid work. The maximum day's run was 2,000 tons and the average daily shipments at time of sampling, 1,350 tons.

For descriptions and analyses of other samples of this coal see Bureau of Mines Bull. 85, pp. 116, 355; and Bull. 123, pp. 122, 413.

JENKINJONES. JENKINJONES NO. 7 MINE.

Analyses 67985, 67987, 68029, 68028, 68099, and 30170, and car sample 30244 (p. 90). Semibituminous coal, Pocahontas field, from Pocahontas (or Jenkinjones) No. 7 mine, a drift mine at Jenkinjones, at the terminus of the Tug River branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 6 to 14 feet thick, dip 2° west; roof, 2 inches "draw slate," above which is hard shale; floor, smooth, dark gray shale, soft in places. There is one persistent bone parting about 4 feet from floor. Rolls and horsebacks are frequent. Commercial samples were taken at tidewater by N. H. Snyder on January 14 to 28, 1918. The bed was sampled by C. A. Allen and S. P. Holt on December 29, 1917, as described below:

Sections of coal bed in Jenkinjones No. 7 mine.

Section	A.		B.		C.	
Laboratory No.	68029		67987, 68099		67985	
Roof, "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		6	2	6	1	10½
"Sulphur" band		a1		a½		
Coal	1	10		1		
Bony coal		1½		a½		a7½
Coal	1	3½		9	4	2
Bone		a2		a3		
Coal		4	1	3½		
"Mother coal"		¼		a¼		
Coal		3½		6½		
Bone		¼		a1		
Coal	1	4	2	2½		
Bony coal		a2				
Coal	1	4				
"Rash"				a10		a7
Floor, shale.						
Thickness of bed	7	6	8	7¾	7	3
Thickness of coal sampled	7	1	7	4½	6	½

a Not included in sample.

Section A (sample 68029) was cut in dip entry near 1 cross entry. Section B (samples 67987 and 68099) was cut at face of 11 room, D–4, main entry. Section C (sample 67985) was cut at face of 1 room, 1 right air course.

Sample 68028 covers analysis of screened bone sample from same location as section A, the rejected portions of sample being picked down and screened through a half-inch screen. The oversize, taken as sample, showed 17.3 per cent ash.

The ultimate analysis of a composite sample made by combining face samples 67985, 67987, 68028, 68029, and 68099 is given under laboratory No. 30170.

System of mining, room and pillar. Coal was undercut by machine. Haulage was by electric motor around the side of the mountain to a 2,000-ton wooden tipple. The coal was all shipped as run of mine. It was picked on a belt by eight pickers as it passed to car conveyor. The company owns 20,000 acres of coal in the vicinity. The probable lifetime of the mine was many years. The capacity of the mine was 1,200 tons a day, and the average output in 1917 was 750 tons a day.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 123, pp. 122, 413.

JENKINJONES. JENKINJONES NO. 8 MINE.

Analyses 68093, 68089, 68095, 68088, and 30172; also car sample 30239 (p. 90). Semibituminous coal, Pocahontas field, from Jenkinjones No. 8 mine, a drift mine, at Jenkinjones, at the terminus of the Tug Fork branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous age, Lower Pottsville series, Pocahontas formation. The bed is 5 to 14 feet thick and dips 10° northwest. Rolls or horsebacks are few. Roof, hard and smooth of black shale; floor, dark-gray shale, smooth and hard. Commercial samples were taken at tidewater by N. H. Snyder, on January 14 to 28, 1918. The bed was sampled by J. J. Bourquin on December 31, 1917, as described below:

Sections of coal bed in Jenkinjones No. 8 mine.

Section	A.		B.		C.		D.	
Laboratory No.	68093		68089		68095		68088	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, hard shale.								
Coal, burned to roof						1		
Coal	2	5½			2	9	3	3¼
Coal, gray, bony				¾				
Coal, gray, too soft to leave		1½						
Coal		10	1	5¼				
Bone		[a]5		[a]3		[a]6		[a]9¼
Coal		2½	1	6		11	1	3
Coal, gray		1¼						
Bony coal			[a]1	1		[a]5½		
Bony coal		9						
Coal			1	5		11		
Bone						[a]3		
Coal						7		
Bone						[a]½		
Coal						9		
Floor, shale.								
Thickness of bed	4	10¾	5	9	7	3½	5	3½
Thickness of coal sampled	4	5¾	4	5	6	0	4	6¼

[a] Not included in sample.

Section A (sample 68093) was cut at face of G–4 heading. Section B (sample 68089) was cut at face of G–3 heading. Section C (sample 68095) was cut at face of 18 room, off G–2 entry, 7–1 mine, off 8. Section D (sample 68088) was cut at face of right air course, G triple entry.

The ultimate analysis of a composite sample made by combining face samples 68088, 68089, 68093, and 68095 is given under laboratory No. 30172.

System of mining, room and pillar. In 1917 the coal was cut by machine in the streak of bone about 3 feet from floor and was shot down by permissible explosive and black powder. Haulage was by electric motors, there being one main line locomotive and seven gathering motors, using reel and cable. The tipple was wood. Practically all coal was shipped as run of mine, although about 60 per cent of the output was run through screens in order to facilitate picking. The slack was screened through 1½-inch openings in 12-foot bar screens. The egg, nut, and lump was picked on tables by eight pickers, and three pickers were employed on the slack. The coal was then reassembled as run of mine. The lumps varied in size from 3 or 4 inches up. There was one loading track, with capacity for 30 empty and 30 loaded railway cars. The probable lifetime of the mine was 50 years, and the tonnage was to be mostly derived from advance work for some time. The average daily output of the mine at time of sampling was 3,000 tons, and the maximum day's run was 4,140 tons. This mine was sampled in 1914.

For description and analyses of other samples of coal from this mine, see Bureau of Mines Bull. 123, pp. 122, 413.

KIMBALL (VIVIAN). CARSWELL MINE.

Analyses 68033, 68034, 68035, and 30006; also car sample 30591 (p. 91). Semibituminous (?) coal, Pocahontas field, from Carswell mine, a shaft mine 2 miles from Kimball, on the Norfolk & Western R. R. Two seams are worked, Pocahontas Nos. 3 and 4, with an interval of 60 feet between them; Carboniferous (Pottsville) age, Pocohontas formation. Average thickness of bed is 4 to 5½ feet, with a persistent bone parting near the middle and a ½-inch band of "sulphur" above. Both beds are worked by the 300-foot shaft, No. 4 bed being 60 feet vertically above No. 3. Main roof, sandstone; immediate roof, 20 feet of clayey shale; floor, hard shale. Samples were collected from cars at tidewater by N. H. Snyder on January 28 to February 1, 1918. The No. 3 bed was sampled by J. W. Paul on December 29, 1917, as described below:

Sections of Pocahontas No. 3 coal bed in Carswell mine.

Section	A.	B.	C.
Laboratory No	68034	68035	68033
Roof, "draw slate" and coal.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal with streaks of "mother coal"	1 7½		
Coal		[a] 4½	2 0
Shale, clayey		[a] 7½	
Coal, with streaks of "mother coal"		1 8¾	
Bone	[a] 3	[a] 3¼	[a] 3¼
Coal	3 1½	8¾	
Shale			[a] 10½
Coal, gray		1 3¼	
Coal		1 3¾	10¾
Floor, not noted.			
Thickness of bed	5 0	6 3	4 ½
Thickness of coal sampled	4 9	5 0	2 10¾

[a] Not included in sample.

Section A (sample 68034) was cut at face of 3 right, off main east, 400 feet from shaft. Section B (sample 68035) was cut at face of 4 left, 500 feet from main west. Section C (sample 68033) was cut at face of 3 right, 350 feet from main west.

The ultimate analysis of a composite sample made by combining samples 68033, 68034, and 68035 is shown under laboratory No. 30006.

System of mining, room and pillar, in panels. In 1917 the coal was undercut by machine in the bottom coal; pieces of the roof and floor became mixed with the coal in mining. About 30 per cent of coal was taken out in advance work. Men employed at time of sampling numbered 75 to 100 underground and 15 to 20 aboveground. The tipple was steel, with self-dumping cage. Haulage was by four electric and one storage-battery locomotive. The mine had five rooms turned off; all tonnage came from these rooms and the entries. The coal was shot down by permissible explosives, which were fired by the miners at any time during shift. The coal was all shipped as run of mine and was picked on railroad cars by three pickers. There were no storage bins. There were four loading tracks, with capacity for 60 loaded and 60 empty cars. The cars were loaded from No. 3 bed, and the car sample represents six cars. There was a new steel tipple, with loading boom and picking tables, not in use at time of sampling. There were still about 1,000 acres to be worked. The estimated lifetime of the mine was 30 to 40 years. The capacity of the mine was 1,500 tons a day, and daily average output was 500 tons, which was to be increased.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 123, pp. 123, 417.

LICK BRANCH. DELTA MINE.

Analyses 67967, 67891, 67894, and 29911; also car sample 30260 (p. 91). Semibituminous coal, Pocahontas field, from Delta mine, a drift mine ½ mile east of Lick Branch, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 6 to 8 feet thick; no faults, rolls, or horsebacks. Roof, very good, hard, smooth shale; floor, good, hard, smooth shale. A commercial sample was collected at tidewater by N. H. Snyder on December 19, 1917, to January 1, 1918. The mine was sampled by C. A. Allen on December 20, 1917, as described below:

Sections of coal bed in Delta mine.

Section Laboratory No.	A. 67967		B. 67891		C. 67894	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal	1	6	1	5	1	7
Bone		[a] 4		[a] 4		[a] 1½
Coal		3		2		3
Bony or gray coal		1½		[a] 1½		[a] 2
Coal	2	2	2	2	2	0
Bone		[a] 3		[a] 3½		1
Coal	1	11½	1	10	2	4½
Floor, shale.						
Thickness of bed	6	7	6	4	6	7
Thickness of coal sampled	6	0	5	7	6	3½

[a] Not included in sample.

Section A (sample 67967) was taken from 8 room, 10–5 left entry. Section B (sample 67891) was taken from first left main heading, 300 feet from main entry. Section C (sample 67894) was taken from 2 room, 3 left cross entry.

The ultimate analysis of a composite sample made by combining samples 67967, 67981, and 67984 is given under laboratory No. 29911.

System of mining, room and pillar. In 1917 the coal was undercut by machine and shot down with black powder and permissible explosives by the miners during shift. The undercutting was done in the coal. Men employed numbered 75 underground and 24 aboveground. Impurities comprised considerable bone, gray coal, and "mother coal." The coal passed over bar screens with 1-inch openings and over shaking screens with ¾-inch holes, and was dumped into a chute to a plunger feeder, which fed it over 1½-inch bars 10 feet long and 6 feet wide; the oversize went to a 4-foot picking conveyor, at which were 10 pickers. The undersize from bars passed over two 5 by 6 foot shaking screens with ¾-inch holes and went directly to a 2½-foot picking conveyor, the oversize feeding on top of the undersize; four pickers worked on this conveyor. After being picked with care, all sizes were run into the car together. Track capacity was 30 loaded and 40 empty railroad cars. Haulage was by two 15-ton electric motor and five 6-ton gathering electric motors. About 45 per cent of the coal was taken out in advance work and the recovery was high. The lease covers about 600 acres, and the estimated lifetime of the mine was 15 to 20 years. The daily average output of the mine at time of sampling was 1,300 tons; capacity, 1.350 tons.

MARYTOWN. MARYTOWN MINE.

Analyses 68002, 68003, and 29918, and tipple samples 70195 to 70198 (p. 314). Semibituminous coal, Pocahontas field, from Marytown mine, a drift mine at Marytown on the main line of the Norfolk & Western R. R. Coal bed, Sewell seam; Carboniferous (Pottsville) age, Sewell formation. Bed is 3 feet 4 inches to 4 feet 6 inches thick, with a shale parting; roof, hard, dark, sandy shale with smooth surface; floor, hard shale. Particles from the roof and floor did not become mixed with the coal in mining. Rolls and horsebacks are frequent. The vertical depth from surface to the coal was about 200 feet and over. Elevation of mine above sea level, about 1,300 feet. Commercial samples were taken at the tipple by J. J. Bourquin and S. S. Shirkey on September 17, 1918. The bed was sampled by G. H. Ashley on December 29, 1917, as described below:

Sections of coal bed in Marytown mine.

Section	A.		B.	
Laboratory No.	68003		68002	
	Ft.	in.	Ft.	in.
Roof, shale.				
Coal	3	1	3	1
Bone and shale		a7	a1	0
Coal		5		5
Floor, slate.				
Thickness of bed	4	1	4	6
Thickness of coal sampled	3	6	3	6

a Not included in sample.

Section A (sample 68003) was cut in 4 crosscut, off 1 main. Section B (sample 68002) was cut in 6 crosscut, off 14 left.

An ultimate analysis of a composite sample made by combining face samples 68002 and 68003 is given under laboratory No. 29918.

System of mining, room and pillar. In 1917 the coal was undercut by machine. Cars were gathered by mules and hauled to head house by three 12-ton and two 8-ton electric locomotives. Coal was lowered to tipple, across railroad tracks and creek, by a conveyor. The coal was shot down during shifts with black powder and permissible explosive by the miners. The output was all being shipped as run of mine. The tipple was equipped with screens for 3½-inch lump, 2½-inch egg, and ¾-inch nut. The coal was picked on railroad car, one picker being employed. There were no storage bins. There were four loading tracks, with capacity for 35 empty and 30 loaded railroad cars. Future production was to come mostly from advance work. About 85 per cent recovery was claimed. The estimated life time of the mine was 15 years. Number of acres still unmined, 500. The daily average output of the mine in 1917 was 520 tons and the maximum day's run 1,100 tons.

For descriptions and analyses of other samples of coal from this mine see Bureau of Mines Bull. 22, pp. 264, 999.

McDOWELL. McDOWELL MINE.

Analyses 68006, 68007, 68010, and 29988; also car samples 68645 to 68646 (p. 91). Semibituminous coal, Pocahontas field, from McDowell mine, a drift mine 1 mile east of McDowell, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3, Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4 feet 9 inches to 5 feet 9 inches thick; dip, northwest; roof, about 4 inches clayey shale over coal, some "draw slate," and shale; floor, hard, smooth shale. Pieces from roof and floor have some tendency to become mixed with coal in shipping. Commercial samples were taken from cars at tidewater by N. H. Snyder on February 7 to 28, 1918. The bed was sampled by R. H. Seip on December 27, 1917, as described below:

Sections of coal bed in McDowell mine.

Section	A.		B.		C.	
Laboratory No.	68006		68007		68010	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal		11½	1	1½		11½
Bone		[a] 3		[a] 2		[a] 3½
Coal	4	1½	2	11	3	2¼
"Sulphur"				[a] ½		[a] ¾
Coal			1	0	1	½
Floor, shale.						
Thickness of bed	5	4	5	3	5	6½
Thickness of coal sampled	5	1	5	½	5	2¼

[a] Not included in sample.

Section A (sample 68006) was cut on 8 pillar, Spain heading, off Pennsylvania main. Section B (sample 68007) was cut at face of 8 room, off Bluefield heading, Ohio district. Section C (sample 68010) was cut at face of Egypt crossheading, off Germany main, Pennsylvania district.

The ultimate analysis of a composite sample made by combining face samples 68006, 68007, and 68010 is given under laboratory No. 29988.

System of mining, by panels. Thirty-five per cent of the coal was taken on the advance, and the balance by pillar-robbing; coal recovery claimed, 96 per cent. Men working numbered 112 underground and 70 aboveground, including coke ovens. Haulage was by three hauling motors, four gathering motors, and mules. The coal was cut by machine and by pick and shot down by FFFF black powder, permissible explosive being used for brushing. The bed carries a streak of bone about 3 feet from floor and varying streaks of "sulphur." Considerable picking on tables and on car was done by 12 pickers on tables and 8 on cars. About 40 per cent of the coal was shipped as run of mine. For large and nut sizes, 24-foot bar screens, with 3½ to 4 inch spaces, and smaller screens, with 1½-inch and ½ to ¾ inch openings, were used. The screenings were coked to the extent of 200 tons of coke a day. The storage bins had capacity for 500 tons slack. The lumps were large and of good appearance on cars. There were four loading tracks, with capacity for 45 empties and 85 loaded cars. Capacity of mine was 1,800 tons a day; average production in 1917 was 900 tons a day.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 263, 997.

NEWHALL. BERWIND NO. 6 MINE.

Analyses 68075, 68066, and 29981, and car sample 30235 (p. 92). Semibituminous coal, Pocahontas field, from Berwind No. 6 mine, a drift mine ½ mile northwest of Newhall, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 5 to 6 feet thick; dip of bed, 3° to 4° northwest; roof, hard fire clay 4½ to 6 feet thick, which disintegrated rapidly; floor, hard fire clay with smooth surface. Commercial samples were taken at tidewater by N. H. Snyder on February 1 to 21, 1918. The bed was sampled by R. H. Seip on January 3, 1918, as described below:

Sections of coal bed in Berwind No. 6 mine.

Section	A.	B.
Laboratory No.	68075	68066
	Ft. in.	*Ft. in.*
Roof, hard fire clay.		
Coal	4 0	4 0
Bone	a 3	a 2
Coal	11	7
Bone	a 3	a 3
Coal	a 7	a 6
Floor, fire clay.		
Thickness of seam	6 0	5 6
Thickness of coal sampled	4 11	4 7

a Not included in sample.

Section A (sample 68075) was cut at face of 1 left. Section B (sample 68066) was cut at face of 1 right.

The ultimate analysis of a composite sample made by combining face samples 68075 and 68066 is given under laboratory No. 29981.

System of mining, room and pillar. In 1918 the coal was undercut by machine and shot down during shifts by FFF black powder and permissible explosive by the miners. The mouth of the mine is 1,577 feet above sea level. Men employed numbered 50 underground and 12 on the surface. Haulage was by five motors. The recovery claimed was about 95 per cent of the total coal in bed. There were 6,000 acres still unmined, and the lifetime was estimated at 25 years. The coal was all shipped as run of mine. Three pickers were employed on cars. There were two loading tracks, with capacity for 100 empty and 70 loaded railroad cars. The bottom coal was loaded out separately and sent to a washery. The capacity of the mine was 600 tons a day, and the average production at time of sampling was 450 tons a day, which was to be increased rapidly.

NEWHALL. BERWIND NO. 7 MINE.

Analyses 68146, 68148, 68164, and 30168 and car sample 30259 (p. 92). Semibituminous coal, Pocahontas field, from Berwind No. 7 mine, a drift mine ½ mile southeast of Newhall, on the Dry Fork branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Potstville) age, Pocahontas formation. Bed is 5 to 6 feet thick and dips 4° northwest. No faults, rolls, or horsebacks were encountered. Roof, "draw slate," then sandy shale; floor, shale. Near top of seam was a persistent band of "rash" or slightly bony coal, averaging about 6 inches wide, and near bottom was a persistent streak of bone; in places the bed contained a still lower streak of bone. Pieces from roof and floor become mixed with the coal in shipping. Commercial samples were taken at tidewater by N. H. Snyder on December 19 to 20, 1917. The bed was sampled by C. A. Allen on January 3, 1918, as described below:

Sections of coal bed in Berwind No. 7 mine.

Section	A.	B.	C.
Laboratory No.	68148	68146	68164
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, shale.			
Coal	3	2	....
"Rash" or slightly bony coal	4	4	a 6
Coal	1 6	4 0	1 8
Coal, gray	1½	....	1½
Coal	2 3½	....	2 2½
Bone	a 4	a 4½	a 4
Coal, slightly bony	3	....	....
Coal	10	10½	4
Bone	a 1	....	....
Bottom coal	a 6	a 5	4
Floor, shale.			
Thickness of bed	6 6	6 2	5 6
Thickness of coal sampled	5 7	5 4½	4 8

a Not included in sample.

Section A (sample 68148) was cut in 11 room neck, 2 left. Section B (sample 68146) was cut in main entry, 12 feet beyond 5 right. Section C (sample 68164) was cut in 3 right, opposite 12 room.

The ultimate analysis of a composite sample made by combining face samples 68146, 68148, and 68164 is given under laboratory No. 30168.

System of mining, room and pillar. In 1918 the coal was cut by machine in the bottom coal and shot down during shift with permissible explosives and a little black powder by the miners. Men employed numbered 75 underground and 10 on the surface. Haulage was by one 18-ton motor and four 6-ton motors. There was a steel tipple. In some places just above the coal is black "draw slate," which is difficult to separate. The bottom 6 inches of coal was higher in ash, and as it was cut by machine the cuttings were loaded out and sent to washery at No. 1 mine. Shale and some bone was discarded by miners; if a car had much impurity it was sent to washery. The coal was all shipped as run of mine, except screenings, which were sent to washery and coked. Fifty tons of coke were produced daily. There were two tracks, with capacity for 30 or more empty and 20 loaded railroad cars. The appearance of the coal on cars was fair. The mine had a large acreage still unmined. About 40 per cent of the coal was taken out in advance work. One-quarter of the tonnage was coming from pillars. The capacity of the mine was 750 tons a day; average shipments at time of sampling, 500 tons a day.

NEWHALL. BERWIND NO. 8 MINE.

Analyses 68071, 68078, 68079, and 29977 and car sample 30262 (p. 92). Semibituminous coal, Pocahontas field, from Berwind No. 8 mine, a drift mine 1½ miles east of Newhall, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 5 to 6 feet thick; roof, 3 inches of fire clay, 6 feet of "draw slate," and sandstone; floor, clay and shale. Commercial samples were taken at tidewater by N. H. Snyder on February 11 to 27, 1918. The bed was sampled by S. P. Holt on January 3, 1918, as described below:

Sections of coal bed in Berwind No. 8 mine.

Section	A.		B.		C.	
Laboratory No.	68079		68078		68071	
Roof, "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal		7¼	4	6½	4	3½
"Mother coal"		½				
Coal	3	6¼				
Bone		[a]3		[a]2		[a]3
Coal		9		8		11
Floor, clay.						
Thickness of bed	5	2	5	4½	5	5½
Thickness of coal sampled	4	11	5	2½	5	2½

[a] Not included in sample.

Section A (sample 68079) was cut at face of main heading. Section B (sample 68078) was cut at face of 3 right. Section C (sample 68071) was cut at face of 1 right.

The ultimate analysis of a composite sample made by combining face samples 68071, 68078, and 68079 is given under laboratory No. 29977.

In 1918 the capacity of the mine was 300 tons a day, and the actual average at time of sampling was 250 tons. It was expected to increase the output to 400 tons a day. Men employed numbered 52 underground and 11 aboveground. Two coal-cutting machines were employed, and four electric locomotives. The coal was all shipped as run of mine. The coal was picked on cars by three pickers. The storage bins had capacity for 40 tons. There was one loading track, with capacity for 30 empty and 47 loaded cars.

RODERFIELD. PREMIER POCAHONTAS NOS. 1, 2, AND 3 MINES.

Analyses car samples 69658, 69659, 69492, 69493, 69020, and 69021 (p. 93). Bituminous coal, Pocahontas field, from Premier Pocahontas mines Nos. 1, 2, and 3, drift mines close to each other, near Roderfield, on a branch of the Norfolk & Western R. R. Coal beds; Welch and Sewell; Carboniferous (Pottsville) age, Sewell formation. Car samples were taken at tidewater by H. W. Jarrett and N. H. Snyder on February 21 to July 3, 1918; June 6 to 19, 1918, and February 18 to April 11, 1918

RODERFIELD. PREMIER POCAHONTAS NO. 4 MINE.

Analyses 70223 and 70224, average of face samples; analyses 70225 to 70228, average of tipple samples, and analysis 30590, car sample (p. 93). Semibituminous coal, Pocahontas field, from Premier No. 4 mine, a drift mine 5 miles east of Roderfield, on the Norfolk & Western R. R. Coal bed, Welch, or No. 6; Carboniferous (Pottsville) age, Sewell formation. Bed is 3 feet 2 inches to 5 feet thick; dip, north 35° west to northwest; roof, hard, black shale; no "draw slate"; floor, hard, smooth black shale. The bed was sampled by S. S. Shirkey on September 20, 1918, as described below. Tipple samples were taken at car loading by J. J. Bourquin on September 20, 1918. Car samples were taken at tidewater by N. H. Snyder on January 15 to February 18, 1918.

Sections of coal bed in Premier No. 4 mine.

Section	A.		B.	
Laboratory No.	70224		70223	
	Ft.	in.	Ft.	in.
Roof, hard, black shale.				
Coal, soft		11	1	0
Coal, hard		3		3
Coal, soft	2	2	2	7
Floor, hard, black shale.				
Thickness of bed	3	4	3	10
Thickness of coal sampled	3	4	3	10

Section A (sample 70224) was cut from face of 1 left entry, 1 right entry, 2,300 feet from main opening. Section B (sample 70223) was cut from face of 3 left air course, 4,400 feet from main opening.

The mine is opened on the panel system. In 1918 the coal was undercut with pick and shot down at any time during the shift with black powder by the miners. Men employed, 40 underground and 7 aboveground. The coal was dumped over a wooden tipple; none of it was shipped as run of mine. About 65 per cent of it passed through bar screens having 3½-inch openings; sizes above this were recombined in loading. Haulage was by two electric locomotives. The coal was cleaned on the railroad cars by four pickers. There were two loading tracks, with capacity for 22 empty and 22 loaded railroad cars. The coal as loaded on the cars was very clean. About 50 per cent of the coal was taken out in the advance work, and the total recovery claimed was 95 per cent. The unmined area consisted of 800 acres. The estimated lifetime of the mine was 40 years. The capacity of the mine at time of sampling was 750 tons a day, and the average daily output was 350 tons. The coal was being shipped to tidewater coal exchange and used for steam purposes.

For descriptions and analyses of other samples of this coal see Bureau of Mines Bull. 22, pp. 267, 1007, 1008.

TWIN BRANCH. J. B. B. (OR MAHER) MINES NOS. 1, 2, 3, 4, AND 5.

Analyses 29681, 68001, 68004, 67997, 67999, 67998, and 29919; also car samples 69039, 69040, 68905, 68906, and 30243 and average of tipple samples 70275 to 70278 (p. 93). Semibituminous coal, Pocahontas field, from J. B. B. (or Maher) group of five adjacent mines, drift mines, about 1 mile north of Twin Branch post office, on a branch line of the Norfolk & Western R. R. Coal bed, Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 2 to 3¾ feet thick; dip, 2 per cent northwest; roof, hard, black shale; floor, hard, shaly underclay with smooth surface. The bed was sampled by G. H. Ashley on December 27, 1917, as described below. Car samples were taken by N. H. Snyder on January 14 to February 1, 1918; February 7 to April 2, 1918, and March 5 to April 22, 1918. Tipple samples were taken by S. S. Shirkey on September 23, 1918.

Sections of coal bed in J. B. B. (or Maher) mines.

Mine No.	1		2		3		4		5		6	
Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	68001		68004		29681		67998		67999		67997	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.												
Coal	3	3	2	2	3	2	3	6	3	2	3	6
Floor, clay.												
Thickness of bed	3	3	2	2	3	2	3	6	3	2	3	6
Thickness of coal sampled	3	3	2	2	3	2	3	6	3	2	3	6

Section A (sample 68001) was taken from No. 1 mine, in 4 northwest entry. Section B (sample 68004) was cut in No. 2 mine, in 3 right entry, left, off 2 main. Section C (sample 29681) was cut in No. 3 mine, in 2 right, off 4 main. Section D (sample 67998) was cut in No. 4 mine, in 5 room, 3 left, 13 right. Section E (sample 67999) was cut in No. 4 mine, in 13 left, off straight entry. Section F (sample 67997) was cut in No. 5 mine, in 3 right, off main.

The ultimate analysis of a composite sample made by combining face samples 68001, 68004, 67997, 67998, 67999, and 29681 is given under laboratory No. 29919.

System of mining, room and pillar. In 1917 open carbide lamps were used. Haulage was by mules and electric motors. The mines were moist. The coal was brought down by black powder and shot by the miners during the shift; permissible explosive was used in brushing roof. The coal was undercut by machine in streak of bony coal near bottom of seam. Some of the roof and floor became mixed with the coal in shipping. About 45 per cent of the coal was taken out in advance work, and a total recovery of 80 to 95 per cent was claimed. There were about 4,000 to 5,000 acres yet to be mined, and the estimated lifetime of the mine was 18 years. At the time of sampling a large portion of the coal was being derived from pillars. The maximum day's run was 2,000 tons, and the capacity was from 1,200 to 1,400 tons a day. About 30 per cent of the output was shipped as run of mine, and the remainder was screened through 4-inch, 2-inch, and 1-inch holes. The appearance of the coal on cars was good and clean; the lumps were moderately large. The track capacity was 65 empty and 65 loaded railroad cars.

For descriptions and analyses of other samples from No. 2 mine, see Bureau of Mines Bull. 22, pp. 270, 1013, and from No. 4 mine see Bureau of Mines Bull. 123, pp. 123, 415.

VIVIAN. KING MINE.

Analyses 68024, 68025, 68027, 68030, and 29974 and car sample 30261 (p. 94). Semi-bituminous coal, Pocahontas field, from King mine, a slope mine at Kimball station, near Vivian, on the Norfolk & Western R. R., on Laurel Creek, 9½ miles from Welch and ½ mile west of West Vivian. Coal beds, Pocahontas Nos. 3 and 4; Carboniferous (Pottsville) age, Pocahontas formation. Between the beds is an interval of 85 feet. No. 4 bed had just been opened and no samples were taken from it. Thickness of No. 3 bed, 5 to 5½ feet; No. 4 bed, 4 feet. Dip of both beds is west. The mine is gaseous. Roof, 4 to 9 inches "draw slate," 1 to 2 inches coal, 6 to 18 inches black shale; floor, hard shale with smooth surface. Some particles from the floor became mixed with the coal in mining. Depth from surface at point where samples were taken, about 1,300 feet. Commercial samples were taken at tidewater on February 6 to March 5, 1918, by N. H. Snyder. The bed was sampled by C. A. Allen on December 26, 1917, as described below:

Sections of Pocahontas No. 3, coal bed in King mine.

Section	A.		B.		C.	
Laboratory No.	68030		68024		68025	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.						
Coal	1	9		4	1	9½
Bone		*a* 3				
"Mother coal"				½		
Coal, slightly bony						1½
Coal	3	3	1	3	3	1
Bone				*a* 2½		
Coal			1	10		
"Mother coal"				½		
Coal				½		
"Mother coal"				½		
Coal			1	4		
Floor, shale.						
Thickness of bed	5	3	5	1	4	11
Thickness of coal sampled	5	0	4	10½	4	11

a Not included in sample.

Section A (sample 68030) was cut in 9 room, 9 cross entry, off main. Section B (sample 68024) was cut in 6 north, at 12 heading. Section C (sample 68025) was cut at face of 5 room, 8 cross entry. Sample 68027 was a sample of bone coal picked out of streaks from sections A and B.

The ultimate analysis of a composite sample made by combining samples 68024, 68025, 68027, and 68030 is given under laboratory No. 29974.

System of mining, room and pillar. In 1917 the coal was shot down with black powder by shot firers during the shift; holes might be loaded by the miner. The coal was undercut by machine and by hand. Haulage was by mule, electric motors, and two 15-ton and two 5-ton locomotives. There were 300 men employed underground and 40 aboveground. At the wooden tipple the coal was elevated by a 6-foot conveyor and discharged over two chutes 6 feet wide. One of these had ¾-inch spaced bars for taking out slack, which was shipped without further grading. When making fully prepared sizes, 4-inch spaced bars were placed in the bottom of the chutes, the oversize going over a picking belt to the railroad car and the undersize going over two 6 by 16 foot shaking bar screens. The top screen, for egg coal, had 1½-inch spaces, and the bottom screen, for nut, had 1-inch spaces. When making prepared sizes, four men picked from egg coal, two from lump coal, and five on the cars. The inside conditions were good, but 4 to 6 inches of "draw slate," and sometimes a second layer of 9 to 18 inches, falls. The storage-bin capacity was 600 tons run of mine, 150 tons nut, and 150 tons egg size. The lumps were small. There were two loading tracks, having capacity for 31 empty and 46 loaded railroad cars. About 1,500 acres were still to be mined, and the estimated lifetime of the mine was 40 years. Half the future tonnage was to come from advance work and half from pillars. Capacity of the mine was 1,500 tons a day, and the average production in 1917 was 650 to 750 tons a day.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 271, 1016.

VIVIAN. TIDEWATER MINE.

Analyses 68005, 68009, 68008, and 29914; also car sample 30236 (p. 94). Semi-bituminous coal, Pocahontas field, from Tidewater mine, a drift mine at Vivian, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4½ to 5½ feet thick; roof, black shale and "draw slate" 8 to 10 inches thick, with cap rock of sandstone; floor, smooth, of massive, hard blue shale. A commercial sample was taken on the cars by N. H. Snyder on February 23, 1918. The bed was sampled by R. H. Seip on December 26, 1917, as described below:

Sections of coal bed in Tidewater mine.

Section	A.	B.	C.
Laboratory No.	68005	68008	68009
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, "draw slate."			
Coal	10	2	1 7½
"Mother coal"	½		
"Sulphur"		[a] ½	
Bone			[a] 2
Coal	9	1 7	
Shale			[a] 1
Bone	[a] 3	[a] 4	
Coal	3	2 11	3 4½
"Mother coal"	½		
Coal	2 5½		
Floor, shale.			
Thickness of bed	4 7½	5 ½	5 3
Thickness of coal sampled	4 4½	4 8	5 0

[a] Not included in sample.

Section A (sample 68005) was cut at face of main heading, at 23 cross entry. Section B (sample 68008) was cut from 5 pillar, 12 cross entry, 6 north. Section C (sample 68009) was cut at face of 26 room, 11 cross entry.

The ultimate analysis of a composite sample made by combining face samples 68005, 68008, and 68009 is given under laboratory No. 29914.

System of mining, room and pillar. In 1917 the coal was undercut by short-wall machines and shot down by FFF black powder by the miners during shift. There were 170 men employed underground and 25 on the surface. Haulage was by mule and electric locomotives, one main and three gathering. There was a persistent streak of bone 3 feet from floor, which the miners endeavored to pick out, also a few other streaks. In advance work 30 per cent of the coal was taken out and there was a total recovery of 95 per cent. All of the coal was shipped as run of mine. It was picked on belt and car by six pickers. There was one loading track, with capacity for 35 empty and 30 loaded cars. In December, 1917, 2,000 tons were turned over to the railroad, 3,150 tons sent to the Government at Lambert Point, Va., and the remainder was shipped to Indiana Harbor for use in by-product coke ovens. The capacity of the mine was 700 tons a day, and the daily average at time of sampling was 500 tons.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 22, pp. 271, 1015.

MARION COUNTY.

Chiefton. Consolidation No. 47 Mine.

Analyses 28570 to 28576 (p. 94). Bituminous coal, Fairmont field, from Consolidation No. 47 mine, a drift mine 1 mile from Chiefton, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 5½ feet to 7½ feet thick; the coal outcrops at about water level. A few faults and one roll are encountered. The bed was sampled by E. H. Denny on June 2, 1917, as described below:

Sections of coal bed in Consolidation No. 47 mine.

Section	A.	B.	C.	D.	E.	F.
Laboratory No.	28570	28571	28572	28573	28574	28575
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, "draw slate" and coal.						
Coal	2 1½	1 1½	2 1¼	1 7	1 3	2 ½
Shale	1	a ½	a 1	a 1	a 1½	a 1
Coal	3	3¼	3	3½	2¾	3¾
Shale	½	¼	a ¾	a ¾	a ¾	a ½
Coal	3½	3½	3¼	3¼	2¾	3
Shale	1	a 1½	a 1	a 1	a 1½	a 1
Coal	4 2	8¾	4 2	4 2½	2 2	4 2
"Sulphur," local	....	a 1¼	....	....	a 1	....
Coal	....	3 4	....	....	1 8½	....
Floor, fire clay.						
Thickness of bed	7 ½	6 ½	7 ¼	6 7	5 11½	6 11¾
Thickness of coal sampled	7 ½	5 9¼	6 9½	6 4¼	5 7¾	6 9¼

a Not included in sample.

Section A (sample 28570) was cut from 16 room, pillar 4 right, off main south. Section B (sample 28571) was cut from 9 room, pillar 3 right, 4 south. Section C (sample 28572) was cut from 16 room, pillar 4 right, off main south. Section D (sample 28573) was cut from 5 south, just inby 6 right. Section E (sample 28574) was cut from 22 room, 1 left, 5 south. Section F (sample 28575) was cut from 3 room, 10 left, main south face heading.

Ultimate analysis of a composite sample made by combining samples 28571 to 28575 is given under laboratory No. 28576.

System of mining, room and pillar, in panels, most of the output, however, being derived from pillars. In 1917 the coal was undercut by machine and shot down with permissible explosive by the miners at any time during the shift, one shot firer being employed to assist inexperienced men. There were 98 men employed underground and 20 above ground. Haulage was by mule and by three electric locomotives. The coal was dumped over a wooden tipple, about half the output being shipped as run of mine. The coal was screened through shaking screens having 1¼ and ¾ inch openings. Three pickers were employed to clean the coal on the railroad cars. The three loading tracks had capacity for 30 loaded and 35 empty railroad cars. In 1917 the estimated lifetime of the mine was 20 years. The capacity was 1,500 tons a day, and the actual daily average was 600 tons.

FAIRMONT. CONSOLIDATION NO. 38 MINE.

Analyses 28106 to 28111 (p. 94). Bituminous coal, Fairmont field, from Consolidation No. 38 mine, a shaft mine 1 mile north of Fairmont, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 7 feet to 8 feet thick; dip, 2 per cent north, with cleat running in same direction. No faults, rolls, or horsebacks were encountered in mining, but the bed had three shale partings near the middle. Roof, 6 to 9 inches of roof coal, above which is tender "draw slate"; floor, hard, rather smooth, of fire clay. The bed was sampled by E. H. Denny on April 23, 1917, as described below:

Sections of coal bed in Consolidation No. 38 mine.

Section	A.	B.	C.	D.	E.
Laboratory No.	28106	28107	28108	28109	28111
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, coal.					
Coal	2 4	1 11	2 7½	2 ½	2 3
Shale	a ¾	a ½	a 1	a ¾	a 1
Coal	2½	2½	2½	2¾	3
Shale	a ¾	a ½	a ¾	a 1	a 1
Coal	2½	2½	3½	3	3
Shale	a 2	a 1	½	a ¾	a ¾
Coal	4 6	4 7½	4 7	4 10	3 3
"Sulphur"	....	....	....	....	a ¾
Coal	....	....	....	....	1 3
Floor, fire clay.					
Thickness of bed	7 6½	7 1½	7 10¾	7 6¾	7 6½
Thickness of coal sampled	7 3	6 11½	7 8½	7 4¼	7 3½

a Not included in sample.

Section A (sample 28106) was taken from face, main butt, off main north heading. Section B (sample 28107) was taken from face 9 right, off main north heading. Section C (sample 28108) was taken from face 4 room, 1 left, 3 left level, off main dip heading. Section D (sample 28109) was taken from face room 2, 1 right, 3 north, off main dip entry. Section E (sample 28111) was taken in 2 cut-through between rooms 3 and 4, 8 right, 2 left heading, off main dip entry (pillar coal).

The ultimate analysis of a composite sample made by combining face samples 28106, 28107, 28108, and 21809 is given under laboratory No. 28110.

System of mining, room and pillar, in panels. In 1917 the coal was cut by machine and shot down with permissible explosive by contractors at any time of the day. There were 135 men employed underground and 40 aboveground. The coal was dumped over a wooden tipple in self-dumping steel cages, all coal being shipped as run of mine. Nut and lump coal over ¾-inch passed through screens. Haulage was by mules and electric locomotives. The coal was cleaned on the railroad cars by four pickers. There were two loading tracks, with capacity for 20 empty and 20 loaded railroad cars. There was much large lump in the coal on the cars. In 1917 estimated lifetime of the mine was 40 years. The capacity was 1,500 tons a day, and the daily average was 800 tons.

FARMINGTON. CONSOLIDATION NO. 87 MINE.

Analyses 28505 to 28509 (p. 95). Bituminous coal, Fairmont field, from Consolidation No. 87 mine, a shaft mine, 1 mile from Farmington, on the Western Maryland R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 6 to 7 feet thick. Occasional rolls or horsebacks are encountered but no faults. Bed carried three bands of shale and occasional "sulphur" bands and bails and "clay veins." Roof, roof coal from 3 to 12 inches, being left up as roof and arched; floor, smooth, fairly hard fire clay. The bed was sampled by E. H. Denny on May 22, 1917, as described below:

Sections of coal bed in Consolidation No. 87 mine.

Section / Laboratory No.	A. 28505	B. 28506	C. 28507	D. 28508
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, coal.				
Coal	9	1 4	1 2	5¾
"Sulphur" band				¼
Shale band	a ¾	a 1	a ¾	
Coal	3	2	4	1 0
Shale band	a ¾	a ½	a ¾	a 1½
Coal	4½	3	2¼	2
Shale band	a 1	a 1	a 1	a 1
Coal	3 1	1 10¼	3	3
"Sulphur" band	¼	¼		
Shale band			a 1	a 1
Coal	2 0	2 5	4 ½	3 1
"Sulphur" band				¼
Coal				5
"Sulphur" band				¼
Coal				9½
Floor, fire clay.				
Thickness of bed	6 8¼	6 5¼	6 3¼	6 6½
Thickness of coal sampled	6 5¾	6 2¾	5 11¾	6 3

[a] Not included in sample.

Section A (sample 28505) was taken at 3 right, off the back switch. Section B (sample 28506) was taken at southeast side of mine, loaded haulage way, main heading, about 1,600 feet from shaft bottom. Section C (sample 28507) was cut from 1 heading of 2 right ("No. 1 top right"). Section D (sample 28608) was taken from last crosscut between 2 and 3 left, off back switch.

The ultimate analysis of a composite sample made by combining samples 28505 to 28508 is given under laboratory No. 28509.

System of mining, room and panel. In 1917 the coal was undercut by machine and shot down with permissible explosive at any time during the shift by four shot firers. The coal was dumped over a steel tipple, all the coal being shipped as run of mine. Haulage was by four storage-battery locomotives and by mules.

HUTCHINSON. CONSOLIDATION NO. 84 MINE.

Analyses 28432 to 28435, 28469 to 28470, and 28440 (p. 95). Bituminous coal, Fairmont field, from Consolidation No. 84 mine, a slope mine, at Hutchinson, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed, 6 to 7 feet thick. The bed contains three bands of shale and occasional "sulphur" bands and balls. Roof, 4 to 12 inches of roof coal left, well arched; floor, hard, smooth fire clay. The bed was sampled by E. H. Denny on May 18, 1917, as described below:

Sections of coal bed in Consolidation No. 84 mine.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	28432		28433		28434		28435		28469		28470	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, coal.												
Coal		5	1	4	1	3	1	8½	1	8	1	5
"Sulphur" band		¼										
Shale band				*a* 1		*a* 1¼		*a* 1¾		*a* ¾		
Shale, soft, brittle												*b* ½
Coal	1	2½		2		3		2		2½		2¼
Shale band		*b* ½		*a* 1		*a* 1		*a* ¾		*a* 1		*a* 1¾
Coal		2		3½		3¼		3½		3½		2¼
Shale band		*a* 1¼		*a* 1¾		*a* 1¾		*a* 1½		*a* 1¼		*a* 1
Coal		3½	2	10½	2	8	2	8	4	5	4	2
Shale band		*a* ¾										
"Sulphur" band						⅜		⅜				
"Sulphur" ball				*a* 1½								
Coal	4	4	1	5	1	5	1	7				
Floor, fire clay.												
Thickness of bed	6	7¾	6	6½	6	2⅝	6	9⅜	6	10	6	3
Thickness of coal sampled	6	5¾	6	1	5	10⅝	6	5⅜	6	7	6	0

a Not included in sample. *b* Included in sample.

Section A (sample 28432) was cut near face of 7 left entry, opposite 5 room neck, 3 south-face heading. Section B (sample 28433) was cut in 4 room neck, 7 right entry, 2 north face. Section C (sample 28434) was cut in 12 room neck, 8 left entry, 2 south face. Section D (sample 28435) was cut in 7 room, crosscut 2 right, 2 north face pillar. Section E (sample 28469) was cut near face of air course of 4 south. Section F (sample 28470) was cut at face of main-entry manway.

The ultimate analysis of a composite sample made by combining samples 28432, 28433, 28434, 28435, 28469, and 28470 is given under laboratory No. 28440.

System of mining, room and panel. In 1917 the coal was undercut by machine and shot down with permissible explosive, the shots being fired electrically by battery at any time during the shift by the shot firers. There were 110 men employed underground and 10 aboveground. Haulage was by three electric locomotives and by mule. There were four loading tracks, with capacity for 70 empty and 75 or more loaded railroad cars. None of the coal was shipped as run of mine. The coal was passed through screens having ¾ and 1½-inch openings and was cleaned on the cars by four pickers. The coal on the cars showed many large lumps. The capacity of the mine was 1,600 to 1,800 tons a day, and the actual daily average was 1,000 to 1,200 tons.

MONONGAH. CONSOLIDATION NO. 43 MINE.

Analyses 28209 to 28212 and 28225 to 28227 (p. 95). Bituminous coal, Fairmont field, from Consolidation No. 43 mine, a slope mine at Monongah, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 7 to 8 feet thick; dip, 2 per cent north, with cleat running north. The bed contains three partings. No faults, rolls, or horsebacks are encountered. Roof,

roof coal, 6 to 9 inches being left, and "draw slate"; floor, rather hard, smooth fire clay. The bed was sampled by E. H. Denny on May 3, 1917, as described below:

Sections of coal bed in Consolidation No. 43 mine.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	28209		28210		28225		28226		28227		28211	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, coal.												
Coal	2	6½	2	½	2	0	2	1½	1	6	2	1
Shale band		a 1		a 1		a 1		a ¾		a 1¾		a ¾
Coal		2¼		2		2¾		2		3		2
Shale band		a 1		a 1		¼		a ½		a 1		a 1
Coal		3		3		3½		3½		4		3
Shale band		a 1½		a 1½		a 1		a 1		a 2		a 1½
Coal	4	5	4	4	4	3	4	5	5	0	4	6
Floor, fire clay.												
Thickness of bed	7	8	7	1	7	0	7	2½	7	5¾	7	3
Thickness of coal sampled	7	4¾	6	9½	6	9¼	7	0	7	1	7	0

a Not included in sample.

Section A (sample 28209) was cut from face 11 room, off 6 butt, off 4 north. Section B (sample 28210) was cut from pillar, 5 room, 4 left, on 5 south. Section C (sample 28211) was cut from face of air course 2 right, off 5 north. Section D (sample 28225) was cut from 4 room, pillar 2 right, 4 south. Section E (sample 28226) was cut from face main, right butt, off 3 north, 1,400 feet from 3 north. Section F (sample 28227) was cut from barrier pillar between room 10 and 11, 2 right.

The ultimate analysis of a composite sample made by mixing samples 28209, 28210, 28211, 28225, 28226, and 28227 is given under laboratory No. 28212.

System of mining, room and pillar in panels. In 1917 the coal was undercut by machine 3 to 4 inches above the fire-clay bottom and shot down with permissible explosive by miners and shot firers at any time during the shift. Sand and ashes were provided for stemming. There were 210 men employed underground. The coal was dumped over a wooden tipple and screened through bar screens with ¾-inch and 1½-inch bars. Haulage was by six electric locomotives. There was track capacity for about 40 empty and 50 loaded railroad cars. The capacity of the mine was estimated to be 1,575 tons a day, and the actual daily average was 1,500 tons.

MONONGAH. CONSOLIDATION NO. 63 MINE.

Analyses 28322 to 28328 (p. 96). Bituminous coal, Fairmont field, from Consolidation No. 63 mine, a slope mine in Monongah, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 6 to 7½ feet thick; dip, about 2 per cent north. No faults are encountered, but there are occasional rolls or horsebacks. Roof, coal, 6 to 9 inches being left; floor, hard, smooth fire clay. The bed was sampled by E. H. Denny on May 11 and 12, 1917, as described below:

Sections of coal bed in Consolidation No. 64 mine.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	28322		28323		28324		28325		28326		28327	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, coal.												
"Sulphur" and shale	.....	.....		a 1½	.....	.....	.....	.....	.....	.....	.....	.....
Coal	1	9	2	2	1	6	1	9½	2	½	1	9¾
Shale band		a ¾		a 1		a ¾		a ½		a 1		a ¾
Coal		2		2		1½		2¼		2½		2¾
Shale band		a ¾		a 1		a 1		a ¾		a 1		a ¾
Coal		3		2¾		3½		3		4½		3
Shale band		a ¾		a 1¾		a 1		a 1		a ¾		a 1¼
Coal	2	0	4	2	2	10	4	4	3	10½	2	9¾
"Sulphur"		½	.....	.....		½	.....	.....		a ¾		¾
Coal	2	4	.....	.....	1	6	.....	.....		7¾	1	7½
Bony coal		a 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Floor, fire clay.												
Thickness of bed	6	10½	7	1½	6	5¼	6	9¼	7	4½	6	11
Thickness of coal sampled	6	6½	6	8¾	6	3	6	7	7	1¾	6	8½

a Not included in sample.

Section A (sample 28322) was cut from 8 room, pillar 2 south, off main. Section B (sample 28323) was cut from pillar, 8 room, 3 right, 4 north, off main. Section C (sample 28324) was cut from last breakthrough between entry and air course, 5 south, off main. Section D (sample 28325) was cut from 2 room, 7 left, 4 south, main. Section E (sample 28326) was cut from 8 room, neck, 2 right, 5 north, off main. Section F (sample 28327) was cut from 16 room, about 50 feet back from fall in crosscut, 2 left, 3 south, off main.

The ultimate analysis of a composite sample made by combining samples 28322 to 28327 is given under laboratory No. 28328.

System of mining, panel, room and pillar, In 1917 the coal was undercut by electric chain machines; cutting was done in the coal from 3 to 4 inches above the fireclay bottom. Machine cuttings were usually loaded into cars before shooting. Holes were driven by electric auger drills mounted on the mining machine. Permissible explosive was used and shots were fired with a battery by shot firers in some sections, and in other sections, chiefly on pillars, by miners at any time during the day. Sand and ashes were generally used for stemming. None of the coal was shipped as run of mine. The coal was passed through bar screens having 1½ and ¾ inch openings. All coal passing through ¾-inch opening was coked, and some of 1½-inch and larger. The coal was cleaned on the cars by six pickers. Haulage was by five electric locomotives and by mules. There were three loading tracks, with capacity for 75 empty and 60 loaded railroad cars. The capacity of the mine was 1,500 tons a day, and the average production was 1,200 tons.

For descriptions and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 121, 365.

WATSON. CONSOLIDATION NO. 26 MINE.

Analyses 28139 to 28144 (p. 96). Bituminous coal, Fairmont field, from Consolidation No. 26 mine, a drift mine at Watson, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 6 to 8 feet 6 inches thick; dip, possibly 1° north. Faults and rolls or horsebacks are numerous. The bed contains three bands and occasional "sulphur" and clay veins. Roof, coal, 6 to 9 inches; floor, hard and reasonably smooth fire clay. The bed was sampled by E. H. Denny on April 27, 1917, as described below:

Sections of coal bed in Consolidation No. 26 mine.

Section	A.		B.		C.		D.		E.	
Laboratory No.	28139		28140		28141		28142		28144	
Roof, coal.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	4	1	7½	1	11	1	2	1	7[illegible]
Shale band		a 1		a 1		a 1		a 1		a [illegible]
Coal		2½		4		2¼		3		2[illegible]
Shale band		a 1		a 1		a ½		¾		a 1[illegible]
Coal		3		4		2¾		3		3[illegible]
Shale band		a 1		a 2		a 1		a ¾		a 1[illegible]
Coal	3	6	3	6½	4	7½	4	6	4	2[illegible]
"Sulphur" band		½		¼						
Coal	1	2	1	11						
Floor, fire clay.										
Thickness of bed	7	8¾	8	1¼	7	2	6	4½	6	8[illegible]
Thickness of coal sampled	7	5¾	7	9¾	6	11½	6	2	6	4[illegible]

a Not included in sample.

Section A (sample 28139) was taken at face of 14 room, off 4 right butt, off 5 north. Section B (sample 28140) was taken at face of 6 north, off river heading. Section C (sample 28141) was taken from 8 room, 2 butt, 8½ south, off main, at face of room. Section D (sample 28142) was taken from 15 room, 4 left butt, 7 south, off main. Section E (sample 28144) was taken from 21 room, 5 left butt, 8 south, off main, 75 feet from room face, left rib (pillar coal).

The ultimate analysis of a composite sample made by combining samples 28139 to 28142 is given under laboratory No. 28143.

System of mining, room and pillar, in panels. In 1917 the coal was undercut by machine and shot down with permissible explosive any time during the day by shot firers or contractors. There were 156 men employed underground. The coal was dumped over a wooden tipple, most of the coal being loaded and shipped as run of mine. The coal was screened through bar screens having bars 1½ inches wide. Haulage was by mules and five electric locomotives. There were two loading tracks, with capacity for 30 empty and a much larger number of loaded railroad cars. The daily capacity of the mine was 1,500 tons, and the average production was nearly 1,000 tons.

WORTHINGTON. CONSOLIDATION NO. 86 MINE.

Analyses 28535 to 28539 (p. 97). Bituminous coal, Fairmont field, from Consolidation No. 86 mine, a shaft mine 4 miles north of Worthington, on the Western Maryland R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Bed is 6 to 7 feet thick; dip, not noted. No faults or rolls encountered. Roof, roof coal, 4 to 12 inches being left up; floor, smooth, hard fire clay. The bed was sampled by E. H. Denny on May 25, 1917, as described below:

Sections of coal bed in Consolidation No. 86 mine.

Section	A.		B.		C.		D.	
Laboratory No.	28535		28536		28537		28538	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, coal.								
Coal	1	4½		7½	1	3	1	6½
"Sulphur" band		a ¾		.....		.....		.....
Shale band		.....		a 1		a 1½		a 1
Coal		2		2½		1½		2
Shale band		a ½		a ¼		a 1		a 1
Coal		2¼		2¾		2¾		2½
Shale band		a ¾		a 1¼		a 1¾		a 1¾
Coal		3¼	4	9½	4	8	4	6
Shale band		a 1		.....		.....		.....
Coal	4	7		.....		.....		.....
Floor, fire clay.								
Thickness of bed	6	10	6	¾	6	7½	6	8¾
Thickness of coal sampled	6	7	5	10¼	6	3¼	6	5

a Not included in sample.

Section A (sample 28535) was cut near 2 face of east main, just inby 1 turned face entries. Section B (sample 28536) was cut at junction of 4 and 5 west main airways. Section C (sample 28537) was cut at 1 south face, off main west headings. Section D (sample 28538) was cut at 2 face of north faces, off east mains, just inby 2 pair of butts.

The ultimate analysis of a composite sample made by mixing samples 28535 to 28538 is given under laboratory No. 28539.

System of mining, room and panel. In 1917 the coal was undercut by machine and shot down with permissible explosive at any time during the shift by four shot firers. Men employed numbered 90 underground and 25 aboveground. The coal was dumped over a steel tipple. Haulage was by storage-battery locomotives. There were five loading tracks, with capacity for 70 empty and 70 loaded railroad cars. The daily average output of the mine in 1917 was 550 tons.

MARSHALL COUNTY.

BENWOOD. HITCHMAN MINE.

Analyses 25606 to 25611 (p. 97). Bituminous coal, Fairmont field, from Hitchman mine, a slope mine about 1 mile south of Benwood Junction station, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh, or No. 8; Carboniferous age, Monongahela formation. Bed is 7 to 10 feet thick; dip, 75 per cent southeast, with cleat running south 15 east. The bed carries clay veins, and there are rolls or horsebacks in the roof. Impurities are two or three middle partings or bands, 1 inch thick, of shale, with about 4 inches of bony coal in between, and several "sulphur" partings in the bottom coal. Roof, immediate, 2 feet of roof coal with 10 inches of "draw slate" below; main roof, weak and dangerous, of soft shale; floor, hard and generally smooth, of black shale underlain with limestone. The bed was sampled by W. B. Plank on July 14 and 15, 1916, as described below:

Sections of coal bed in Hitchman mine.

Section	A.		B.		C.		D.		E.	
Laboratory No.	25610		25609		25606		25607		25608	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.										
Roof coal [a]	2	0	1	10	2	0	2	0	2	0
"Draw slate" [a]		1½	1	0	2	4		9		4
Coal	2	1	2	½	2	1	2	6½	2	1
Bony coal [a]		½								
Shale band [a]				½		½		1½		¼
Coal [a]		4								
Bony coal [a]				2½		4		4		5
Shale band [a]		1		½		½		1		¼
Bony coal [a]				2						
Shale band [a]				¾						
Coal	2	10½	2	3	2	7	1	11	2	7
Dirt								1		
Coal								1½		
Bottom coal [a]				8				8		4
Floor, hard shale.										
Thickness of bed	7	6½	8	3¾	9	5	8	7½	7	9½
Thickness of coal sampled	4	11½	4	3½	4	8	4	8	4	8

[a] Not included in sample.

Section A (sample 25610) was taken from rib of 1 room, on 1 east, off 14 north. Section B (sample 25609) was taken from 4 room, on 18 west, off 12 south. Section C (sample 25606) was taken from face of 14 north, 50 feet inby 8 east. Section D (sample 25607) was taken from face 9 west, off 14 south, 12 feet from 14 south. Section E (sample 25608) was taken from 16 south, 30 feet from 2 main.

The ultimate analysis of a composite sample made by combining samples 25606, 25607, 25608, 25609, and 25610 is given under laboratory No. 25611.

System of mining, room and pillar. In 1916 the coal was undercut by electric breast machines and shot down with FFF black powder by the miners during the shift. About 280 men were employed underground and 45 aboveground. The coal was dumped over a steel tipple, all being shipped as run of mine. Forty per cent of the coal passed through bar screens which had 1½-inch and 6-inch openings. Haulage was done by four electric locomotives, with mules used for gathering. The coal was cleaned on the car by three pickers. There were three loading tracks, with capacity for 20 empty and 40 loaded railroad cars. The appearance of the lump coal and screenings on the cars was good. About 70 per cent of the coal was taken out in advance work, and the total recovery claimed was 70 per cent. The unmined area comprised 4,000 acres in 1916, and the estimated lifetime of the mine was 30 years. Daily capacity of the mine was 2,000 tons, and the average output was 1,800 tons. The production in 1915 was 525,000 tons. The entire output was sold to the Baltimore & Ohio R. R. for use on locomotives.

MERCER COUNTY.

COALDALE. COALDALE MINE.

Analyses 67890, 67897, 67905, and 29923; also average of tipple samples 70271 to 70274 (p. 97). Semibituminous coking coal, Pocahontas field, from Coaldale mine, a drift mine ½ mile west of Coaldale station, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 9 to 12 feet thick; roof, hard shale and "draw slate," about 10 inches thick; floor, hard, smooth shale. The bed was sampled by R. H. Seip and S. P. Holt on December 19, 1917, as described below. Commercial samples were taken at the tipple by J. J. Bourquin on September 27, 1918.

Sections of coal bed in Coaldale mine.

Section	A.		B.		C.	
Laboratory No	67890		67897		67905	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate."						
Coal	3	8	3	8½	1	3
"Sulphur"						a ½
Bone		a 9		a 10		
Coal	5	2½	5	3½	2	4½
Bone						a 6½
Coal					3	6½
Coal, gray						2
Coal					2	0
Floor, shale.						
Thickness of bed	9	7½	9	10	9	10¾
Thickness of coal sampled	8	10½	9	0	9	7¾

a Not included in sample.

Section A (sample 67890) was cut in Statley entry, off 7 left, 1½ miles east of drift mouth. Section B (sample 67897) was cut in Keystone entry, off 7 left, 1 mile east of drift mouth. Section C (sample 67905) was cut in 5 entry, off main, 4,000 feet southeast of drift mouth.

The ultimate analysis of a composite sample made by combining samples 67890, 67897, 67905 is given under laboratory No. 29993.

System of mining, room and pillar. In 1917 the mine had been reached to its boundaries and the coal was all taken from pillars. It was shot down with permissible explosive and FFF black powder by the miners during the shift; it was undercut a little by hand. The haulage was by motor on the main line, and the cars were gathered by mule. The coal was all shipped run of mine and was picked on railroad car by two pickers. All impurities were loaded out of the mine, and the cleaning was done outside. Track capacity was 20 empty and 20 loaded railroad cars. There was no storage-bin capacity. The lumps on the cars were small. The capacity of the mine was 300 tons, and the actual daily average at time of sampling was 200 tons. The estimated lifetime of the mine was 6 years.

CRYSTAL. CRYSTAL NO. 1 MINE.

Analyses 67984, 67986, 67988, and 29920; also car sample 29653 (p. 97). Semibituminous coal, Pocahontas field, from Crystal No. 1 mine, a drift mine 1 mile north of Crystal station, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4 to 4½ feet thick; dip of bed, slight; roof, "draw slate" and shale above; floor, shale with smooth surface. The bed was sampled by S. P. Holt, on December 27, 1917, as described below. Commercial samples were collected at the tipple by J. J. Bourquin on January 26, 1918.

Sections of coal bed in Crystal No. 1 mine.

Section	A.	B.	C.
Laboratory No	67984	67986	67988
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, "draw slate."			
Coal	11½	1 6½	1 ⅛
"Sulphur"	*a* ½	....	*a* ⅜
Coal	4	....	3¼
Bone	*a* 3	*a* 2½	*a* 1⅞
Coal	2 4½	2 8¼	2 8
Floor, shale.			
Thickness of bed	3 11½	4 5¼	4 1⅝
Thickness of coal sampled	3 8	4 2¾	3 11⅜

a Not included in sample.

Section A (sample 67984) was cut at face of 2 room, 3 cross entry, left. Section B (sample 67986) was cut at face of 14 room, 1 right. Section C (sample 67988) was cut on chain pillar in 20 room, hallway on 1 cross entry.

The ultimate analysis of a composite sample made by combining face samples 67984, 67986, and 67988 is given under laboratory No. 29920.

System of mining, room, and pillar. In 1917 the coal was undercut by machines and shot down by permissible explosives and black powder. Men employed numbered 90 underground and 50 on the surface, many of whom were at the coke ovens. Haulage was by three electric locomotives and by mules. None of the coal was shipped as run of mine. About half of the coal passed through the screens. The bar screens were 20 feet long and had 4½-inch wide openings; the small-coal screens had 1¼-inch, ¾-inch, and ⅝-inch openings. There were 8 to 10 pickers on tables. The coal was washed, nut and slack being produced; the screenings were coked. There were three loading tracks, with capacity for 15 empty and 40 loaded cars. The actual average shipments at time of sampling were 250 to 300 tons a day, with capacity for shipping 400 tons daily.

Crystal. Crystal No. 2 Mine.

Analyses 68014, 68015, 68017, and 29975, also car sample 29655 (p. 98). Semibituminous coal, Pocahontas field, from Crystal No. 2 mine, a drift mine 1½ miles from Crystal, around the mountain, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4 to 5 feet thick, dip, 1½ to 2° northwest; main roof, sandstone and shale; immediate roof, 6 feet of shale and 2½ inches of "muck," the latter coming down with the coal; floor, rough shale. No cleat, rolls, faults, or horsebacks were encountered in mining. Commercial samples of Crystal No. 2 coal were collected at the tipple by J. J. Bourquin on February 8, 1918. The bed was sampled by J. J. Bourquin and E. B. Sutton on December 14, 1917, as described below:

Sections of coal bed in Crystal No. 2 mine.

Section	A.	B.	C.
Laboratory No	68017	68015	68014
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, shale.			
Coal	1 7¼	6	7⅜
Bone	*a* 6⅛	....	....
"Mother coal"	....	½	⅛
Coal	2 3½	7⅝	11⅜
Bone	....	*a* 2	*a* 3
Coal	....	6¼	2 9¼
Bone	....	*a* 5⅛	....
Coal	....	1 11⅝	....
Floor, rough shale.			
Thickness of bed	4 4⅞	4 3⅛	4 8⅞
Thickness of coal sampled	3 10¾	3 8	4 5⅞

a Not included in sample.

Section A (sample 68017) was cut at face of 25 room, 6 entry. Section B (sample 68015) was cut in split on 1 pillar, 7 entry. Section C (sample 68014) was cut in 34 room, 6 entry.

The ultimate analysis of a composite sample made by combining face samples 68014, 68015, and 68017 is given under laboratory No. 29975.

System of mining, entry, room and pillar. In 1917 the coal was shot off the solid with FFFF black blasting powder. One electric locomotive was used. Impurities comprised clay and shale over the bed and bone in it. Particles of roof and of bone-coal bands became mixed with the coal in shipping. A 2½-inch band of muck immediately over the coal came down with it. Very little of the coal was shipped as run of mine. Shaking screens were used with pear-shaped openings 6 inches long and 4 inches wide, with a neck about 2 inches wide for upper half of hole. Small coal screens had 1½-inch round openings; slack was put through 1½-inch screens and also through a washery; the tonnage of washery was 150 tons a day. The coal was picked on tables and on cars by 10 pickers. There were two loading tracks. About 40 per cent of the coal was taken out in advance work. There were still about 300 acres to be mined, and the estimated lifetime of the mine was 15 years. Capacity of the mine was 400 tons a day, and the average daily production was 275 tons a day.

McComas. Sagamore Nos. 1 and 2 Mines.

Analyses 67911, 67952, and 67928 from No. 1 mine; 68013, 68012, and 68016 from No. 2 mine; also 29985 and 29986 and car samples 69016 and 69017 (p. 98). Semibituminous coal, Pocahontas field, from Sagamore Nos. 1 and 2 mines, drift mines ½ mile from Mora or McComas, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4½ to 6 feet thick; dip, slight; no cleat; commercial samples were taken at tidewater by N. H. Snyder on March 11 to April 11, 1918. The bed was sampled by J. J. Bourquin on December 22 and 26, 1917, as described below:

Sections of coal bed in Sagamore Nos. 1 and 2 mines.

Section	A.	B.	C.	D.	E.	F.
Laboratory No.	67911	67952	67928	68013	68012	68016
Roof, "draw slate"	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	10	9	11	1 0	11	1 3
Bone	a 2	a 3	a 1	a ½	a 3½	a 2½
Coal	3 10	3 4	3 6	1	6	3
Bone	a 2¾	....	a 1½	a 4	a 3½	a 3½
Coal	....	....	4	10	2 5	2 3
Bony coal	....	a 11	....	a 1	....	....
Bone	....	....	....	....	....	a ½
Coal	11	....	....	4	....	....
Bone	....	....	....	a ¾	a ½	....
Coal	....	....	....	1 7½	1	1
Floor, shale.						
Thickness of bed	5 11¾	5 3	4 11½	4 4¾	4 6½	4 4½
Thickness of coal sampled	5 7	4 1	4 9	3 10½	3 11	3 10

a Not included in sample.

Section A (sample 67911) was cut in No. 1 mine, 15 feet from face of crooked entries. Section B (sample 67952) was cut from left rib of 5 entry, at face. Section C (sample 67928) was cut at break through, 10 feet from face, 2 angle entry. Section D (sample 68013) was cut in No. 2 mine, 8 room neck, H–9 entry. Section E (sample 68012) was cut in last break-through, F–6 heading. Section F (sample 68016) was cut at face of 20 room, G–8 entry.

The ultimate analysis of a composite sample made by combining face samples 67911, 67952, and 67928 from No. 1 mine is given under laboratory No. 29985. The ultimate analysis of a composite sample made by combining face samples 68013, 68012, and 68016 is given under laboratory No. 29986.

System of mining, entry, room, and pillar. In 1917 in No. 1 mine the coal was undercut by pick, and in No. 2 mine it was undercut by machine and shot down by FFF black powder. There were 37 and 60 men employed underground and 5 and 35 on the surface, respectively. In No. 1 mine one electric motor and six mules were in use, and in No. 2 mine, seven electric motors.

Of the future tonnage of the mines 25 per cent was to be derived from pillar work and 75 per cent from advance work. No information was obtainable as to plans for future increase or decrease in production. Seventy-five per cent of the coal was shipped as run of mine; the other coal passed over shaking screens with openings as follows: 4½ by 7 inches; 1½, 2, and 2½-inch round holes. The egg and lump sizes went over picking tables, where eight pickers were employed. A tub washer was used. None of the coal was coked. There were three loading tracks, with capacity for 35 empty and 70 loaded cars. No. 1 mine had capacity for 600 tons, with average production at time of sampling of 300 tons a day; No. 2 mine had capacity for 1,500 tons, with average production of 600 tons a day.

McComas. Thomas No. 1 Mine.

Analyses 67906, 67907, 67908, 67912, 67914, and 29916 (p. 98); and car sample No. 29657. Semibituminous coal, Pocahontas field, from Thomas No. 1 mine, a drift mine at McComas, 1 mile from Mora station, on the Crane Creek branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3, Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4 to 7 feet thick; roof, bad, composed of "draw slate," with sandstone above; floor, hard, smooth shale. There is a persistent 6-inch band of shale and bone at top of seam and 1 to 2 inches of bone 1 foot from top. Commercial samples of Thomas No. 1 coal were collected at the tipple by J. J. Bourquin on January 28 and 30, 1918. The bed was sampled by E. B. Sutton, J. J. Bourquin, R. H. Seip, and S. P. Holt on December 21, 1917, as described below:

Sections of coal bed in Thomas No. 1 mine.

Section	A.		B.		C.		D.		E.	
Laboratory No.	67907		67906		67908		67914		67912	
Roof, shale.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Cube coal		[a] ½		[a] ½				[a] ½		[a] ½
"Mud"						[a] 1				
Coal		11		9¾	1			11		11½
"Sulphur"								[a] ½		[a] ½
Bone		[a] 4		[a] 2½		[a] 2½				
Coal	3	3	3	2½	3			10½	3	6½
Bone								[a] 4		
"Bottom shale" (taken up)		[a] 11½								
Coal							2	7		
Floor, shale.										
Thickness of bed	5	6	4	3¼	4	3½	4	9½	4	7
Thickness of coal sampled	4	2	4	¼	4		4	4½	4	6

[a] Not included in sample.

Section A (sample 67907) was cut at face of pinnacle heading. Section B (sample 67906) was cut from 13 pillar, 22 entry. Section C (sample 67908) was cut at face of 11 room, off 2, 20 heading. Section D (sample 67914) was cut from 7 pillar, off 16 heading, off 2 main. Section E (sample 67912) was cut from face of 3 room, 18 heading, 22 main.

The ultimate analysis of a composite sample made by combining face samples 67906, 67907, 67908, 67912, and 67914 is given under laboratory No. 29916.

System of mining, entry, room, and pillar. In 1917 the coal was not undercut, but was shot off the solid with FFF black powder. Haulage was by one 13-ton and one 6-ton motor and by mules. A recovery of 95 per cent of the coal was claimed. There were 70 men employed underground and 30 aboveground. The mine had four loading tracks, with capacity for 12 empty and 12 loaded railroad cars. The coal was mostly screened through 1, 2, and 3 inch openings. The coal was picked on the loading boom and on cars by eight pickers. The screenings were washed, 200 tons of ¾ and 1½ inch sizes being put through the washery; about 150 tons were coked daily. The storage bins had capacity for 325 tons. The daily average output at time of sampling was 500 tons.

MATOAKA. THOMAS NO. 2 MINE.

Analyses 67909, 67968, 67963, 67913, and 29983; also tipple sample 29659 (p. 99). Semibituminous coal, Pocahontas field, from Thomas No. 2 mine, a drift mine, 2 miles west of Matoaka, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 4 to 5 feet thick; dip, 1½°. There are no faults, rolls, or horsebacks, but a characteristic bone parting at about the middle of the bed. Roof, soft "draw slate," with hard shale above; floor, hard, smooth shale. Commercial samples were collected at the tipple by J. J. Bourquin on February 6, 1918. The bed was sampled by R. H. Seip and S. P. Holt on December 22, 1917, as described below:

Sections of coal bed in Thomas No. 2 mine.

Section	A.		B.		C.		D.	
Laboratory No	67909		67968		67963		67913	
Roof, "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal, cube		a ¾		a ½		a ½		a ½
Coal		11¾	4	3		11		10½
Bone		a 2¾		a 1		a 2		a 3
Coal	3	¼		4½	3	6	3	6
Bone		a 1½						
Coal		5						
Floor, shale.								
Thickness of bed	4	10	4	9	4	7½	4	8
Thickness of coal sampled	4	5	4	7½	4	5	4	4½

a Not included in sample.

Section A (sample 67909) was cut at face of E entry, off B entry. Section B (sample 67968) was cut at face of D entry, off B entry. Section C (sample 67963) was cut on rib off A heading. Section D (sample 67913) was cut at face of 4 heading.

The ultimate analysis of a composite sample made by combining face samples 67909, 67968, 67963, and 67913 is given under laboratory No. 29983.

System of mining, entry, room, and pillar. In 1917 the coal was shot off the solid by FFF black blasting powder. There were 50 men employed underground and 16 on the surface. Haulage was by mules and one electric locomotive. Very little of the output was shipped as run of mine. The coal first went over shaking screens with pear-shaped holes 2½ by 3½ inches in size; then over small-coal screens with 1½ and 1 inch holes. It was picked on table and cars by six pickers. The screenings were washed, producing fine coal, slack, and nut. The average daily tonnage washed was 100 tons; none was coked. There was storage-bin capacity for 150 tons. The lumps as shipped were large. The slack and nut could be separated by screens in washery, if desired. The track capacity was 20 empty and 15 loaded cars. No impurities were excluded in the mine, washing and picking being relied on for cleaning the coal. The general appearance of the coal was good. The output was being shipped to tidewater pool No. 2 for the Panama Railroad and to Portsmouth, Ohio. Average daily shipments were 300 tons in 1917. About half of the future tonnage of the mine was to be from advance work and half from pillars. The estimated lifetime of the mine was 12 to 15 years.

SIMMONS. BOOTH-BOWEN MINE.

Analyses 67895, 67930, 67932, and 29910, also car samples 69018 and 69019 (p. 99). Semibituminous coal, Pocahontas field, from Booth-Bowen mine, a drift mine 2 miles northwest of Simmons, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Bed is 5 to 9 feet thick; dip, slightly to northwest; roof, shale; floor, hard, smooth shale. A commercial sample was taken on the cars by N. H. Snyder on February 21 and April 10, 1918. The bed was sampled by R. H. Seip and S. P. Holt on December 20, 1917, as described below:

Sections of coal bed in Booth-Bowen mine.

Section	A.		B.		C.	
Laboratory No	67895		67930		67932	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	4		11½	1	6
Bone and "sulphur"		a 2¾		a 1¼		a 2
Coal	3	7½	2	9	1	7¼
Shale		a 3				
"Sulphur"				a ¼		
"Mother coal"						¼
Coal		9		¾	1	11½
Coal, gray				2		
Shale						a 2
Coal			4			7½
Floor, shale.						
Thickness of bed	6	2¼	8	¾	6	1½
Thickness of coal sampled	5	8½	7	11¼	5	9

a Not included in sample.

Section A (sample 67895) was cut at face of 10 room, off northwest cross air course, 3,900 feet northeast of drift mouth. Section B (sample 67930) was cut in new drift-section room pillar, 500 feet south of drift mouth. Section C (sample 67932) was cut in Klondike section, 16 room, 4,800 feet northwest of drift mouth.

The ultimate analysis of a composite sample made by combining face samples 67895, 67930, and 67932 is given under laboratory No. 29910.

System of mining, room and pillar. In 1917 the coal was undercut by pick and shot down by FFFF black powder by the miners during shift. Men employed numbered 65 underground and 25 aboveground. Pieces of roof or floor did not tend to become mixed with the coal in shipping. About 85 per cent of the coal was shipped as run of mine; the balance was screened over bar screens with 4½-inch openings and small bar screens with 2½ and ¾ inch openings. The coal was picked on railroad car by five pickers. Some screenings were coked, at the rate of 50 tons of coke a day. Capacity of storage bins was 150 tons slack, 50 tons egg, and 20 tons nut coal. The lumps were large. There was track capacity for 45 empty and 30 loaded cars. The lower shale band was thrown out by the miners underground. Thirty per cent of the coal was taken in advance work. Of the future tonnage 15 per cent was to come from advance work and 85 per cent from pillars. Tonnage was to be decreased gradually. Capacity of the mine, 1,000 tons a day; daily shipments at time of sampling, 300 tons; maximum day's run, 1,800 tons. The estimated lifetime of the mine was 25 years, there being 600 acres still to be mined.

For descriptions and analyses of other samples from this mine, see Bureau of Mines Bull. 22, pp. 277, 1029.

SIMMONS. BUCKEYE NOS. 1 AND 2 MINES.

Analyses 26707 to 26711, 26712 to 26718, 67961, 67893, 67931, 67981, 67983, 67982, 29921, and 29922; also car samples 69494 and 69495 (p. 99). Semibituminous coal, Pocahontas field, from Buckeye Nos. 1 and 2 mines, 2 miles northwest of Simmons, on the Norfolk & Western R. R. Coal beds, Pocahontas No. 3 and Pocahontas No. 6, respectively; Carboniferous (Pottsville) age, Pocahontas formation. No. 3 bed is from 4½ to 6½ feet thick; No. 6 bed is from 3½ to 4 feet thick. Dip of these beds is slight. Roof of No. 1 mine, shale and sandstone; the shale varies from a knife edge to 6 inches in thickness; floor, shale and fire clay, generally smooth. Roof of No. 2 mine, "draw slate," 10 to 18 inches thick, with hard shale above; floor, hard, smooth shale. Material from the roof and floor did not become mixed with coal in mining. A commercial sample was taken from the cars at tidewater by H. W. Jarrett on May 2 to June 19, 1918. These mines were sampled by S. P. Holt and J. J. Bourquin on December 20 and 26, 1917, as described below:

Sections of coal beds in Buckeye Nos. 1 and 2 mines.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	67961		67893		67931		67981		67983		67982	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale.												
Coal	2	0	2	6½	2	7½		3		2½		3½
Hard "sulphur" band		a ¼		a 1								
Bone						a 7½		a ¾		a ¾		¼
Coal		4½		6¼	3	2½	3	4	3	6	3	3½
Bone		a 2		a 3¾								
Coal	2	10	2	9								
Floor, shale.												
Thickness of bed	5	4¾	6	2½	6	5½	3	7¾	3	9¼	3	7
Thickness of coal sampled	5	2½	5	9¾	5	10	3	7	3	8½	3	7

a Not included in sample.

Section A (sample 67961) was cut in No. 1 mine on 7 pillar, 1 parting, north entry. Section B (sample 67893) was cut in No. 1 mine on chain pillar, face of Simmons entry. Section C (sample 67931) was cut in No. 1 mine in 6 room, 7 cross entry, 10 feet from face. Section D (sample 67981) was cut in No. 2 mine, 1 left main heading, 300 feet from main. Section E (sample 67983) was cut in No. 2 mine in main heading, on cross entry, 500 feet from entry. Section F (sample 67982) was cut in No. 2 mine in heading on main, 1,300 feet from drift.

The ultimate analysis of a composite sample made by combining face samples 67961, 67893, and 67931 from Buckeye No. 1 mine is given under laboratory No. 29921. The ultimate analysis of a composite sample made by combining face samples 67981, 67982, and 67983 from Buckeye No. 2 mine is given under laboratory No. 29922.

The coal bed of No. 1 mine was sampled also by E. H. Denny on November 16 and 17, 1916, as described below:

Sections of coal bed in Buckeye No. 1 mine in 1916.

Section	A.		B.		C.		D.		E.		F.	
Laboratory No.	26712		26713		26714		26715		26716		26717	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate" or sandstone.												
Impure coal and shale				a ½						a ½		a ½
Coal		7		6½		8½	1	1		8½		11
Coal, hard												3
"Mother coal"				½				1/16		¼		
Impure coal and shale		1/16				½						
Coal		2¼		3			1	3		6½		11
"Mother coal" or shale band		1/16		½				1/16		⅜		
Coal		2¼			1	6½				9		
"Mother coal," shale, and "sulphur" band		1/16				a ½				⅛		
Coal	1	½	1	3½		5				3		
Bony coal		a 5		a 3		a 4		a 4½		a 6½		a 3
Coal	2	5	1	2⅛		10½	3	2	2	7		2
"Mother coal"		½		⅜		½				⅛		
Shale parting												1/16
Coal		11	2	1	1	10				5		2
"Mother coal"												½
Coal and shale				1½								
Coal				3								2
"Mother coal"												½
Coal											1	3
"Mother coal"												½
Coal											1	1½
Floor, shale.												
Thickness of bed	5	9 11/16	6	1½	5	10	5	10⅝	5	10⅞	5	3 11/16
Thickness of coal sampled	5	4 11/16	5	10	5	5½	5	6⅛	5	3⅞	5	3/16

a Not included in sample.

Section A (sample 26712) was measured on 3-room pillar from the daylight hole on the right of the north entry and 2,850 feet north 49° east from the drift mouth. Section B (sample 26713) was measured on 9-room pillar to the left of Price's entry and 1,875 feet north 10° west from the drift mouth. Section C (sample 26714) was measured in 4 room, 200 feet off, 3 right, and 5,475 feet south 25° east from the drift mouth. Section D (sample 26715) was measured on 6-room pillar 100 feet off Bennett's air course and 1,950 feet north 85° east from the drift mouth. Section E (sample 26716) was measured on the left, inby rib of 4 room, 160 feet from 5 cross entry and 4,050 feet south 56° east from the drift mouth. Section F (sample 26717) was measured at the face of 8 room, about 100 feet off Sinai air course and 6,075 feet south 77° east from the drift mouth.

The ultimate analysis of a composite sample made by combining samples 26712, 26713, 26714, 26715, 26716, and 26717 is given under laboratory No. 26718.

The coal bed of No. 2 mine was sampled also by E. H. Denny and W. B. Plank on November 17, 1916, as described below:

Sections of coal bed in Buckeye No. 2 mine.

Section	A.		B.		C.		D.	
Laboratory No.	26707		26708		26709		26710	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate".								
Coal, blocky, impure		[a]6		[a]7		[a]6		[a]5
Coal		4	3	2	3	6	1	3½
"Mother coal" and shale		1/16	.....	.....	.....	.....		1/16
Coal	1	0	.....	.....	.....	.....	1	5
"Mother coal"		1/16	.....	.....	.....	.....		½
Coal		2¼	.....	.....	.....	.....		9
"Mother coal"		⅛	.....	.....	.....	.....	.....	.....
Coal	1	6½	.....	.....	.....	.....	.....	.....
Floor, black shale.								
Thickness of coal bed	3	7	3	9	4	0	3	11 1/16
Thickness of coal sampled	3	1	3	2	3	6	3	6 1/16

[a] Not included in sample.

Section A (sample 26707) was measured at the face of 12 room, 120 feet off the main entry and 490 feet north 53° east from drift mouth. Section B (sample 26708) was measured at the face of air course, 800 feet north 31° east from drift mouth. Section C (sample 26709) was measured on the pillar of 7 room, 150 feet from the entry and 300 feet north 83° east from drift mouth. Section D (sample 26710) was measured on 3 pillar stump, next to 2 room neck, and 75 feet south 38° east from drift mouth.

The ultimate result of an analysis of a composite sample made by combining samples 26707, 26708, 26709, and 26710 is given under laboratory No. 26711.

System of mining, room and pillar. At time of sampling Nos. 1 and 2 mines the coal was mined by hand and shot down with FFFF black powder. Haulage in No. 1 was by steam locomotive and mule; in No. 2 by storage-battery locomotive. Carbide miners' lamps were used. In 1917 in No. 1 mine the coal was won mostly from pillars; the estimated lifetime of the mine was ten years; No. 2 derived 40 per cent of its tonnage from advance work and 60 per cent from pillars. There were 175 acres unmined, giving No. 2 an estimated lifetime of 10 years. About 60 per cent of the coal from No. 1 mine and all coal from No. 2 mine was shipped as run of mine. The rest of the coal from No. 1 mine was screened into lump, egg, nut, and slack; 90 to 100 tons were coked daily. Coal from No. 1 mine was picked over picking table by four men and occasionally by two men on the cars; coal from No. 2 mine was picked occasionally on a belt by two men. Track capacity of No. 1 mine, 77 empty and 26 loaded railroad cars; No. 2 mine, 15 empty and 15 loaded railroad cars. In 1916 the output of No. 1 mine was 600 tons a day. In 1917 the output of No. 2 mine was about 100 tons a day. Capacity of No. 1 mine in 1917 was 900 tons a day; in 1916 capacity of No. 2 mine was 125 tons a day.

For description and analyses of other samples of this coal see Bureau of Mines Bull. 22, pp. 277, 1028.

SPRINGTON. MODOC MINE.

Analyses 26701 to 26706, 26697 to 26699, and 26700 (p. 100). Semibituminous coal, Pocahontas field, from Modoc mine, a drift mine 1½ miles northwest of Springton, on the Wenonah branch of the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Average thickness of bed is about 4 feet 6 inches; bed lies practically flat; main roof, sandstone; immediate roof, shale; floor, sandstone. Material from the roof and floor did not tend to become mixed with the coal in mining. The bed was sampled by W. B. Plank on November 16, 1916, as described below. Four of these samples came from No. 1 drift, the other four from Nos. 2 and 3 drifts.

Sections of coal beds in Modoc mines.

Section	A.	B.	C.	D.	E.	F.	G.	H.
Laboratory No.	26702	26703	26704	26706	26697	26698	26699	26700
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal, impure or "rash"	[a]2½	[a]1	[a]½		[a]2	[a]2½	[a]3	[a]2½
Coal	9½	10½	3	11½	10	10½	11	11
"Mother coal"			1					
Coal			3½					
"Mother coal"			½					
Coal			5					
Shale, hard, black	[a]4½	[a]4	[a]4½	[a]4	[a]4	[a]5½	[a]5	[a]7
Cube coal [b]	[a]7	[a]7	[a]5½	[a]9	[a]7	[a]4½	[a]4½	
Coal	3	2 2	2 4	2 1	5	2 5½	2 3	2 7½
"Mother coal"	½				[a]½			
Coal	5½							
"Mother coal"	½							
Coal	4½							
"Mother coal"	[a]2							
Coal	10				1 11			
Floor, sandstone.								
Thickness of bed	4 1½	4 ½	4 3½	4 1½	4 3½	4 4½	4 2½	4 4
Thickness of coal sampled	2 9½	3 ½	3 5	3 ½	3 2	3 4	3 2	3 6½

[a] Not included in sample.
[b] Cube coal is a hard bone coal, which merges into the black shale, and between the two there is no easy dividing plane, which causes the coal to adhere to the shale. It is therefore thrown out by the miner, and consequently was excluded from the sample.

Section A (sample 26702) was measured at face of 1 right, off the mains, 400 feet from main entry and 475 feet north 40° east from drift mouth No. 1. Section B (sample 26703) was measured at face of 1 main, 1,200 feet north 9° west from drift mouth No. 1. Section C (sample 26704) was measured at the face of 5 room, off A entry left, 400 feet from the entry and 500 feet south 60° west from drift mouth No. 1. Section D (sample 26706) was measured on the pillar of 3 room, off B entry, 200 feet from entry and 825 feet north 26° west of drift mouth No. 1. Section E (sample 26697) was measured at the face of main, 200 feet from the north entry and 900 feet north 3° east from drift mouth No. 2. Section F (sample 26698) was measured at the face of the 6 left entry, 400 feet from the main entry and 1,075 feet south 80° east from drift mouth No. 2. Section G (sample 26699) was measured at the face of 8 left, 400 feet from the main and 900 feet north 60° east from drift mouth No. 2. Section H (sample 26700) was measured at the face of 5 room, off Q entry, 600 feet from the entry and 750 feet south 34° east from drift mouth No. 2.

The ultimate analysis of a composite sample made by combining face samples 26702, 26703, and 26704 from drift No. 1 mine is given under laboratory No. 26705. The ultimate analysis of a composite sample made by combining face samples 26697, 26698, 26699, and 26700 is given under laboratory No. 26701.

System of mining, room and pillar. In 1916 the coal was undercut by electric mining machines and shot down with FFF black powder. Haulage was by electric locomotive and mule. Carbide miners' lamps were used. At the time of sampling the output was about 400 tons a day; total capacity, 500 tons a day. The output was to be increased greatly, up to the capacity of the new 2,000-ton tipple which was being built. Future output was to come from advance work, the mine being a new one and in process of development. All coal was shipped as run of mine. The railroad cars were loaded at a temporary tipple. About 3,000 acres were to be mined from the openings.

WEYANOKE. WEYANOKE NO. 1 MINE.

Analyses 67965, 67936, 67966, and 29984; also car sample 30233 (p. 101). Semibituminous coal, Pocahontas field, from Weyanoke No. 1 mine, a drift mine, at Weyanoke, on the Norfolk & Western R. R. Coal bed, Pocahontas No. 3; Carboniferous (Pottsville) age, Pocahontas formation. Average thickness of bed is 4 to 4½ feet; bed is practically horizontal, except for a few local dips, and the cleat is well marked. No faults or horsebacks are encountered. Roof, 6 inches "draw slate," with shale and sandstone above; floor, 1 foot shale, with an occasional coal streak, sandstone or shale below. Commercial samples were taken at tidewater by N. H. Snyder on February 1 to 21, 1918. The bed was sampled by C. A. Allen on December 21, 1917, as described below:

Sections of coal bed in Weyanoke No. 1 mine.

Section	A.		B.		C.	
Laboratory No.	67965		67936		67966	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate," "cube" shale or bone, ½ to 1½ inches [a].						
Coal	1	0	1	0½	1	1
Rock		[a] 3½		[a] 1½		[a] 3½
Coal	2	10½	3	0		5½
Coal, gray						1
Coal					2	5
Floor, 1 foot poor coal and shale.						
Thickness of bed	4	2	4	2	4	4
Thickness of coal sampled	3	10½	4	½	4	½

[a] Not included in sample.

Section A (sample 67965) was cut at face of 2 room, 18 right cross entry. Section B (sample 67936) was cut at face of 15 right. Section C (sample 67966) was cut at face of 13 left.

The ultimate analysis of a composite sample made by combining samples 67965, 67936, and 67966 is given under laboratory No. 29984.

System of mining, room and pillar. In 1917 the coal was cut on top by machine and shot down by black powder or permissible explosive by the miner during shift. Men employed numbered 225 underground and 39 on the surface. The tipple was of steel and wood. Haulage was by one 12-ton, one 3½-ton, seven 4-ton, and one 5-ton motor. About 20 per cent of the output was shipped as run of mine; the portion going to screens produced 48 per cent slack, 30 per cent lump, 12 per cent egg, and 8 per cent nut. The slack went through 1½-inch round holes, the nut through 2½ by 3½ inch holes, egg through 3½ by 5 inch holes, and lump over 3½ by 5 inch holes. The coal was picked on a steel conveyor by 15 pickers. No screenings were coked. There was 50-ton storage bin capacity for slack and 30-ton bin capacity for nut. There were three loading tracks, with capacity for 31 empty and 32 loaded cars. In advance work 30 per cent of the coal was taken out, and there was a total recovery claimed of 94 per cent. There were about 960 acres still unmined, giving the mine an approximate lifetime of 25 years. The capacity of the mine was 1,500 tons a day; average output during time of sampling, 800 tons a day; maximum day's run, 1,800 tons.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 126, 375

MINERAL COUNTY.

EMORYVILLE. LOW VOLATILE NO. 1 MINE.

Analysis 69072 (p. 101). Semibituminous coal, Abram Creek-Stony River field, from Low Volatile No. 1 mine, ¾ mile southeast of Emoryville. Coal bed, Thomas (Bakerstown); Carboniferous age, Conemaugh formation. Thickness of bed and dip, not noted. Roof, black shale; floor, clay. The bed was sampled by G. H. Ashley on April 23, 1918, as described below:

Section of coal bed in Low Volatile Coal Co. mine.

	Ft.	in.
Roof, black shale.		
Coal, bony [a]		3½
Coal		6
Coal, bony [a]		8
Coal		9
Shale [a]		½
Coal	2	3
Floor, clay.		
Thickness of bed	4	6
Thickness of coal sampled	3	6

The section was measured at face of main entry, 500 feet from mine mouth.

HARRISON. OAKMONT MINE.

Analysis 69071 (p. 101). Semibituminous coal, Abram Creek-Stony River field, from Oakmont mine, 2 miles up Abram Creek from Harrison. Coal bed, Thomas (Bakerstown); Carboniferous age, Conemaugh formation. Thickness, dip, and cleat not noted. Roof very good, of shale; floor, clay. The bed was sampled by G. H. Ashley on April 23, 1918, as described below:

Section of coal bed in Oakmont mine.

	Ft.	in.
Roof, shale.		
Coal		11
Shale [a]		1½
Coal		5½
Bone [a]		5
Coal	2	7
Floor, clay.		
Thickness of bed	4	6
Thickness of coal sampled	3	11½

The section was measured in 11 room, 13 right entry, 5,100 feet from mine mouth.

MINGO COUNTY.

THACKER. THACKER NO. 11 MINE.

Analysis 17482 (p. 101). Bituminous coal from Thacker No. 11 mine, 4 miles southeast of Thacker. Coal bed, Thacker; Carboniferous (Pottsville) age; Kanawha series. Bed at point of sampling is 5 feet 3½ inches thick, clear coal, all included in sample. Part of the coal is splint. Sampled in room 1, on 5 left entry, off south entry, 1,000 feet from mine mouth, on June 5, 1913, by E. Stebinger.

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[a] Not included in sample.

THACKER. THACKER NO. 3 MINE.

Analysis 17484 (p. 101). Bituminous coal from Thacker No. 3 mine, 2 miles east of Thacker. Coal bed, Thacker; Carboniferous (Pottsville) age; Kanawha series. Bed at point of sampling is 5 feet 11 inches thick, clear coal, all included in sample. Part of coal was splint. Sampled in room 3, off 4 left entry, off main entry, 1,000 feet from mine mouth, on June 4, 1913, by E. Stebinger.

THACKER. THACKER NO. 5 MINE.

Analysis 17485 (p. 101). Bituminous coal from Thacker No. 5 mine, 2½ miles east of Thacker. Coal bed, Thacker; Carboniferous (Pottsville) age; Kanawha series. Bed at point of sampling is 5 feet 11 inches thick, clear coal, all included in sample. Part of coal was splint. Sampled in 14 room, 6 right entry, off main entry, 1,500 feet from mine mouth, on June 4, 1913, by E. Stebinger.

THACKER. THACKER NO. 9 MINE.

Analyses 17486 to 17488 (p. 101). Bituminous coal from Thacker No. 9 mine, 3½ miles east of Thacker. Coal bed, Thacker; Carboniferous (Pottsville) age; Kanawha series. Part of coal was splint. This mine was sampled on June 4, 1913, by E. Stebinger, as described below:

Sections of coal bed in Thacker No. 9 mine.

Section	A.	B.
Laboratory No.	17486	17487
	Ft. in.	*Ft. in.*
Coal	3 7	3 7½
Shale	[a] 1	[a] 1
Coal	1 5	1 5
Thickness of bed	5 1	5 1½
Thickness of coal sampled	5 0	5 ½

[a] Not included in sample.

Section A (sample 17486) was cut at face of main entry, 1,200 feet from mine mouth. Section B (sample 17487) was cut at 7 right entry, off main entry, 700 feet from mine mouth.

The ultimate analysis of a composite sample made by combining samples 17484, 17485, 17486, and 17487 is given under laboratory No. 17488.

OHIO COUNTY.

ELM GROVE. ELM GROVE NO. 1 MINE.

Analyses 31621 to 31625 (p. 102). Bituminous coal, Wheeling district, from Elm Grove No. 1 mine, a slope and shaft mine at Elm Grove, on the Baltimore & Ohio R. R. Coal bed, Pittsburgh; Carboniferous age, Monongahela formation. Thickness of workable coal is 4 feet 6 inches to 5 feet 3 inches. Bed dips slightly southeast. A few rolls and "clay veins" are encountered. Impurities consist of two shale partings and some "sulphur" streaks. Roof, "draw slate" 3 to 18 inches thick; floor, smooth fire clay which becomes soft; limestone below. The bed was sampled by P. D. Browning on March 19, 1919, as described below:

Sections of coal bed in Elm Grove No. 1 mine.

Section	A.		B.		C.		D.	
Laboratory No.	31621		31622		31623		31624	
Roof, shale and "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	0		11½		6		6¼
Bony coal	....		....			¼		¼
"Mother coal"		¼		¼	....		....	
Coal		9		11½		7½	1	11
Bony coal		⅛	....		....		....	
"Mother coal"	....			½		¼	....	
Coal		3		7	1	4¼	....	
Bony coal		*a* ½		½		¼	....	
Shale	....		....		....			¼
Coal	....			2½		2		3
Shale	....			*a* ¾		*a* ½		*a* 1
Coal	1	4½		6	1	5		6
"Mother coal"	....			¼	....			¼
Coal	....		1	1	....		1	0
"Sulphur stone"		*a* ¾		*a* ½		*a* 1½		*a* ½
Coal		11		9		11		10½
Floor, fire clay.								
Thickness of bed	4	5⅛	5	3	5	2½	5	3
Thickness of coal sampled	4	3⅞	5	1¾	5	½	5	1½

a Not included in sample.

Section A (sample 31621) was cut at left rib, 50 feet from face of 27 left butt. Section B (sample 31622) was cut at right rib, at face of 21 right butt. Section C (sample 31623) was cut at left rib, at face of main north. Section D (sample 31624) was cut at right rib, 35 feet from face, 27 right butt.

The ultimate analysis of a composite sample made by combining face samples 31621, 31622, 31623, and 31624 is given under laboratory 31625.

System of mining, double and triple entry, room and pillar, in panels. In 1919 the coal was undercut by machine in the bottom of coal and shot down with black powder, dynamite being used for "clay veins." Men employed numbered 60 underground and 14 aboveground. The tipple was of wood. Fifty per cent of the output was shipped as run of mine. The coal was screened through bar screens 12 feet long by 6 feet wide, with 1¼-inch spaces, and 45 per cent of the coal passed through the screens. Haulage was by two electric locomotives and by mules. Two pickers were employed on cars. There were three loading tracks, with capacity for 15 empty and 15 loaded railroad cars. The lump coal, in medium-sized lumps, presented a fairly good appearance on the cars. Sixty per cent of the coal was taken out in advance work, and the recovery claimed was 60 per cent. The unmined area included approximately 1,500 acres. The estimated lifetime of the mine was 30 years. At time of sampling the capacity of the mine was 800 tons a day, the average daily output 425 tons, and the maximum day's run 510 tons.

PRESTON COUNTY.

CORINTH. WILLS NO. 3 MINE.

Analysis 26516 (p. 102). Bituminous coal from Wills No. 3 mine, ½ mile southwest of Corinth, on a switch of the Baltimore & Ohio R. R. Coal bed, Lower Kittanning; Carboniferous age, Allegheny formation. Bed is 3 feet 6½ to 7 inches thick; roof and floor, shale; cover at point of sampling, 120 feet. The bed was sampled by the Maryland Geological Survey on September 16, 1916, as described below:

Section of coal bed in Wills No. 3 mine.

	Ft.	in.
Roof, shale.		
Coal	1	3½
Shale[a]		1–1½
Coal	1	2
Bone and shale[a]		6
Coal		6
Floor, shale.		
Thickness of bed	3	6½–7
Thickness of coal sampled	2	11½–12

This sample was taken in 1 room, 1 right heading. At time of sampling the daily output was 50 to 60 tons.

KEMPTON. KEMPTON OR NO. 42 MINE.

Analysis 26578 (p. 102). Semibituminous coal from Kempton shaft or No. 42 mine, at Kempton, ¾ mile north of Beachwood station, on a spur of the Western Maryland R. R. Coal bed, Middle Kittanning; Carboniferous age, Allegheny formation. Bed is 10 feet 3½ inches thick; roof and floor, shale; cover at point of sampling, about 300 feet. The bed was sampled by the Maryland Geological Survey on October 30, 1916, as described below:

Section of coal bed in Kempton or No. 42 mine.

	Ft.	in.
Roof, shale.		
Coal	2	0
Shale[a]		2
Coal	3	0
Bone[a]		2
Shale[a]	1	1
Coal, dirty[a]		3
Shale[a]		5
Coal[a]		2½
Bone[a]		2½
Coal[a]	2	9½
Floor, shale.		
Thickness of bed	10	3½
Thickness of coal sampled	5	0

This sample was measured at face of main heading, 3,500 feet from shaft bottom. The daily output in 1916 was 800 tons.

RALEIGH COUNTY.

AFFINITY. AFFINITY MINE.

Analyses 68123, 68122, 68115, and 30169, 26691, 26692, 26693, 26694, and 26695 and car samples 69148, 69149 (p. 102). Semibituminous coal, New River field, from Affinity mine, a slope mine at Affinity, on the Winding Gulf branch of the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age, Quinnemont formation. Average thickness of coal is 3 to 4 feet; dip, about 1½° northeast; roof, sandstone and shale; where shale is encountered roof is bad in places; floor, shale. Pieces of the roof and floor did not become mixed with the coal in mining. A car sample was taken at tidewater by N. H. Snyder on March 18 to May 7, 1918. The coal bed was sampled by W. T. Lee on January 1, 1918, as described below:

[a] Not included in sample.

Sections of coal bed in Affinity mine in 1918.

Section	A.		B.		C.	
Laboratory No.	68123		68122		68115	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone and shale.						
Coal	1	7	2	6	2	8
Shale		a 2		a 1		a 2
Coal	1	10	1	0	1	2
Floor, shale.						
Thickness of bed	3	7	3	7	4	0
Thickness of coal sampled	3	5	3	6	3	10

a Not included in sample.

Section A (sample 68123) was cut from pillar in 3 left crosscut, 1 south. Section B (sample 68122) was cut at face of 1 left, 1 north. Section C (sample 68115) was cut in dip heading off 1 west.

The ultimate analysis of a composite sample made by combining face samples 68123, 68122, and 68115 is given under laboratory No. 30169.

The coal bed was sampled also by E. H. Denny on November 14, 1916, as described below:

Sections of coal bed in Affinity mine in 1916.

Section	A.		B.		C.		D.	
Laboratory No.	26691		26692		26693		26695	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, sandstone and shale.								
Coal	1	3	2	3	2	7	1	2¼
"Mother coal"		½		½	.....	.....		⅜
Coal		10		3	.....	.....		5½
Bony coal		a 2¾		a 3		a 2½		a 3½
Coal		9¼	1	1		8		11
"Mother coal"		½	.....	.....	.....	.....	.....	.....
Coal		4	.....	.....	.....	.....	.....	.....
Bony coal		a 4½	.....	.....	.....	.....		a 3⅛
Coal		4½	.....	.....	.....	.....		5½
Floor, shale.[b]								
Thickness of bed	4	3	3	10½	3	5½	3	7¼
Thickness of coal sampled	3	7¾	3	7½	3	3	3	⅝

a Not included in sample.
b Second bone in sections A and D corresponds to floor in sections B and C.

Section A (sample 26691) was measured at the face of the air course of 1 right entry, off 2 north entry, and 2,425 feet north 75° east from slope mouth. Section B (sample 26692) was measured at the face of 2 west entry, 1,200 feet north 40° west from the slope mouth. Section C (sample 26693) was measured at the face of the fan entry, 1,550 feet south 60° west from the slope mouth. Section D (sample 26695) was measured on the right inby rib of old 2 south entry, about 50 feet outby 3 right entry and 2,425 feet north 75° east from the slope mouth.

The ultimate analysis of a composite sample made by combining samples 26691, 26692, and 26693 is given under laboratory No. 26694.

System of mining, room and pillar. In 1918 the coal was undercut by electric machines and shot down by permissible explosive. Brushing of roof and floor was also done with permissible explosive. Mine haulage was by electric motors. Carbide miners' lamps were used. At the time of sampling the output was 250 tons a day; about 1,000 acres were still to be mined, and 55 per cent of the future output of the mine was to come from advance work. All coal was shipped as run of mine. The coal was picked on the car by two trimmers. There was one loading track, with capacity for 14 empty and 25 loaded railroad cars. As shipped on car the coal contained about 70 per cent lump. The Affinity mine adjoins the Big Stick mine.

BIG STICK. BIG STICK MINE.

Analyses 68118, 68134, 68135, and 30167, and 26683 to 26689, and car samples 68806, 68807 (p. 103). Semibituminous coal, New River field, from Big Stick mine, a drift mine at Big Stick, on the Winding Gulf branch of the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age, Quinnemont formation. Average thickness of coal is 4 to 6 feet; average of nine sections taken by the bureau is 5 feet 7 inches. The coal bed dips about 1½° northeast. Main roof, sandstone; immediate roof, "draw slate," floor, mostly hard, smooth clay. Material from the roof and floor did not tend to become mixed with the coal in shipping. Commercial sample was collected on the cars by N. H. Snyder on March 12, 1918. The bed was sampled by W. T. Lee on January 2, 1918, as described below:

Sections of coal bed in Big Stick mine in 1918.

Section	A.	B.	C.
Laboratory No.	68134	68118	68135
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	3 5	5 4	3 3
Bone	1		a 3
Coal	2 7	....	2 1
Floor, clay.			
Thickness of bed	6 1	5 4	5 7
Thickness of bed sampled	6 1	5 4	5 4

a Not included in sample.

Section A (sample 68134) was measured in 3 right, 1 right air course, off 3 main. Section B (sample 68118) was measured in 2 right, 3 left, off 3 main. Section C (sample 68135) was measured in 8 right, 1 crosscut, off 1 main.

The ultimate analyses of a composite sample made by combining samples 68134, 68135, and 68118 is given under laboratory No. 30167.

The bed was sampled by W. B. Plank on November 14, 1916, as described below:

Sections of coal bed in Big Stick mine in 1916.

Sections	A.	B.	C.	D.	E.	F.
Laboratory No.	26683	26684	26685	26686	26688	26689
Roof, shale.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	....	....	a 1	....	....	a 1
Shale	....	....	a 2	a 3	....	2
Bony coal	....	....	....	....	....	a ½
"Mother coal"	....	....	....	....	a 2	....
Coal	2 4½	3 1	1 8	2 1	2 1	2 1
Bony coal	....	a 5½	....	....	....	a 2½
"Mother coal"	½	....	a ½	a 1½	a 3	....
Coal	9	4	1 ½	6	6	11
Bony coal	a 3	....	a 4½	a 4½	a 4½	a 3½
"Sulphur"	....	a 1	....	....	....	....
Coal	9½	3	11½	1 4	1 5	1 5
"Sulphur," soft	½	....	....	....	....	....
Dirt	....	....	....	....	....	a ¼
"Mother coal"	....	a 1	....	....	....	....
Coal	1 2	1 ½	....	....	....	1 0
Floor, fire clay.						
Thickness of bed	5 5	5 4	4 4	4 8	4 9½	6 1¼
Thickness of coal sampled	5 2	4 8½	3 8	3 11	4 0	5 5

a Not included in sample.

Section A (sample 26683) was measured on the rib of 10 room, off 4 left entry, 200 feet from the entry and 2,300 feet north 10° east from the drift mouth. Section B (sample 26684) was measured at face of 16 room, off 2 right, 300 feet from entry, and 3,700 feet north 35° east from drift mouth. Section C (sample 26685) was measured at face of 3 right entry, off 3 main, 4,500 feet north 38° east from drift mouth. Section D (sample 26686) was measured 300 feet from face of 1 main, and 4,300 feet north 48° east from drift mouth. Section E (sample 26688) was measured on the pillar slant, off 9 room, off 4 right, 200 feet from entry and 3,850 feet north 22° east from drift mouth. Section F (sample 26689) was measured on a pillar of the straight entry, opposite 7 room, and 1,900 feet north 70° east from drift mouth.

Ultimate analysis of a composite sample made by combining samples 26683, 26684, 26685, 26686, is given under laboratory No. 26687. Ultimate analysis of a composite sample made by combining samples 26688 and 26689 is given under laboratory No. 26690.

System of mining, room and pillar. In 1918 the coal was undercut by electric cutting machines and was shot down by permissible explosive, which was used also for brushing roof and floor. Haulage was by electric motor. Carbide lamps were used. Average daily output in 1918 was about 500 tons, a large part of which came from pillars. The coal was all shipped as run of mine, and was picked on the railroad car. The lumps were mostly large. Track capacity was 40 empty and 40 loaded cars. About 1,000 acres of coal were still to be mined.

For description and analyses of other samples from this mine see Bureau of Mines Bull. 85, pp. 127, 378.

The mine was sampled in both 1916 and 1918.

MISTLETOE. LYNWIN MINE.

Analyses 68136, 68137, and 30148, and tipple samples 70283 to 70286 (p. 103). Semibituminous coal, New River field, from Lynwin mine, Kanawha-New River district, a drift mine at Mistletoe, near Winding Gulf, on the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age, Quinnemont formation. Bed is 4 to 6 feet thick; dip, 2° or 3° northwest; no cleat or faults; roof, light-blue shale, which adhered more or less to the coal; floor, hard smooth shale, which did not become mixed with the coal in mining. Tipple samples were taken by S. S. Shirkey on September 27, 1918. The bed was sampled by E. W. Shaw on January 2, 1918, as described below:

Sections of coal bed in Lynwin No. 2 mine.

Section	A.	B.
Laboratory No.	68136	68137
	Ft. in.	*Ft. in.*
Roof, shale.		
Coal	3 2	3 6
Bone	[a] 2	[a] 3
Coal	1	1 4
Floor, shale.		
Thickness of bed	4 4	5 1
Thickness of coal sampled	4 2	4 10

[a] Not included in sample.

Section A (sample 68136) was cut at face of 6 room, 2 left, in No. 2 mine; depth of cover at point of sampling, 150 feet; lies across creek from old opening. Section B (sample 68137) was cut in main heading of 7 right, 6,000 feet northwest of main entrance; cover at point of sampling, 300 feet.

The ultimate analysis is of a composite sample made by combining face samples 68136 and 68137 is given under laboratory No. 30148.

System of mining, room and pillar. In 1918 the coal was undercut by electric cutting machines and shot down with black powder and permissible explosive. The capacity of No. 2 mine was 400 tons a day, and the actual average at time of sampling was 200 tons. There were 40 men employed underground and 14 aboveground. There were two storage-battery locomotives, two trolley motors, and one gasoline motor.

The coal was all shipped as run of mine, and was picked on belt by two pickers. The lumps were of medium size. Some thin lenses of bone were shipped with the coal. There were about 3,000 acres to be mined, and the probable lifetime of the mine was 15 years.

Oswald. Oswald No. 3 Mine.

Analyses 68165, 68169, 68170, and 30156, and car samples 69099 and 69100 (p. 104). Semibituminous coal, New River field, from Oswald No. 3 mine, a drift mine at Oswald, on the Kanawha, Glen Jean & Eastern R. R. Coal bed, Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 3 to 4½ feet thick; roof, 1 foot "draw slate," then 1 foot 10 inches of top coal, above which is shale; floor, hard, blue, shaly underclay with smooth surface. Commercial samples were taken at tidewater by N. H. Snyder on March 16 to April 29, 1918. The bed was sampled by C. A. Allen on January 7, 1918, as described below:

Sections of coal bed in Oswald No. 3 mine.

Section	A.		B.		C.	
Laboratory No	68170		68165		68169	
Roof, "draw slate."	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	10	1	8½	1	9
Coal, rashy		1				2
Bony coal				1½		
Coal	1	11	1	6½	2	9
Bone		[a] 1				
"Mother coal"				½		
Coal			1	4		
Floor, clay.						
Thickness of bed	3	11	4	9	4	8
Thickness of coal sampled	3	10	4	9	4	8

[a] Not included in sample.

Section A (sample 68170) was cut at face of 2 right, at 4 south. Section B (sample 68165) was cut at face of 5 room, 2 south, 1 right. Section C (sample 68169) was cut on 21 pillar, straight 7 entry.

The ultimate analysis of a composite sample made by combining samples 68165, 68169, and 68170 is given under laboratory No. 30156.

System of mining, room and pillar. In 1918 the coal was shot down with permissible explosives and undercut by machine. The mine had a modern steel tipple, with loading booms; one 10-ton, one 6-ton, and four 5-ton electric motors were used. Pieces of rock from roof and floor sometimes became mixed with the coal in shipping. In advance work 65 per cent of the coal was taken out. The coal was all shipped as run of mine. When coal was screened, shaking screens 5 by 12, with 4 by 5½ inch holes and 3 by 1½ inch and 1 inch holes were used. The coal was picked on car by two pickers. The coal was usually screened. In mining, only about 4½ feet of practically clean coal was taken; the "draw slate" and top coal were not removed. In places there is a thin streak of bone near the floor, and the machine cut on top of it. The capacity of the mine was 600 tons a day, and the average daily output was 400 tons, which was to be increased to 500 tons.

Slab Fork. Slab Fork Nos. 2, 3, and 5 Mines.

Analyses 68154, 68156, 68161, and 30175 from No. 2 mine; analyses 68155, 68157, 68160, 68184, and 30176, also two samples of bone, analyses 68158, 68159, and 30177 from No. 3 mine; analyses 68152, 68150, 68151, and 30178 from No. 5 mine; car samples 68808 and 68809 (p. 104). Semibituminous coal, New River field, from Slab Fork Nos. 2, 3, and 5 mines, at Slab Fork, on the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age, Quinnemont formation. Bed is 3½ to 7½ feet thick and dips about 2 per cent northwest. Main roof, good, a sandy shale containing about 3 inches of roof coal. There is some "draw slate," which falls, but parts from the coal. The combined thickness of the shale and roof coal is 3 inches to 18 feet; above, in places, is a sandstone cap rock. Floor, hard, smooth shale. Material from roof and floor did not tend to become mixed with the coal in mining. A cleat in No. 3 mine runs north 50° west. There are a few faults and no horsebacks. There is a persistent streak of light bone in the coal as mined, otherwise the coal is clean; this bone coal is not picked out. Commercial samples were taken at tidewater by N. H. Snyder on March 16, 1918. The bed was sampled on January 4 and 5, 1918, by C. A. Allen and S. P. Holt as described below. Two samples of bone were taken in No. 3 mine.

Sections of coal bed in Slab Fork Nos. 2, 3, and 5 mines.

Section	A.	B.	C.	D.	E.	F.	G.
Laboratory No	68161	68156	68154	68160	68184	68155	68150
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Roof, "draw slate" and coal.							
Coal	3 10	4 1	1	3 8	1 10		
"Rash"						a 1½	a 2¼
Bony coal	a 2½	a 3		a 3			
Shale			¼				a ½
Coal and "rash"					4		
Coal	4½	11	11½	1 5	1 9	3 1	4 2¾
"Mother coal"			¼				
Bony coal					1		
Bone					a 2	a 5½	
Coal			3 0		3 0		
Bony coal			a 3				
Floor, shale.							
Thickness of bed	4 5	5 3	4 4	5 4	5 2	3 8	4 5½
Thickness of coal sampled	4 2½	5 0	4 1	5 1	5 0	3 1	4 2¾

Section	H.	I.	J.
Laboratory No	68152	68151	68157
	Ft. in.	*Ft. in.*	*Ft. in.*
Roof, "draw slate" and coal.			
"Rash" and coal	a 2	a 2¼	
Bone	a 2½	a 3	
Coal	1 2¾	1 1¼	1½
Shale	a ½		
Coal	2 9		
Bone		a 2	a 1
Coal		2 8½	3 7
Bone			a 4
Bony coal			5½
Floor, shale.			
Thickness of bed	4 4¾	4 5	4 7
Thickness of coal sampled	3 11¾	3 9¾	4 2

a Not included in sample.

Section A (sample 68161) was cut in No. 2 mine, at face of 11 room, 19 left. Section B (sample 68156), cut in No. 2 mine, at face of 9 room, 21 left. Section C (sample 68154), cut in No. 2 mine, in 22 right, 150 feet from main. Section D (sample 68160) was cut in No. 3 mine, in 19 room, A entry. Section E (sample 68184), cut in No. 3 mine, in 13 room, D entry. Section F (sample 68155), cut in No. 3 mine, main air course, at 10 right. Section G (sample 68150) was cut in No. 5 mine, at extension of 22 left, off 1 right off 21 left. Section H (sample 68152), cut in No. 5 mine, dip workings, 9 room, 19 right, off dip. Section I (sample 68151), cut in No. 5 mine, 6 room, 19 left entry. Section J (sample 68157), cut in No. 3 mine, 3 room, 5 right, off left panel. Sample 68159 represents bone partings excluded from section D and section E. Sample 68158 represents bone partings excluded from section F.

The ultimate analysis of a composite sample made by combining face samples 68154, 68156, and 68161 from No. 2 mine is given under laboratory No. 30175. The ultimate analysis of a composite sample made by combining face samples 68155, 68160, 68157, and 68184 from No. 3 mine is given under laboratory No. 30176. The ultimate analysis of a composite sample made by combining bone samples 68158 and 68159 is given under laboratory No. 30177. The ultimate analysis of a composite sample made by combining face samples 68152, 68150, and 68151 from No. 5 mine is given under laboratory No. 30178.

System of mining, double entry, room and pillar. In 1918 the coal was undercut with shortwall mining machines and shot down with permissible explosives. The number of men employed were 56, 144, and 94 underground for Nos. 2, 3, and 5 mines, respectively, and 38 aboveground for Nos. 2 and 3 mines and 6 for No. 5 mine. Haulage was by electric motors and mules, there being 13 motors in all. The original area of No. 2 mine was 502 acres, of No. 3 mine, 2,006 acres, and of No. 5 mine, 348 acres. The coal bed is very clean except for a streak of light bone up to 3 inches thick which occurs up to a foot above the floor. In some places this is too close to the floor for machines to cut under it; then machine cuts on top of it and it is left in floor; where machine cuts under it, it goes with coal. The main roof is good; 6 or 8 inches of "draw slate" falls with the coal but is mostly gobbed. The capacity of No. 2 mine was 700 tons, of No. 3 mine, 800 tons, and of No. 5 mine, 600 tons. Actual average shipments in 1918 were 200, 560, and 425 tons, respectively. At the time of sampling about 93 per cent of the coal was shipped to Sewalls Point, where part of it was turned over to the Government and part shipped to the New England States. Part of the remainder was shipped to the Virginian R. R. The loading track capacity was as follows: Nos. 2 and 3 mines had a joint tipple; car capacity, 36 empty and 40 loaded railroad cars when railroad permits loads to stand on runaround track; car capacity at No. 5 mine, 14 empty and 14 loaded railroad cars. The coal was all shipped as run of mine, no screens being used. Nos. 2 and 3 mines had joint storage capacity for about 100 tons; No. 5 mine had no storage room. The coal was picked on cars, each mine having two pickers.

These mines were sampled in 1912.

For description and analyses of other samples see Bureau of Mines Bull. 85, pp. 129, 381.

TAMS. TAMS NOS. 1, 3, AND 4 MINES.

Analyses 68086, 68080, 68084, and 29973; also car samples 68804 and 68805 (p. 105). Semibituminous coal, Beckley field, from Tams Nos. 1, 3, and 4 mines, one large mine opened by drifts one-fourth mile east of station at Tams, on the Virginian and Chesapeake & Ohio Railroads. Coal beds, Main Beckley and Lower Beckley; Carboniferous (Pottsville) age, Quinnemont formation. The Main Beckley seam is 3 feet 8 inches to 6½ feet thick, the Lower Beckley 2 feet 2 inches to 3 feet 8 inches thick. The dip of the beds is irregular, up to 12 per cent. There is a faint cleat, and one fault 4,000 feet east of opening of No. 1 mine. Commercial samples were taken at tidewater by N. H. Snyder on March 12, 1918. The beds were sampled in Nos. 1, 3, and 4 mines by E. W. Shaw on January 1, 1918, as described below:

Sections of coal beds in Tams mines.

Section	A.		B.		C.	
Laboratory No.	68086		68084		68080	
Roof, shale.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal			4	0	4	0
Coal with thin bone lenses	[a] 2	8				
Bone		[b] 2		[b] 2		[b] 3
Coal	1	2	2	0	1	0
Bone	[c] 1	6			[b] 1	0
Coal					1	4
Bone						[b] 2
Coal					2	0
Floor, shale.						
Thickness of bed	5	6	6	2	9	9
Thickness of coal sampled	3	10	6	0	8	4

[a] Bone over $\frac{3}{8}$ inch excluded from sample.
[b] Not included in sample.
[c] Bone lying between seams not mined in this portion of mine.

Section A (sample 68086) was cut in No. 1 mine, face of 6 right, 1,500 feet south of nouth; depth from surface to point of sampling, 300 feet. Section B (sample 68084) vas cut in No. 3 mine, face of air course, 6,000 feet southeast of opening, where cover s 300 feet over place of sampling. Section C (sample 68080) was cut in No. 4 mine, ace of main, 800 feet north of drift mouth. Depth from surface to point of sampling, 150 feet.

The ultimate analysis of a composite sample made by combining face samples 38080, 68084, and 68086 is given under laboratory No. 29973. Laboratory No. 68086, which gives 6.2 per cent ash, is abnormal because of 2 feet 8 inches of coal laminated with thin bone lenses in section A.

System of mining, room and pillar. In 1918 two arc wall machines and one breast machine were used; all advance work, half of the output, was cut by machine and all pillar work was cut by pick. Bottom coal was to be mined later. The capacity of the four mines was 1,500 tons a day, which was equal to the maximum day's run; average shipments, 1,000 to 1,500 tons a day. There were 225 men employed underground and 75 on the surface. Haulage was by motor and by mule. At the time of sampling all coal was shipped as run of mine, but in normal times the coal is sized and marketed as lump, egg, nut, and slack. Shaker screens were used, and four men were employed on picking table. At the time the commercial samples were secured labor conditions were abnormal and coal was loaded without the care in cleaning that had prevailed. There was track capacity for 40 empty and 40 loaded cars on the Virginian R. R. and for 30 empty and 30 loaded cars on the Chesapeake & Ohio R. R.

TAMROY. TAMROY MINE.

Analyses 68166 to 68168 and 30159; also car samples 68843 and 68844 (p. 105). Semibituminous coal, New River field, from Tamroy mine, a drift mine at Tamroy, on the Kanawha, Glen Jean & Eastern R. R. Coal bed, Sewell; Carboniferous (Pottsville) age, Sewell formation. Bed is 3 to 4½ feet thick; dip, northwest; roof, 3 feet "draw slate"; floor, smooth shale. The coal has a cleat and occasional faults. Elevation above sea level, 2,100 feet. Commercial samples were taken at tidewater by N. H. Snyder on March 16 to 20, 1918. The bed was sampled by J. J. Bourquin on January 7, 1918, as described below:

Sections of coal bed in Tamroy mine.

Section	A.		B.		C.	
Laboratory No.	68167		68168		68166	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, "draw slate."						
Coal	3	9			3	5½
Bony coal				[a] ¼		
Coal				3¼		
Bone				[a] 1¾		
Coal			3	9		
Floor, shale.						
Thickness of bed	3	9	4	2¼	3	5½
Thickness of coal sampled	3	9	4	¼	3	5½

[a] Not included in sample.

Section A (sample 68617) was cut at face of 3 heading. Section B (sample 68168) was cut at face of 3 room, 4 south; depth of cover, 400 feet. Section C (sample 68166) was cut at face of 5 west.

The ultimate analysis of a composite sample made by combining samples 68166, 68167, and 68168 is given under laboratory No. 30159.

System of mining, room and pillar. In 1918 the coal was undercut by machine and shot down by permissible explosives. There were 85 men employed underground and 15 aboveground. Haulage was by electric motors, two main-line and seven gathering. At time of sampling all coal was shipped as run of mine, but the mine was equipped to screen the coal over shaker screens with 4, 3½, and 1½ inch openings. Sizes of coal, lump, egg, and nut. The coal was picked on belt and on car by three pickers. There was a storage bin for slack coal with capacity for 150 tons. There were three loading tracks, with capacity for 25 empty and 25 loaded cars. In advance work 40 per cent of the coal was taken, and a total recovery of 85 per cent was claimed. There were about 1,000 acres still to be mined from this opening. The capacity of the mine was 1,000 tons a day, and the average production was 450 tons a day.

WOOD BAY. MACALPIN NOS. 1 AND 3 MINES.

Analyses 68259, 68260, and 30154; also car samples 68810 and 68811 (p. 105). Semibituminous coal, New River field, from MacAlpin Nos. 1 and 3 mines, one large mine, opened by drifts ½ mile south of station at MacAlpin and ½ mile south of Woodbay station, on the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age, Quinnemont formation. Bed is 3 to 6 feet thick; dip, 1½° northwest. Several faults and rolls or horsebacks are encountered in mining. Roof, shale 2 to 3 feet thick, containing streaks of coal; cap rock above; floor, hard, smooth, carbonaceous shale. Material from floor and roof did not tend to become mixed with the coal in shipping. Thickness of cover at points of sampling, 200 to 300 feet. A commercial sample was taken from the cars by N. H. Snyder on March 16, 1918. The coal bed was sampled by E. W. Shaw on January 2, 1918, as described below:

Sections of coal bed in MacAlpin mine.

Section	A.		B.	
Laboratory No.	68260		68259	
	Ft.	in.	Ft.	in.
Roof, shale.				
Coal, clean	3	6	4	2
Bone		[a] 2		
Coal		10	....	
Floor, shale.				
Thickness of seam	4	6	4	2
Thickness of coal sampled	4	4	4	2

[a] Not included in sample.

Section A (sample 68260) was cut in 16 room, 5 panel, 3 right, 3,600 feet south of main entrance. Section B (sample 68259) was cut in 7 room, 8 panel, 3 right, 4,500 feet south-southwest of main entrance.

The ultimate analysis of a composite sample made by combining face samples 68259 and 68260 is given under laboratory No. 30154.

System of mining, room and pillar and panel. In 1918 the coal was undercut by electric punchers and shot down by permissible explosives. Haulage was by four 13-ton electric locomotives and 13 gathering motors. The coal was all shipped as run of mine. The capacity of mine at time of sampling was 1,000 tons a day, and the average shipments were 500 tons a day, requiring 250 to 300 men underground and 15 on the surface. In May, 1919, the productive capacity was 1,500 tons per day and the average production was 1,000 tons a day. There were 1,300 to 1,400 acres still to be mined, and the estimated lifetime of the mine was 40 years. The coal was picked on belt and 200-foot table by four pickers. The coal as shipped appeared to be excellent, in medium-size lumps. There were two loading tracks, with capacity for 40 empty and 40 loaded cars.

Mine No. 1 was sampled in 1912. For description and analyses of other samples from that mine see Bureau of Mines Bull. 85, p. 131, 385.

RANDOLPH COUNTY.

LANESVILLE. OUTCROP MINE.

Analysis 69067 (p. 106). Semibituminous coal, Abram Creek-Stony River field, from outcrop mine near head of South Fork, Red Creek, above Lanesville. Coal bed known locally as Red Creek; Carboniferous age; unknown formation. Thickness, dip, and cleat of bed not noted. Roof, brown shale; floor, clay. The bed was sampled by G. H. Ashley on April 26, 1918. The sample represented 2 feet 7 inches of coal, the entire thickness of the bed. The section was measured at bare outcrop, faced back 3 or 4 feet.

WYOMING COUNTY.

ALPOCA. ALPHA MINE.

Analyses 68147, 68163, 68162, 68149, and 30166; also car samples 68841 and 68842 (p. 106). Semibituminous coal, New River field, from Alpha mine, a drift mine at Alpoca, 1½ miles back on mountain from station, on the Virginian R. R. Coal bed, Beckley; Carboniferous (Pottsville) age; Quinnimont formation. Bed is 4 feet 10 inches to 7½ feet thick; dip, 2 per cent northwest; roof and floor, sandstone. Commercial samples were taken on the cars by N. H. Snyder on March 19 to 21, 1918. The bed was sampled by J. J. Bourquin on January 5, 1918, as described below:

Sections of coal bed in Alpha mine.

Section	A.		B.		C.		D.	
Laboratory No.	68147		68163		68162		68149	
Roof, sandstone.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	2	6	2	5	2	1¼	1	2
Bony coal, or "rash"		[a] 9		[a] 5½	[a] 1	3¾	....	
"Mother coal"	....		....		....			½
Coal	2	½	1	7½	2	7½		8½
Shale (not present in many places)		½		½	....		....	
Shale	....		....				[a] 2	1
Coal		11	2	9½	....		2	6½
Floor, sandstone.								
Thickness of bed	6	3	7	3½	6	0	6	6½
Thickness of coal sampled	5	6	6	10	4	8¾	4	5½

[a] Not included in sample.

Section A (sample 68147) was cut 40 feet from face of 22 room, off main entry. Section B (sample 68163) was cut from pillar in 5 room, off 3 air course. Section C (sample 68162) was cut 10 feet from face of 36 room, off main. Section D (sample 68149) was cut 50 feet from face of cross-entry heading.

The ultimate analysis of a composite sample made by combining face samples 68147, 68163, 68162, and 68149 is given under laboratory No. 30166.

System of mining, entry room and pillar. In 1918 the coal was undercut in the coal 2 to 4 feet from top by machine. It was shot down with permissible explosive during the shift by the miners. There were four coal-cutting machines, two main-line motors, and four reel-and-cable motors. Mules were used for gathering. About one-fifth of the tonnage was to come from pillars and the rest from advance work. The cutting was done just above the "middleman;" after coal above was shot down and loaded out, parting was loaded out and gobbed; then lower part of seam was mined. There was one loading track, with capacity for 14 empty and 14 loaded railroad cars. The coal was all shipped as run of mine. There were no screens in the wooden tipple. The coal was picked on car by two pickers. The capacity of the mine at time of sampling was 800 tons a day, and the average daily output was 650 tons. There were 65 men employed underground and 13 aboveground. There were still about 450 acres to be mined from this opening, and the estimated lifetime of the mine was 50 years.

WYOMING.

LINCOLN COUNTY.

ELKOL. ELKOL MINE.

Analyses 30735 and 30762 (p. 106). Subbituminous or lignite coal, Kemmerer field, from Elkol mine, a slope mine at Elkol, about 6 miles southwest of Kemmerer, on the Oregon & Short Line R. R. Coal bed, Elkol; Cretaceous age, Frontier formation. Bed is 1 foot 8 inches to 6 feet 8 inches thick. The bed contains two ½-inch rock bands, one 14 feet above floor and the other 14 feet below roof; dip, 16° west. Occasional faults are encountered. Roof, soft, friable sandstone; floor, coal. Above this coal are a number of coal seams 6 to 25 feet thick, said to total 300 feet. Cover at points of sampling, about 650 to 700 feet. The bed was sampled by C. A. Allen and K. T. Sparks on June 5 and 6, 1918, as described below:

Sections of coal bed in Elkol mime.

Section	A.	B.
Laboratory No	30735	30762
Roof, shale and soft sandstone above roof coal.	*Ft. in.*	*Ft. in.*
Coal	5 0	22 3
Rock	[a] ½	
Coal	8 11½	
Floor, coal.		
Thickness of bed [b]	14 0	22 3
Thickness of coal sampled	13 11½	22 3

[a] Not included in sample.
[b] Fourteen feet of thickness was sampled, but coal in roof and floor and vein is from 20 to 30 feet thick.

Section A (sample 30735) was cut in 6 room, 1 south entry. Section B (sample 30762) was cut in 21 room, 3 north entry.

System of mining, room and pillar. In 1918 the coal was cut by machine in entries only and shot off the solid with black powder at any time by the miners. Giant powder was used for brushing roof or floor. There were 65 men employed underground and about 6 aboveground. The tipple was of wood and well equipped with screens. The sizes of coal depended on the market. Haulage was by mules. About 20 per cent of the total coal was taken out in advance work, and the percentage of recovery was low. The estimated lifetime of the mine was very long. At the time of sampling the daily capacity of the mine was approximately 1,500 tons, the actual average being 650 tons.

SUBLET. KEMMERER NO. 5 MINE.

Analyses 30793 to 30797 (p. 107). Bituminous coal, Green River field, Kemmerer from No. 5 mine, a slope mine located at Sublet, on a spur of the Oregon Short Line R. R. Coal bed, No. 5, or Willow Creek; Cretaceous age, Frontier formation. Bed is 5 to 6 feet; dip, 15° to 20° west, with cleat running slightly east of north. At the top there is a thin streak of bone and rock that sometimes falls with the coal. No rolls or horsebacks are encountered in mining. Roof, shale, weak in upper part; sandstone below; floor, smooth, fairly soft, of shale; cover at points of sampling, 600 to 1,200 feet. The bed was sampled by C. A. Allen on June 15, 1918, as described below:

Sections of coal bed in No. 5 mine.

Section	A.	B.	C.	D.
Laboratory No.	30793	30794	30795	30796
	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Roof, shale.				
Coal, soft	1 0			
Coal, very hard	2 0			
Coal, soft	2 5			
Coal		a ½		
"Sulphur" band		a 1		
Sand rock, soft			1½	
Coal, dirty	a 1		a 1½	
Rock, soft			a ½	
Coal		2 10½	5 8	5 6
Coal with two ½-inch lenses of "sulphur"		6		
Coal		2 0		
Floor, soft clay.				
Thickness of bed	5 6	5 6	5 10	5 6
Thickness of coal sampled	5 5	5 4½	5 8	5 6

a Not included in sample.

Section A (sample 30793) was cut 20 feet south of neck, 46 room, 7 north entry. Section B (sample 30794) was cut 15 feet south of neck, 70 room, 6 south entry. Section C (sample 30795) was cut 45 feet from main slope, 9 south, back entry. Section D (sample 30796) was cut at face of 8 south entry, 11 room.

The ultimate analysis of a composite sample made by combining face samples 30793, 30794, 30795, and 30796 is given under laboratory No. 30797.

System of mining, room and pillar. In 1918 the coal was shot off the solid and shot down with black powder by the miners twice daily. Giant powder was used for brushing roof or floor. The tipple was of wood. Haulage was by five electric locomotives and by mules. Less than half the coal was taken out in advance work, and the percentage of recovery claimed was high. The average daily output was 850 tons.

BIBLIOGRAPHY.

This bibliography does not include those publications of the United States Geological Survey that contain coal analyses, inasmuch as samples of coal gathered by the Survey have been analyzed by the Bureau of Mines. The analyses are published in Bulletins 22, 85, 123, Bureau of Mines, and in this report.

GENERAL TREATISES.

Great Britain, Royal Commission on Coal Supplies. Final report. Pt. 11, Append. 6, 1905, pp. 33–43. Gives production statistics and analyses of coal from Europe, North and South America, Asia, and Australasia.

International Geological Congress, XII. The coal resources of the world; edited by William McInnes and others. Toronto, Can., 1913, 3 vols. Discusses the geology and occurrence of coal beds, the characteristics of coal, and presents analyses of coal from different countries.

NORTH AMERICA.

UNITED STATES.

ALABAMA.

GIBSON, A. M. Report on the coal measures of Blount Mountain, with map and sections. Ala. Geol. Survey, 1893, pp. 7–80. Describes the topography and geologic structure of the region and the stratigraphy of the lower and upper coal measures, with a detailed description of the coal seams. Gives chemical analyses of some of the coals.

MCCALLEY, HENRY. Report on the coal measures of the plateau region of Alabama. Ala. Geol. Survey, 1891, 238 pp.

——— Report on the Tennessee Valley region. Ala. Geol. Survey Rept., pt. 1, 1896, 436 pp. Describes the general features of the stratigraphy, and the occurrence of coal, etc. Gives local geologic details by counties.

——— Report on the Warrior coal basin. Ala. Geol. Survey, 1900, 327 pp. Gives numerous sections of coal beds.

SQUIRE, JOSEPH. Report on the Cahaba coal field. Ala. Geol. Survey, 1890, 187 pp.

ALASKA.

UNITED STATES NAVY DEPARTMENT. Report of experimental tests of Matanuska coal for naval ships. Senate Doc. 26, 64th Cong., 1st sess., 1915, 76 pp. Describes methods of making tests and the results. Analyses are given.

——— Report on coal in Alaska for use in the United States Navy. House Doc. 876, 63rd Cong., 2d sess., 1914, 123 pp. Discusses topography and geology of the Bering River coal field, the chemical and physical qualities of the coal, and gives results of tests and analyses.

ARIZONA.

ARIZONA BUREAU OF MINES. Mineralogy of useful minerals in Arizona. Bull. 41, 1916–17, 70 pp. Analyses of Arizona minerals, including coal.

RUBEL, A. C. Coal in Arizona. Ariz. Bureau of Mines Bull. 17, 1915–16, 12 pp. Describes situation and geology of the coal fields. Gives analyses of coal.

ARKANSAS.

STEEL, A. A. Coal mining in Arkansas. Geol. Survey of Ark., vol. 1, 1910, 632 pp.; vol. 2, 1910, 383 pp.

WINSLOW, ARTHUR. The geology of the coal regions. Ann. Rept. Geol. Survey of Ark. for 1888, vol. 3, 1888, 122 pp. Gives geologic sections, also analyses of coals.

COLORADO.

BOWIE, ALEXANDER. The burning of coal beds in place. Trans. Am. Inst. Min. Eng., vol. 48, 1914, pp. 180–193. Describes character of the New Mexico and Colorado coal beds burned and gives some analyses of the coal.

COLORADO STATE BUREAU OF MINES. Report of the State Bureau of Mines for the years 1905–6. 1907, 127 pp.

GEORGE, R. D. Common minerals and rocks, their occurrence and uses. Colo. Geol. Survey Bull. 6, 1913, pp. 86–95. Discusses the character of Colorado coals and extent of the coal fields.

——— Common minerals and rocks. Colo. Geol. Survey Bull. 12, 1917, 463 pp. Includes analyses of Colorado coals.

HEADDEN, W. P. A study of some Colorado coals—a comparison of some coals from Boulder, Routt, and Delta counties. Colo. Sci. Soc. Proc., vol. 8, May, 1907, pp. 281–300.

——— An examination of some coals from Routt County, Colo. Colo. Sci. Soc. Proc., vol. 8, March, 1917, pp. 257–280.

PARSONS, H. F., AND LIDDELL, C. A. The coal and mineral resources of Routt County. Colorado School of Mines Bull., vol. 1, no. 4, 1903, pp. 47–59.

WHITESIDE, F. W. Yampa coal field in Colorado. Coal Age, vol. 11, 1917, pp. 654–655. Outlines geology of region and analyzes coals from district.

GEORGIA.

McCALLIE, S. W. A preliminary report on the coal deposits of Georgia. Geol. Survey Ga. Bull. 12, 1904, 121 pp.

——— A preliminary report on the mineral resources of Georgia. Geol. Survey Ga. Bull. 23, 1910, pp. 67–75.

ILLINOIS.

ANDROS, S. O. Coal mining in Illinois. Ill. State Geol. Survey Bull. 13, 1915, 250 pp. Briefly describes the coal seams and gives chemical composition and calorific value of the coal. Contains a bibliography of the geology, chemistry, and exploitation of the beds.

——— Coal mining practice in District 1, Longwall. Ill. State Geol. Survey Bull. 5, 1914, pp. 10–11. Presents average analyses of 33 face samples.

——— Coal mining practice in District II, Jackson County. Ill. State Geol. Survey Bull. 7, 1914, pp. 9–10. Describes coal bed: gives analyses.

——— Coal mining practice in District III. Ill. State Geol. Survey Bull. 9, 1915, p. 11–12. Contains analyses of coal from several counties.

——— Coal mining practice in District IV. Ill. State Geol. Survey Bull. 12, 1915, pp. 15–18. Describes topography and coal seams in several counties; gives analyses.

——— Coal mining practice in District V, Saline and Gallatin counties. Ill. State Geol. Survey Bull. 6, 1914, p. 9. Table gives proximate analyses of the coals.

——— Coal mining practice in District VI, Franklin, Jackson, Perry, and Williamson counties. Ill. State Geol. Survey Bull. 8, 1914, pp. 10–11. Discusses character of the coal, thickness of beds, and gives average analyses.

——— Coal mining practice in District VII. Ill. State Geol. Survey Bull. 4, 1914, p. 11. Contains average analyses of 134 samples of coal from several counties.

——— Coal mining practice in District VIII, Danville. Ill. State Geol. Survey Bull. 2, 1914, pp. 12–13. Gives comparative analyses of the coal.

BAIN, H. F., AND OTHERS. Studies of Illinois coals. Am. Inst. Min. Eng. Bull. 24, 1908, pp. 1099–1170.

——— Studies of Illinois coal. Ill. State Geol. Survey Bull. 14, 1909, pp. 183–253.

BEMENT, A. Distribution of the coal beds of the State [of Illinois]. Ill. State Geol. Survey Bull. 3, 1906, pp. 19–25. Discusses the occurrence and mining of the workable seams of Illinois.

——— The Illinois coal field. Ill. State Geol. Survey Bull. 16, 1910, pp. 182–202.

CADY, G. H. Coal resources of District I, Longwall. Ill. State Geol. Survey Bull. 10, 1915, 149 pp. Presents chemical composition and average analyses of of coal samples.

Cady, G. H. Coal resources of District II (Jackson County). Ill. Coal-Mining Investigations Bull. 16, 1917, 53 pp. Discusses character of coals of Jackson County and gives analyses.

——— Coal resources of District V (Saline and Gallatin counties). Ill. Coal-Mining Investigations Bull. 19, 1919. 135 pp.

——— Coal resources of District VI, Franklin, Jefferson, and Williamson counties. Ill. State Geol. Survey Bull. 15, 1915, 94 pp. Discusses structure of the coal beds; gives average analyses of the coal.

——— Geology and mineral resources of the Hennepin and La Salle quadrangles. Ill. State Geol. Survey Bull. 37, 1919, 136 pp. Describes structure of the district and occurrence of minerals, including coal.

——— The geology and coal resources of the West Frankfort quadrangle. Ill. State Geol. Survey Bull. 16, 1910, pp. 244–265.

——— Mines producing low-sulphur coal in the Central District. Ill. Coal-Mining Investigations Bull. 23, 1919, 14 pp. Gives analyses of coal samples from Central District, with especial reference to sulphur content.

De Wolf, F. W. Coal investigations in Saline and Williamson counties, Ill. Ill. State Geol. Survey Bull. 8, 1908, pp. 230–245. Describes the stratigraphy and structure of the field, and the occurrence and character of the coals.

——— Coal investigations in the Saline-Gallatin field, Illinois, and the adjoining area. Ill. State Geol. Survey Bull. 8, 1908, pp. 211–229.

——— The coal resources of Illinois. Am. Inst. Min. Eng. Bull. 24, November, 1908, pp. 1103–1112.

——— The coal resources of Illinois. Ill. State Geol. Survey Bull. 14, 1909, pp. 189–196.

De Wolf, F. W., and others. Studies of Illinois coal. Ill. State Geol. Survey Bull. 16, 1910, pp. 177–301.

Hinds, Henry. Geology and economic resources of Colchester and Macomb quadrangles. Ill. State Geol. Survey Bull. 30, 1917, pp. 75–108.

Illinois State Geological Survey. Coal-mining investigations; preliminary report on organization and method. Bull. 1, 1913, pp. 48–58. Presents geology of the coal fields. Discusses character of Illinois coal and gives analyses of mine samples.

Kay, F. H. Coal resources of District VII, southwestern Illinois. Ill. State Geol. Survey Bull. 11, 1915, 233 pp. Contains diagrams showing average composition and comparative value of Illinois coal.

Kay, F. H., and White, K. D. Coal resources of District VIII, Danville. Ill. State Geol. Survey Bull. 14, 1915, 68 pp. Describes physical characteristics of the coal seams.

Lindgren, J. M. The sampling and analysis of Illinois coals. Ill. State Geol. Survey Bull. 14, 1909, pp. 196–203. Gives analyses of coals from various parts of the State.

Ovitz, F. K. Carbonization of Illinois coals in inclined gas retorts. Ill. Coal-Mining Investigations Bull. 20, 1918, 24 pp.

Parr, S. W. Chemical analyses of certain coals. Ill. State Geol. Survey Bull. 4, 1907, pp. 188–197.

——— Composition and character of Illinois coals. Ill. State Geol. Survey Bull. 3 1906, pp. 27–78.

——— Chemical study of Illinois coals. Ill. Coal-Mining Investigations Bull. 3, 1916, 86 pp.

PARR, S. W. The chemical composition of Illinois coal. Ill. State Geol. Survey Bull. 16, 1910, pp. 203–243.

——— Purchase and sale of Illinois coal on specification. Ill. State Geol. Survey and Univ. Ill., 1914, 80 pp. Describes methods of sampling, gives analyses of samples, and discusses composition of coal.

SAVAGE, T. E. The geology and coal resources of the Herrin, Ill., quadrangle. Ill. State Geol. Survey Bull. 16, 1910, pp. 266–285.

SHAW, E. W. The geology and coal resources of the Murphysboro quadrangle, Illinois. Ill. State Geol. Survey Bull. 16, 1910, 286–294.

UDDEN, J. A. Coal deposits and possible oil field near Duquoin, Ill. Ill. State Geol. Survey Bull. 14, 1909, pp. 254–262.

UDDEN, J. A., AND DE WOLF, F. W. Notes on the Belleville-Breese area. Ill. State Geol. Survey Bull. 8, 1908, pp. 313–334.

INDIANA.

ASHLEY, G. H. Supplementary report [to report of 1898] on the coal deposits of Indiana. Ind. Dept. Geol. and Nat. Res., 33d Ann. Rept., 1909, pp. 13–150.

——— The coal deposits of Indiana. Ind. Dept. Geol. and Nat. Res., 23d Ann. Rept., 1899, pp. 1–1428. Describes general geologic occurrence and distribution of coal, the general geology of the coal measures of Indiana, and the detailed geology in various counties. Presents analyses of certain coals.

CADY, G. H. Mines producing low-sulphur coal in the Central District. Ill. Coal-Mining Investigations Bull. 23, 1919, 14 pp. Consists largely of analyses of coal samples, with especial reference to sulphur content.

NOYES, W. A. Composition of Indiana coals. Ind. Dept. of Geol. and Nat. Hist., 21st Ann. Rept., 1897, pp. 97–107. Describes the methods of analyses and in tabular forms shows the chemical composition of coal from various mines.

IOWA.

AREY, M. F. Geology of Davis County. Iowa Geol. Survey, vol. 20, 1910, pp. 487–524.

——— Geology of Wayne County. Iowa Geol. Survey, vol. 20, 1910, pp. 199–236.

BEYER, S. W. Coal statistics [Iowa]. Iowa Geol. Survey, vol. 19, 1909, pp. 591–597.

——— Mineral production in Iowa in 1905. Iowa Geol. Survey, vol. 16, 1906, pp. 17–36.

BEYER, S. W., AND YOUNG, L. E. Geology of Monroe County [Iowa]. Iowa Geol. Survey, vol. 13, 1903, pp. 355–422. Describes the character and occurrence of coal seams and the coal-mining operations in the county, and gives analyses of certain coals.

HINDS, HENRY. The coal deposits of Iowa. Iowa Geol. Survey, vol. 19, 1909, pp. 21–396.

KEYES, C. R. Coal deposits of Iowa. Iowa Geol. Survey, vol. 2, 1894, 536 pp.

——— Stages of the Des Moines or chief coal-bearing series of Kansas and southwest Missouri and their equivalents in Iowa. Iowa Acad. Sci. Proc., vol. 4, 1897, pp. 22–25.

LEES, J. H. Bibliography of Iowa coals. Iowa Geol. Survey, vol. 19, 1909, pp. 659–697.

——— History of coal mining in Iowa. Iowa Geol. Survey, vol. 19, 1909, pp. 523–588.

LEES, J. H., AND HIXON, A. W. Analyses of Iowa coals. Iowa Geol. Survey, vol. 19, 1909, pp. 476–519.

MACBRIDE, T. H. Geology of Hamilton and Wright counties. Iowa Geol. Survey, vol. 20, 1910, pp. 97–149.

SAVAGE, T. E. Report on tests of Iowa coals made at the Government coal-testing plant at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. Iowa Geol. Survey Bull. 2, 1905, pp. 22–38.

TILTON, J. L. Geology of Cass County. Iowa Geol. Survey Annual Report, 1916, vol. 27, pp. 171–276. Includes discussion of minerals native to Cass County, with analyses of coal from Plowman shaft.

WAGNER, H. W. Costs of producing power in Iowa with Iowa coals, with a comparison of estimated costs and costs from actual tests. Iowa State College of Agric. and Mech. Arts, Eng. Exper. Sta. Bull. 29, 1912, 36 pp.

WILDER, F. A. Fuel values of Iowa coals. Iowa Geol. Survey, vol. 19, 1909, pp. 397–475.

KANSAS.

CRANE, W. R. Goegraphy and detailed stratigraphy of the Kansas coal measures; description of mines, mining methods, and mining machinery; chemical and physical properties of Kansas coals; output and commerce; mining directory and mining laws. Kans. Univ. Geol. Survey, vol. 3, 1898, pp. 108–336.

HAWORTH, ERASMUS. The coal fields of Kansas. Kans. Univ. Quar., vol. 3, 1895, pp. 297–309.

——— The stratigraphy of the Kansas coal measures. Kans. Univ. Quar., vol. 3, 1895, pp. 271–290.

LANGWORTHY, A. E. The Atchison [Kansas] diamond-drill prospect hole. Kans. Acad. Sci. Trans., vol. 17, 1901, pp. 45–52.

WALKER, P. F., AND BOHNSTENGEL, WALTER. Kansas fuels: coal, oil, gas, heating value and proximate analyses of coal. Kans. Univ. Bull. 5, vol. 14, 1913, 40 pp.

KENTUCKY.

BROWNING, I. M., AND RUSSELL, PHILIP. The coals of Magoffin County. Ky. Geol. Survey, 1919, 552 pp. Includes detailed analyses of types of coal mined in part of the eastern Kentucky coal field.

CADY, G. H. Mines producing low-sulphur coal in the Central District. Ill. Coal-Mining Investigations Bull. 23, 1919, 14 pp. Consists largely of analyses of samples from Central District, with especial reference to their sulphur content.

CRANDALL, A. R. Coals of the Licking Valley region. Ky. Geol. Survey Bull. 10, 1910, 90 pp.

——— The coals of the Big Sandy Valley south of Louisa and between Tug Fork and the headwaters of the north fork of the Kentucky River. Ky. Geol. Survey Bull. 4, 1905, 141 pp. Describes the general geology and topography of the area, the occurrence, character, thickness, and relations of the coal seams, giving numerous sections, and the character and composition of the coals.

CRANDALL, A. R., AND SULLIVAN, G. M. Report on the coal field adjacent to Pineville Gap in Bell and Knox counties. Ky. Geol. Survey Bull. 14, 1912, 130 pp. Discusses composition of the coal and gives analyses.

CRIDER, A. F. The coals of Letcher County. Ky. Geol. Survey, 4th ser., vol. 4, part 1, 1916, 234 pp. Discusses types of coal mined in Letcher County and includes a number of analyses of samples.

DILWORTH, J. B. The Black Mountain coal district, Kentucky. Trans. Am. Inst. Min. Eng., vol. 43, 1912, pp. 129–156. Gives analyses and discusses physical characteristics of the coal.

FOHS, F. J. Coals of the region drained by the Quicksand Creeks in Breathitt, Floyd, and Knott counties. Ky. Geol. Surv. Bull. 18, 1912, 79 pp. Discusses geology of the coal beds and presents analyses of coals.

FOSTER, J. R. The coking coal industry in Harlan County, Ky. Coal Age, vol. 10, 1916, pp. 1002–1003.

GARDNER, J. H. Preliminary report on the economic geology of the Hartford quadrangle. Ky. Geol. Survey Bull. 20, 1912, pp. 10–17. Discusses quality of the coal.

GLENN, L. C. A geological reconnaissance of the Tradewater River region, with special reference to the coal beds. Ky. Geol. Survey Bull. 17, 1912, 75 pp.

HODGE, J. M. Coals of Middle Fork of Kentucky River in Leslie and Harlan counties. Ky. Geol. Survey, 4th ser., vol. 5, part 1, 1916, 166 pp. An investigation of coal openings of Middle Fork, with analyses of samples collected.

——— Coals of the North Fork of the Kentucky River in Perry and a portion of Breathitt and Knott counties. Ky. Geol. Survey, 4th ser., vol. 3, part 3, 1918, 418 pp. Reports on coals of eastern Kentucky, including occurrence and analyses.

——— Report on the coals of the three forks of the Kentucky River. Ky. Geol. Survey Bull. 11, 1910, 280 pp. Presents analyses and discusses the geology.

——— Report on the Upper Cumberland coal field; the region drained by Poor and Clover Forks in Harlan and Letcher counties. Ky. Geol. Survey Bull. 13, 1912. 223 pp. Analyses of coal from the various beds are given.

——— Summary of report on the region drained by the three forks of the Kentucky River. Ky. Geol. Survey Rept. of Progress for 1906 and 1907, 1908, pp. 36–45. Includes an account of the distribution and character of the coal beds in this area.

——— Supplementary report on the coals of Clover Fork and Poor Fork in Harlan County. Ky. Geol. Survey, 1916, 64 pp. Gives analyses of coals from sections drained by tributaries of Cumberland River in eastern Kentucky.

——— The coals of Goose Creek and its tributaries. Ky. Geol. Survey, 4th ser., vol. 4, pt. 3, 1918, 260 pp.

——— The Big Stone Gap coal field. Trans. Am. Inst. Min. Eng., vol. 21, 1893, pp. 922–938, 1005–1006. Describes the geology of the region, illustrated by sections of Little and Big Black Mountain and the geologic position of the different coal beds with a statement of the character of the coal found in each bed.

HUTCHINSON, F. M. Report on the geology and coals of the Central City, Madisonville, Calhoun, and Newberg quadrangles. Ky. Geol. Survey Bull. 19, 1912, 127 pp. Describes character and size of coal seams, and gives analyses.

JILLSON, WILLARD, AND HODGE, J. M. The geology and coals of Stinking Creek. Dept. of Geology and Forestry, Kentucky, 1919, ser. 3, Bull. 3, 1919, 89 pp.

MACFARLANE, GRAHAM. The eastern coal region of Kentucky. Trans. Am. Inst. Min. Eng., vol. 25, 1896, pp. 518–532. Gives a section showing the vertical distribution of the coal seams and describes the general features of the coal measures of the region.

MILLER, A. M. Abstract of report on the lower (or "conglomerate") measures along the western border of the eastern coal field. Ky. Geol. Survey Rept. of Progress for 1906 and 1907, 1908. pp. 27–35.

——— Coals of the lower measures along the western border of the eastern coal field. Ky. Geol. Survey Bull. 12, 1910, 83 pp.

Norwood, C. J. Annual reports of the inspector of mines of the State of Kentucky for 1901 and 1902. 1903. 140 pp. Coals of the different districts described.

Peter, Robert. Chemical report of the coals, clays, mineral waters, etc., of Kentucky. Ky. Geol. Survey Bull. 3, 1905, 77 pp.

MARYLAND.

Clark, W. B., and others. Report on the coals of Maryland. Md. Geol. Survey, special publication, vol. 5, pt. 4, pp. 221–651.

Clark, W. B., and Mathews, E. B. Maryland mineral industries, 1896–1907. Md. Geol. Survey, vol. 8, 1909, pp. 97–223.

MICHIGAN.

Cooper, W. F. Geological report on Bay County [Michigan]. Mich. State Board of Geol. Survey, Ann. Rept., 1905, 1906, pp. 135–426.

Lane, A. C. Coal of Michigan: its mode of occurrence and quality. Mich. Geol. Survey, vol. 8, pt. 2, 1902, pp. 1–232.

——— Fifth annual report of the State geologist [Michigan]. Mich. Geol. Survey, Ann. Rept. for 1903, 1905, 342 pp.

——— Sixth annual report of the State geologist [of Michigan] for 1904. Mich. Geol. Survey, Ann. Rept. for 1904, 1905, pp. 113–168.

Smith, R. A. Nonmetallic minerals. Mich. Geol. and Biol. Survey Pub. 19, 1915, pp. 247–270. Describes the thickness of the coal beds, and occurrence of the coal, and gives analyses of 19 samples.

MINNESOTA.

Soper, E. K. The peat deposits of Minnesota. Minn. Geol. Survey Bull. 16, 1919, 261 pp. A few peat analyses by counties are included.

MISSISSIPPI.

Brown, C. S. Lignite of Mississippi. Miss. Geol. Survey Bull. 3, 1907, 71 pp.

MISSOURI.

Barbour, E. H. Report on the Honey Creek coal mine. Mo. Geol. Survey, vol. 2, 1907, pp. 349–364.

Bush, B. F. The coal fields of Missouri. Am. Inst. Min. Eng. Bull. 1, 1905, pp. 165–179; Trans., vol. 35, 1905, pp. 903–917.

Gordon, C. H. A report of the Bevier sheet, including portions of Macon, Randolph, and Chariton counties [Missouri]. Mo. Geol. Survey, vol. 9, 1896, 75 pp. Describes the physiographic character of the region and the economic geology of the coal beds.

Hinds, Henry. The coal deposits of Missouri. Mo. Bureau Geol. and Mines, vol. 11, ser. 2, 1912, 503 pp. Gives a detailed comprehensive account of the geologic relations of the coal beds and the character and composition of the coal.

Sharp, H. N. Firing tests on Missouri coal. Univ. Missouri Bull. 8, 1912, 44 pp. Gives analyses of coals used in 30 tests.

White, David. Age of the lower coals of Henry County, Missouri. Geol. Soc. Am. Bull., vol. 8, 1897, 287–304.

WINSLOW, ARTHUR. A preliminary report on the coal deposits of Missouri. Mo. Geol. Survey, 1891, pp. 19-226. Describes the topographic and geologic features of the coal measures, the process of its deposition, the distribution and character of the contained coal beds, and the conditions of the coal industry. Gives a description of the coal seams now worked in each county.

——— A report on the Higginsville sheet, Lafayette County [Missouri]. Mo. Geol. Survey, vol. 9, 1896, 99 pp. Describes the physiography of the region, the distribution and character of the Carboniferous and Quarternary formations, and the occurrence and character of the coal seams.

MONTANA.

ROSE, J. P., AND WILSON, R. A. Geology and economic deposits of a portion of eastern Montana. Mont. Univ. Studies, series 1, 58 pp., 1916.

ROWE, J. P. Montana coal and lignite deposits. Mont. Univ. Bull. 37 (Geol. Ser. 2), 1906, 82 pp.

STEBINGER, EUGENE. The coal fields of Montana. Am. Inst. Min. Eng. Bull. 81, September, 1913, pp. 2329–2359.

NEBRASKA.

BARBOUR, E. H. Report of the State geologist. Nebr. Geol. Survey, vol. 1, 1903, 258 pp. Includes analyses of certain coals.

——— The natural fuels of Nebraska. Nebr. Geol. Survey, vol. 4, 1916, part 25, pp. 339–345. Includes several analyses of coal samples.

PEPPERBURG, R. V. Coal in Nebraska. Nebr. Geol. Survey, vol. 3, pt. 10, 1910, pp. 275–307.

NEW MEXICO.

LEE, W. T. Stratigraphy of the coal fields of Northern Central New Mexico. Bull. Geol. Soc. Am., vol. 23, 1912, pp. 571–686.

SHERIDAN, J. E. Report of the mine inspector for the Territory of New Mexico to the Secretary of the Interior for the year ended June 30, 1906. 1906. 87 pp. Includes notes on the occurrence and character of coal seams and chemical analyses of coals.

STEVENSON, J. J. The Cerillos coal fields near Santa Fe, New Mexico. N. Y. Acad. Sci., Trans., vol. 15, 1896, pp. 105–122. Describes the character of the Cretaceous deposits and the occurrence and chemical composition of the coals.

NORTH DAKOTA.

LEONARD, A. G., AND OTHERS. Geology of southwestern North Dakota, with special reference to the coal. N. Dak. Geol. Survey, 5th Bienn. Rept., 1908, pp. 27–114.

OKLAHOMA.

GOULD, C. N., AND OTHERS. Brief chapters on Oklahoma's minerals. Okla. Geol. Survey Bull. 6, 1910, pp. 33–95.

OHIO.

BOWNOCKER, J. A. Coals of the Monongahela formation or upper productive coal measures. Ohio Geol. Survey, 4th ser., Bull. 9, 1908, pp. 9–170.

LORD, N. W., AND SOMERMEIER, E. E. Chemical analyses and calorific tests of the Clarion, Lower Kittanning, Middle Kittanning, and Upper Freeport coals. Ohio Geol. Survey, 4th ser., Bull. 9, 1908, pp. 170–339.

Orton, Edward. The coal fields of Ohio. Ohio Geol. Survey, vol. 7, 1893, pp. 253–290. Discusses the origin of coal and describes the various coal seams of the Carboniferous strata in Ohio.

Ray, F. A. The Ohio coal supply and its exhaustion. Ohio Univ. Bull. 12, 1914, 46 pp.

Stout, Wilber. Geology of Muskingum County. Ohio Geol. Survey, 4th ser., Bull. 21, 1918, 351 pp. Includes coal analyses by townships.

——— Geology of southern Ohio. Ohio Geol. Survey, 4th ser., Bull. 20, 1916, 723 pp. Gives a detailed description of geology of southern Ohio, with analyses of coals native to district.

OREGON.

Williams, I. A. The occurrence of coal in Squaw Creek Basin, Coos County, Oregon. The Mineral Resources of Oregon, vol. 1, January, 1914, pp. 28–48. Discusses composition of the coal and gives analyses.

PENNSYLVANIA.

Ashburner, C. A. First report of progress in the anthracite district, southern field, Panther Creek basin. 2d Geol. Survey Pa. Rept. AA, 1883, 407 pp.

Boileau, J. W. Coal fields of southwestern Pennsylvania, Washington, and Greene counties. 1907. 90 pp.

Chance, H. M. A revision of the bituminous coal measures of Clearfield County. 2d Geol. Survey Pa. Rept. H7, 1884, pp. XI–XV.

Gardner, J. H. The Broad Top coal field of Huntington, Bedford, and Fulton counties. Topographic and Geol. Survey Pa., Rept. no. 10, 1913, 81 pp. Describes the character and quality of the commercial coals.

Hill, F. A. Geology and mining in the northern coal field of Pennsylvania. Trans. Am. Inst. Min. Eng., vol. 15, 1887, pp. 699–707.

Hill, F. A. Report on the anthracite region. Geol. Survey Pa. Rept. for 1886, pt. 3, 1887, pp. 919–1329.

Lesley, J. P. Manual of coal and its topography illustrated by original drawings chiefly of facts in the geology of the Appalachian region of the United States of North America. 1856. 224 pp.

——— Note on classification of coals. 2d Geol. Survey Pa. Rept. MM, 2d Rept. of progress in the laboratory of the survey at Harrisburg, 1879, pp. 144–157.

——— On the Broad Top coal basin in central Pennsylvania. Am. Assoc. Adv. Sci. Proc., vol. 10, pt. 2, 1857, pp. 78–81.

——— The coal beds and fire clays of the Wellersburg basin, in Somerset County. Geol. Survey Pa. Ann. Rept. for 1885, 1886, pp. 227–239.

Lesquereaux, Leo. On the character and distribution of Paleozoic plants. Geol. Survey Pa. Ann. Rept. for 1886, 1887, pp. 457–522.

——— On the vegetable origin of coal. Geol. Survey Pa. Ann. Rept. for 1885, 1886, pp. 95–121.

Platt, Franklin, and Platt, W. G. Report of progress in the Cambria and Somerset district of the bituminous coal fields of western Pennsylvania, part 1, Cambria. 2d Geol. Survey Pa. Rept. HH, 1877, 194 pp.

——— Report of progress in the Cambria and Somerset district of the bituminous coal fields of western Pennsylvania. 2d Geol. Survey Pa. Rept. HHH, 1877, 348 pp.

ROGERS, H. D. The geology of Pennsylvania. Vol. 1, 586 pp.; vol. 2, 1045 pp., 1858.

STEVENSON, J. J. Report of progress in the Greene and Washington district of the bituminous coal fields of western Pennsylvania. 2d Geol. Survey Pa. Rept. K for 1875, 1876, 419 pp.

WHITE, I. C. Geology of Lawrence County. 2d Geol. Survey Pa. Rept. QQ, 1879, pp. 1–213.

——— Geology of Susquehanna River region in the six counties of Wyoming, Lackawanna, Luzerne, Columbia, Montour, and Northumberland. 2d Geol. Survey Pa. Rept. G7, 1883, 464 pp.

——— Report of the progress of the second geological survey of Pennsylvania in parts of Beaver, Allegheny, and Butler counties lying north of the Ohio River. 2d Geol. Survey Pa. Rept. Q for 1875, 1878, pp. 1–273.

——— Special report on the correlation of the coal measures in western Pennsylvania and eastern Ohio. 2d Geol. Survey Pa. Rept. QQ, 1879, pp. 215–303.

——— Stratigraphy of the bituminous coal fields of Pennsylvania, Ohio, and West Virginia. U. S. Geol. Survey Bull. 65, 1891, 212 pp.

——— The geology of Mercer County. 2d Geol. Survey Pa. Rept. QQQ, 1880, 233 pp.

RHODE ISLAND.

BROWN, C. W. Preliminary report of the natural resources survey of Rhode Island. R. I. Bureau Industrial Statistics, Ann. Rept. for 1909, pt. 3, 1910, pp. 59–128. Includes an account of the coal deposits.

TENNESSEE.

ASHLEY, G. H. The Tennessee coal field. Resources of Tennessee, vol. 1, October, 1911, pp. 188–202.

GLENN, L. C. The general features of the Tennessee coal field north of the Tennessee Central Railroad. Resources of Tennessee, vol. 3, January, 1913, pp. 26–49. Describes the occurrence and thickness of coal beds. (Also published in Tenn. Geol. Survey Bull. 2-B.)

CHEMICAL AND METALLURGICAL ENGINEERING. Kingsport, Tenn., and its chemical industries. Vol. 20, 1919, p. 567. Includes analyses of coals from neighborhood of Kingsport.

GLENN, L. C. General features of the Tennessee coal field north of the Tennessee Central R. R. Resources of Tennessee, vol. 6, July, 1916, pp. 127–154. Describes coal area and coals of northern Tennessee.

NELSON, W. A. The Tennessee coal field south of the Tennessee Central Railroad. Resources of Tennessee, vol. 3, January, 1913, pp. 26–49. (Also published in Tenn. Geol. Survey Bull. 2-B.)

NELSON, WILBUR. The Tennessee coal field south of the Tennessee Central R. R. Resources of Tennessee, vol. 6, 1916, July, pp. 155–183. Preliminary report on southern Tennessee coal field.

PHALEN, W. C. Preliminary report of the coal resources of the Pikeville special quadrangle of eastern Tennessee. Resources of Tennessee, vol. 1, September, 1911, pp. 117–162.

TEXAS.

ASHBURNER, C. A. Brazos coal field, Texas. Trans. Am. Inst. Min. Eng., vol. 9, 1881, pp. 495–506.

DRAKE, N. F. Report on the Colorado coal field of Texas. Univ. Texas Bull. 1755, 1917, 75 pp.

DUMBLE, E. T. Report on the brown coal and lignite of Texas. Tex. Geol. Survey, 1892, pp. 17–243. Describes the origin, formation, and properties of brown coal, the geology of the Texas deposits, and the occurrence and composition of the Tertiary brown coals in the different States, and compares them with European brown coals.

M'CRACKEN, R. H. Coal lands in Maverick County, Texas, near Eagle Pass. Austin, Tex., 1912, 11 pp. Average analyses of the coal are given.

PHILLIPS, W. B. Coal, lignite, and asphalt rocks [Texas]. Univ. Tex. Mineral Survey Bull. 3, 1902, pp. 137.

——— The coal, lignite, and asphalt rocks of Texas. Western Soc. Engrs. Jour., vol. 9, 1904, pp. 571–592.

PHILLIPS, W. B., AND WORRELL, S. H. The composition of Texas coals and lignites. Univ. Tex. Bull., Sci. Ser. No. 19, 1911, pp. 5–57.

——— The fuels used in Texas. Univ. Tex. Bull. 307, 1913, 287 pp. Discusses composition of Texas coal and lignite and gives analyses of coal samples.

SCHOCH, E. P. Chemical analyses of Texas rocks and minerals. Univ. Texas Bull. 1814, 1918, pp. 88–95, 196–198. Analyses of Texas coals, grouped by geologic eras.

SCOTT, A. C. The fuels of Texas. Coal Age, vol. 11, 1917, pp. 658–661. Describes occurrence and gives analyses of fuels in Texas, including coal and lignite.

SIMONDS, F. W. The minerals and mineral localities of Texas. Univ. Tex. Min. Survey Bull. 5, 1902, pp. 3–95.

UDDEN, J. A. A sketch of the geology of the Chisos country, Brewster County, Texas. Univ. Tex. Bull. 93, Apr. 15, 1907, 101 pp.

UDDEN, J. A., BAKER, C. L., AND BÖSE, EMIL. Review of the geology of Texas. Univ. of Texas, No. 44, 1916 (rev. 1919), pp. 148–154. Gives average analyses of coal samples by counties.

UTAH.

HARRINGTON, D. Coal mining at Sunnyside, Utah. Colo. Sch. Mines Bull., vol. 1, 1901, pp. 227–235. Describes the general geology, the occurrence of the coal in the Laramie group, and the mining operations.

WATTS, A. C. Coal-mining methods in Utah. Coal Age, vol. 10, 1916, pp. 296–302. Gives analyses of coals mined in Utah, with methods of extraction.

VIRGINIA.

BACHE, FRANKLIN. Coal sections developed by recent operations in Wise County, Virginia. Trans. Am. Inst. Min. Eng., vol. 24, 1895, pp. 70–80. Describes the coal developments and gives sections from various parts of the coal area of the country.

BUTTS, CHARLES. The coal resources and general geology of the Pound quadrangle in Virginia. Va. Geol. Survey Bull. 9, 1914, 61 pp. Discusses correlation of the coal beds and chemical composition of the coal.

HARNSBERGER, T. K. Geology and coal resources of the coal-bearing portion of Tazewell County, Va. Va. Geol. Survey Bull. 19, 1919, 195 pp. Includes analyses of nearly 100 samples of Tazewell County coal.

HINDS, HENRY. Geology and coal resources of Buchanan County, Va. Va. Geol. Survey Bull. 18, 1918, 250 pp. Includes analyses of numerous samples of Buchanan County coal.

—— The coal resources of the Clintwood and Bucu quadrangles, Virginia. Va. Geol. Survey Bull. 12, 1916, 206 pp. Presents analyses of 50 coals from mines included within the Clintwood and Bucu quadrangles or the near vicinity.

HODGE, J. M. The Big Stone Gap coal field. Trans. Am. Inst. Min. Eng., vol. 21, pp. 922–938 and 1005–1006.

LESLEY, J. P. The geological structure of Tazewell, Russell, and Wise counties in Virginia. Am. Phil. Soc. Proc., vol. 12, 1873, pp. 489–513.

WATSON, T. L. Mineral resources of Virginia. Va. Jamestown Exposition Commission, Lynchburg, 1907, 618 pp. Includes analyses of coals.

WASHINGTON.

CULVER, HAROLD. The coal fields of southwestern Washington. Wash. Geol. Survey Bull. 19, 1919, 155 pp. Gives data on southwestern coal field of Washington, prepared for commercial and scientific use.

DANIELS, JOSEPH. The coal fields of Pierce County. Wash. Geol. Survey Bull. 10, 1914, 146 pp. Describes character of the coal and gives analyses.

EVANS, G. W. The coal fields of King County. Wash. Geol. Survey Bull. 3, 1912, 247 pp.

HILL, F. A. Coal mining in Washington. Coal Age, vol. 13, 1918, pp. 833–834. Includes typical analyses of lignite, coking coal, and subbituminous coal.

LANDES, HENRY. The coal deposits of Washington. Wash. Geol. Survey Ann. Rept. for 1901, vol. 1, 1902, pp. 257–281.

LANDES, HENRY, AND RUDDY, C. A. Coal deposits of Washington. Wash. Geol. Survey Ann. Rept. for 1902, vol. 2, 1903, pp. 165–277. Describes character, geographic distribution, and geologic relations of the Washington coal beds, the occurrence, thickness, and value of the coal seams, and the constitution and value of the coals.

SAUNDERS, E. J. The coal fields of Kittitas County. Wash. Geol. Survey Bull. 9, 1914, 204 pp. Classification and analyses of the coals are given.

WEST VIRGINIA.

GRIMSLEY, G. P. Jefferson, Berkeley, and Morgan counties. W. Va. Geol. Survey, 1916, 644 pp. Geology and analyses of mineral products of three counties.

—— Report on the geology of the Panhandle counties of West Virginia. W. Va. Geol. Survey, County Rpts. and Maps: Ohio, Brooke, and Hancock counties, 1907, 378 pp.

GRISWOLD, W. T. The coals of the Steubenville quadrangle in West Virginia. W. Va. Geol. Survey County Rpts. and Maps: Ohio, Brooke, and Hancock counties, 1907, pp. 224–237.

HENNEN, RAY. Braxton and Clay counties. W. Va. Geol. Survey, 1917, 883 pp. Detailed geological study of territory, with exhaustive material on mineral resources.

—— Doddridge and Harrison counties. W. Va. Geol. Survey County Rpts., 1912, 712 pp. Gives chemical composition, calorific value, and fuel ratio of the coals.

—— Fayette County. W. Va. Geol. Survey, 1919, 1,002 pp. Geology and mineral resources of Fayette County, with analyses of native coals.

HENNEN, RAY. Marshall, Wetzel, and Tyler counties. W. Va. Geol. Survey County Rpts., 1909, 654 pp. Describes the area mentioned and the mineral resources, including coal.

——— Wirt, Roane, and Calhoun counties. W. Va. Geol. Survey, 1911, 573 pp.

HENNEN, R. V., AND REGER, D. B. [Report on the history and physiography, geology, and mineral resources of Marion, Monongalia, and Taylor counties. W. Va. Geol. Survey, 1913, 844 pp.

——— Logan and Mingo counties. W. Va. Geol. Survey County Rpts., 1914, 776 pp. Shows analyses of coal from 153 mines and prospects.

KREBS, C. E., AND TEETS, D. D., JR. Cabell, Wayne, and Lincoln counties. W. Va. Geol. Survey County Rpts., 1913, 483 pp. Discusses the character, thickness, calorific value, and fuel ratio of the coals. Raleigh County and the western portions of Mercer and Summers counties. W. Va. Geol. Survey, 1916, 778 pp. Geology of district and analyses of mineral products.

RAMSAY, G. S. The northeastern bituminous coal measures of the Appalachian System. Trans. Am. Inst. Min. Eng., vol. 25, 1896, pp. 76–83.

REGER, DAVID. Lewis and Gilmer counties. W. Va. Geol. Survey, 1916, 660 pp. Study of geology and mineral resources of two West Virginia counties, including analyses of coal samples from district covered.

REGER, DAVID, AND TEETS, D. D., JR. Barbour and Upshur counties and the western portion of Randolph County. W. Va. Geol. Survey, 1918, 867 pp.

ROBINSON, NEIL. The Kanawha and New River coal fields of West Virginia, U. S. A. 1904. 23 pp. Includes notes on the occurrence, geologic relations, composition, fuel values, and production of coal.

WEEKS, J. D. The Elk Garden and Upper Potomac coal fields of West Virginia. Trans. Am. Inst. Min. Eng., vol. 24, 1895, pp. 351–364. Gives a general description of the region and tables of chemical analyses of the coal and of coal production.

WHITE, I. C. Characteristics of the New River coals. Black Diamond, vol. 62, pp. 154–155.

——— Levels. Coal analyses. W. Va. Geol. Survey, Bull. 2, 1910, 385 pp.

——— Shortage of coal in the norther Appalachian coal field. Bull. Geol. Soc. Am., vol. 20, 1909, pp. 333–340. Discusses the distribution of workable beds, the method of deposition of the coal, and the duration of the field under present methods of mining and use.

——— Supplementary coal report. W. Va. Geol. Survey, vol. 2 (A), 1908, 720 pp. A detailed account of the distribution, geologic relations, and economic value of the coal beds of West Virginia.

——— The Appalachian coal field [West Virginia]. W. Va. Geol. Survey, vol. 2, 1903, pp. 81–716. Gives a detailed account of the Carboniferous system in West Virginia, including geologic sections, the extent, character, and geologic position of the various formations, and the character, occurrence, constitution, and fuel value of the coals.

WYOMING.

KNIGHT, W. C. Coal fields of southern Uinta County, Wyo. Abstracted in Bull. Geol. Soc. Am., vol. 13, 1903, pp. 542–544. Describes briefly the Cretaceous strata of the region and gives chemical analyses of the coals.

TRUMBULL, L. W. A preliminary report upon the coal resources of Wyoming. Wyo. Univ. School of Mines Bull. 7, 1905, 19 pp.

CANADA.

BLIZARD, JOHN. The economic use of coal for steam-raising and house-heating. Canada Dept. of Mines, Mines Branch, Bull. 28, 1919, 21 pp. Includes summary analyses of coals from various fields of Canada, with emphasis on their heating value.

CAMSELL, CHARLES, AND MALCOLM, WYATT. The Mackenzie River basin. Canada, Dept. of Mines, Geol. Survey Mem. 108, 1919, 154 pp. Describes geology and enumerates mineral resources of Mackenzie River district of western Canada. Gives analyses of 11 Peace River and 16 Smoky River coals.

GRAY, FRANCIS. The coal field and coal industry of eastern Canada. Canada Dept. of Mines, Mines Branch, Bull. 14, 1917, 67 pp. Discusses eastern Canadian coal fields and mining methods and gives average analyses of coals from maritime Provinces.

HAANEL, B. F. Peat, lignite, and coal. Canada, Mines Branch, 1914, 261 pp. Gives analyses and calorific value of coal and lignite.

HAYES, ALBERT. Investigations in Nova Scotia and New Brunswick. Canada, Dept. of Mines, Geol. Survey, Summary report, 1918, pp. 5F–18F. Includes analyses of coals from Nova Scotia and New Brunswick.

PORTER, J. B. Investigations of the coals of Canada with reference to their economic qualities. Canada, Mines Branch, 1915. 194 pp. Discusses weathering and oxidation; gives analyses of the coal. These investigations supplement those published in Report 83.

PORTER, J. B., AND DURLEY, R. J. Investigations of the coals of Canada with reference to their economic qualities. Canada, Mines Branch, Report 83, 1912, 6 vols. Describes methods of sampling and gives analyses and composition of Canadian coals.

SHERWIN, P. M. Bituminous coal mines of Crow's Nest Pass. Coal Age, vol. 10, 1916, pp. 1034–1037, 1074–1077. Describes mining methods and analyzes coal deposits of Kootenay formation in mines between Burmis, Alberta, and Elko, British Columbia.

STANSFIELD, EDGAR, AND GILMORE, ROSS. Lignite carbonization. Canada, Dept. of Mines, Mines Branch, Summary report, 1918, Chapter IV, pp. 87–106.

STANSFIELD, EDGAR, AND NICOLLS, J. H. H. Analyses of Canadian fuels; Part I, The Maritime Provinces. Canada, Dept. of Mines, Mines Branch, Bull. 22, 1918, 2? pp. This is the first of a series of five reports covering Canada by districts and presented in uniform style. Practically every type of fuel native to Canada is analyzed in the series. Detailed and numerous analyses of coals.

——— Analyses of Canadian fuels; Part II, Quebec and Ontario. Canada, Dept. of of Mines, Mines Branch, Bull. 23, 1918, 25 pp.

——— Analyses of Canadian fuels; Part III, Manitoba and Saskatchewan. Canada, Dept. of Mines, Mines Branch, Bull. 24, 1918, 13 pp.

——— Analyses of Canadian fuels; Part IV, Alberta and the northwest territories. Canada, Dept. of Mines, Mines Branch, Bull. 25, 1918, 68 pp.

——— Analyses of Canadian fuels; Part V, British Columbia and the Yukon Territory. Canada, Dept. of Mines, Mines Branch, Bull. 26, 1918, 24 pp.

WHITE, JAMES. Coal resources of western Canada. Coal Age, Vol. 15, 1919, pp. 744–748, 858–862. Includes analyses of 5 Saskatchewan lignites, 38 samples of Alberta lignites and anthracite and bituminous coals, and 56 British Columbia coals arranged by districts. Analyses of 11 Nova Scotia coals are included for comparison.

ALBERTA.

HAANEL, B. F. Results of the investigation of six lignite samples obtained from the Province of Alberta. Canada, Mines Branch, 1915, 110 p. Describes methods and results of gas producer and boiler tests. Contains analyses of coals tested.

MAC VICAR, JOHN. Foothill coal areas north of the Grand Trunk Pacific R. R. Canada, Dept. of Mines, Geol. Survey, Summary report, 1916, pp. 85–93. In addition to discussion of geology of district, report gives analyses of 9 coals from the foothills and 6 coals from the Smoky River.

——— Yellowhead coal district. Coal Age, vol. 15, 1919, pp. 608–610. Includes approximate analyses of coals of yellowhead district and analyses of mine-run coal.

ROSE, BRUCE. Crowsnest coal field. Canada, Dept. of Mines, Geol. Survey, Summary report, 1916, pp. 107–114. Includes description of field and analyses of samples collected in the locality.

STEWART, J. S. Coal mines of west central Alberta. Canada, Dept. of Mines, Geol. Survey, Summary report, 1916, pp. 94–106. Gives analyses of 15 coal samples, representing product of 7 mining companies; in addition, the report has detailed analyses of coals from different parts of one mine.

BRITISH COLUMBIA.

BRITISH COLUMBIA, MINISTER OF MINES' OFFICE. Annual report for the year ending 31st December, 1912. 1913. 349 pp. Some analyses of coal are given.

——— Annual report for the year ending 31st December, 1913. 1914. 459 pp. Discusses occurrence and thickness of coal seams.

——— Annual report for the year ending 31st December, 1914. 1915. 54 pp. Describes occurrence of coal seams and gives analyses.

——— Annual report for the year ending 31st December, 1915. 1916. 473 pp. Some analyses of coal are given.

DOWLING, D. B. Coal fields of Manitoba, Saskatchewan, Alberta, and eastern British Columbia. Canada, Geol. Survey, Memoir 53, 1914, 142 pp. Contains tables of analyses of Canadian and United States coals.

DUNN, ROBERT. Coal in the Peace River district of British Columbia. Coal Age, vol. 15, 1919, p. 1085.

EVANS, G. W. Some notes on the Groundhog anthracite coal field. Trans. Canadian Min. Inst., vol. 16, 1913, pp. 434–441. Presents analyses of 21 coal samples.

MACKENZIE, J. D. Geology of a portion of the Flathead coal area, British Columbia. Canada, Dept. of Mines, Geol. Survey, Mem. 87, 1916, 53 pp.

——— Geology of Graham Island, British Columbia. Canada Dept. of Mines, Geol. Survey, Mem. 88, 1916, 221 pp. Includes analyses of 13 coals frem neighborhood of Camp Wilson.

NEWFOUNDLAND.

MCGRATH, J. W. Newfoundland coal deposits. Canadian Min. Jour., vol. 37, 1916, pp. 439–441. Reports contains analyses of 15 Newfoundland coals.

NOVA SCOTIA.

DRUMMOND, R. Minerals and mining in Nova Scotia. Stellarton, N. S., 1918, 368 pp.

HUDSON, J. G. S. Sections of the Sydney coal fields, Cape Breton, Nova Scotia. Canada, Mines Branch, 1913, 6 pp. Gives geologic sections and analyses of coals.

SASKATCHEWAN.

Rose, Bruce. Wood Mountain-Willowbunch coal area, Saskatchewan. Canada, Dept. of Mines, Geol. Survey, Mem. 89, 1916, 104 pp. Includes 17 analyses of lignite and chemical analyses, boiler tests, and gas-producer tests of Souris coal.

SOUTH AMERICA.

BRAZIL.

Coal Age. Progress in utilizing pulverized fuel. Vol. 15, 1919, p. 993. Article includes analyses of three Brazilian bituminous coals and one lignite.

De Oliveira, Eusebio. Noticia sobre as minas de carvão de pedra de bacio de Rio das Anzas. [Notice of the coal mines of the basin of the Rio das Anzas.] Serviço geologico e mineralogico do Brasil, Rio de Janeiro, 1916, 18 pp.

——— Regiões carboniferous dos estados do sul. [Coal regions of the southern States.] Serviço geológico e mineralogico do Brasil, Rio de Janeiro, 1918, 125 pp.

White, I. C. Relatorio sobre "coal measures" e rochas associados, do sul do Brazil. [Report on the coal measures and associated rocks of southern Brazil.] Brazil, Commissão de estudos das minas de carvão de pedra Brazil, Relatorio final, 1908, pp. 1–285. Describes geology and gives analyses of coal.

PERU.

Dueñas, Enrique. Informe sobre el reconocimiento geológico-minero de la cuenc carbonifera setentrional, Lima-Junin (Hoyas de Oyon, Checras y Pasco). [Report on the geological and mining survey of the northern coal basin (Oyon, Checras, and Pasco mines).] Boletin del Cuerpo de Ingenieros de Minas del Peru, 1919, 292 pp.

Figuerola, A. P. Yacimientos carboníferos del distrito de Llapo. [Coal beds of the Llapo district.] Boletin del Cuerpo de Ingenieros de Minas del Peru, No. 89, 1918, 24 pp. Particular emphasis is laid on the dry coal of the district, which has an average analysis of 20 per cent volatile, 72 per cent fixed carbon, and 2 to 9 per cent ash.

Cuerpo de Ingenieros de Minas del Peru. Estadistica minera en 1918. [Mining statistics of 1918.] Bol. 96, 1918, pp. 27–43.

——— Yacimientos carboníferos de las provincias de Pallasca, Huaylas y Yungay. [Coal beds of the provinces of Pallasca, Huaylas, and Yungay.] Bol. 90, 1918, 85 pp.

EUROPE.

Stoek, H. H. Coal resources of the western front. Black Diamond, vol. 61, 1918, pp. 576–578; vol. 62, 1919, pp. 5–7. Gives analyses of coal from France, the Ruhr district, the Saar basin, and Lorraine.

AUSTRIA-HUNGARY.

Austria, Komittee des Allgemeines Bergmannstages. Die Mineralkohlen Osterreichs. [The coal of Austria.] Vienna, 1903, 490 pp. Describes geology and occurrence of coal beds, and gives analyses of the coal.

BELGIUM.

Habets, Paul. Les travaux recents de reconnaissance dans les bassins houillers de Belgique. [Recent reconnaissance in the coal basins of Belgium.] Ann. des mines Belgique, t. 15, 1910, pp. 1047–1068. Gives percentage of volatile matter in the coal.

SCHMITZ, R. P., AND STAINIER, M. X. Le bassin houiller du nord de la Belgique [The northern coal basin of Belgium.] Ann. des mines Belgique. t. 15, 1910, pp 1811–1867. Presents geology of beds and thickness of coal seams. Analyses of coal are given.

GERMANY.

VEREIN FÜR DIE BERGBAULICHEN INTERESSEN IM OBERAMTSBEZIRK DORTMUND. Die Entwickelung des Niederrheinisch-Westfälischen Steinkohlen-Bergbaues. Berlin.

GREAT BRITAIN.

BARROW, GEORGE. The geology of the country around Lichfield, including the northern parts of the South Staffordshire and Warwickshire coal fields. London, 1919, 302 pp.

CLOUGH, C. T., HINXMAN, L. W., WRIGHT, W. B., ANDERSON, E. M., AND CARRUTHERS, R. G. The economic geology of the central coal field of Scotland; description of area V. Geol. Survey, Scotland, Memoirs, 1916, 146 pp.

GREAT BRITAIN ROYAL COMMISSION ON COAL SUPPLIES. Final report. 1905, pts. 1–13. Discusses the coal resources of Great Britain and gives production statistics. Describes geologic relations and occurrence of coal measures and thickness of coal seams. Analyses are given.

HINXMAN, L. W., CRAMPTON, C. B., ANDERSON, E. M., AND MACGREGOR, M. The economic geology of the central coal field of Scotland; description of area II. Geol. Survey, Scotland, Memoirs, 1917, 89 pp.

RITCHIE, A. E. The Kent coal field, its evolution and development. London, 1919, 301 pp. Includes analyses of coals from various seams.

STOEK, H. H. The coal resources of England. Black Diamond, vol. 62, 1919, pp. 298–300. Includes a few typical analyses of English coals.

STRAHAN, AUBREY, AND POLLARD, W. The coals of South Wales. Mem. Geol. Survey, England and Wales, 2 ed., 1915, 91 pp. Describes coal beds, methods of sampling and analyzing the coal.

HOLLAND.

CLEMENT, —. La houille en Hollande. [Coal in Holland.] Ann. des mines, 11th ser. t. 3, 1913, pp. 355–419. Discusses occurrence of coal and the geologic formation of coal basins, the size and thickness of the coal seams. Gives percentage of volatile matter in the coal.

ASIA.

CHINA.

WANG, C. F. Coal and iron deposits of the Pen-hsi-hu district, Manchuria. Trans. Am. Inst. Min. Eng., vol. 59, 1918, pp. 395–423. Analyses are given (pp. 408–410) of coals from district.

YUNG, M. B. Tin and coal deposits of the Fu Chuan district, China. Trans. Am. Inst. Min. Eng., vol. 50, 1914, pp. 695–697. Describes occurrence and thickness of coal beds and presents analyses of the coal.

INDIA.

COTTER, G. DEP. Some newly discovered coal seams near the Yaw River, Pakokku district, upper Burma. India Geol. Survey Records, vol. 44, November, 1914, pp. 163–185. Describes geology and structure, occurrence and size of coal seams; contains analyses of 22 samples of coal.

FOX, CYRIL. Note on a dyke of white trap from the Pench Valley coal field, Chhindwara district. India Geol. Survey Records, vol. 44, June, 1912, pp. 124–126. Gives analyses and discusses composition.

HOLLAND, T. H., AND OTHERS. Quinquennial review of the mineral production of India. India Geol. Survey Records, vol. 46, August, 1915, pp. 42–71. Discusses geologic relations of Indian coal and the results of analyses.

STUART, MURRAY. The geology of the Henzada district, Burma. India Geol. Survey Records, vol. 41, January, 1912, pp. 254–259. Gives analyses of coal and discusses results of fuel tests.

JAPAN.

COAL AGE. Japan has good metallurgical coals. Vol. 13, 1918, p. 832. Analyses of Japanese coal by districts, arranged in order of percentage of fixed carbon.

AFRICA.

CAPE OF GOOD HOPE.

CAPE OF GOOD HOPE GEOLOGICAL COMMISSION. Fifteenth annual report, 1910, 1911, pp. 25–32, 80–85. Describes occurrence of coal. Gives analyses with discussion of the same.

TRANSVAAL.

MELLOR, E. T. The geology of the Transvaal coal measures with special reference to the Witbank coal field. Transvaal Geol. Survey Mem. 3, 1906, 60 pp. Geology and physical characteristics of coal beds are described and analyses of the coals are given.

OCEANIA AND MALAYSIA.

NEW SOUTH WALES.

ATKINSON, A. A. Coal and oil-shale mines. New South Wales, Dept. of Mines, Ann. Rept., 1912, pp. 98–169, 196. Contains coal-mining statistics and table of coal analyses, as to reports for 1913, 1914, and 1915.

——— Coal and oil-shale mines. New South Wales, Dept. of Mines, Ann. Rept., 1913, pp. 110–178, 189.

——— Coal and oil-shale mines. New South Wales, Dept. of Mines, Ann. Rept., 1914, pp. 105–181, 215.

——— Coal and oil-shale mines. New South Wales, Dept. of Mines, Ann. Rept., 1915, pp. 101–199.

PITTMAN, E. F. The coal resources of New South Wales. New South Wales, Geol. Survey, 1912, 99 pp. Gives proximate analyses of 194 samples of coal.

——— Mineral resources of New South Wales. New South Wales Geol. Survey, 1901, pp. 307–348. Discusses geology of coal seams and gives analyses of the coals.

NEW ZEALAND.

HENDERSON, J. The coal deposits of Reefton, New Zealand. Coll. Guard., vol. 114, pp. 543–544. Gives origin of coal beds and relation of age of the coal to its composition.

MORGAN, P. G., AND BARTRUM, J. A. The geology and mineral resources of the Buller-Mokihiniu subdivision, Westport division. New Zealand Geol. Survey Branch Bull. 17, 1915, 210 pp. Describes occurrence and chemical composition of coals and gives analyses.

QUEENSLAND.

Dunstan, Benjamin. Coal resources of Queensland; a general review. Queensland Geol. Survey, Pub. no. 239, 1913, 29 pp. Describes coal areas and gives proximate analyses of the coal. Contains bibliography of references to coal literature.

Marks, E. O. Coal measures of southeast Moreton. Queensland Geol. Survey, Pub. no. 225, 1910, 53 pp. Describes geology and occurrence of coal measures and character of the beds. Analyses of the coal are given.

Reid, J. H. The coal measures at Oxley Creek, Hughenden district. Queensland Dept. of Mines, Geol. Survey Pub. 258, 1918, 16 pp.

SOUTH AUSTRALIA.

Chapman, R. W. Summary report on the utilization of Leigh Creek coal by the Leigh Creek coal committee. Dept. of Mines, Mining Review, No. 29, 1918, pp. 31–35.

Ward, L. K., and Winton, B. E. Reports on the Leigh Creek coal field. Dept. of Mines, Mining Review, No. 27, 1917, pp. 34–51. Includes detailed analyses of coal from Leigh Creek district.

TASMANIA.

Hills, Loftus. The Preolenna coal field and the geology of the Wynyard district. Tasmania Geol. Survey Bull. 13, 1913, 71 pp. Describes occurrence and character of the coal seams. Discusses composition of the coal and gives analyses.

Reid, A. M. The Mount Pelion mineral district. Dept. of Mines, Geol. Survey Bull. 30, 1919, pp. 75–80. Gives occurrence and analyses of coals.

Twelvetrees, W. H. The Catamaran and Strathblane coal fields and coal and limestone at Ida Bay (southern Tasmania). Tasmania Geol. Survey Bull. 20, 1915, 61 pp. Discusses the geologic age, quality of the coal, and analyses.

VICTORIA.

Kitson, A. E. The Jumbunna and Powlett Plains district, South Gippsland. Geol. Survey of Victoria, Bull. 40, 1917, 26 pp.

Report of the Advisory Committee on Brown Coal. Melbourne, Sept., 1917, 32 pp. Appendix A contains analyses of typical brown coals of Victoria.

Stirling, James. Reports on the Victorian coal fields (Nos. 3 and 4). Victoria Dept. of Mines Spec. Repts., 1895, 19 and 4 pp. Describes coal seams, gives analyses of coal.

——— Reports on the Victorian coal fields (No. 6). Victoria Dept. of Mines Spec. Repts., 1897, 6 pp. Describes geologic structure of coal measures and contains analyses.

Victoria Royal Commission on Coal. Final report as to the best means of developing and promoting the coal industry of Victoria. Melbourne, 1891, pp. 327–380. Includes tables showing quality of the coal.

WESTERN AUSTRALIA.

Saint-Smith, E. C. A geological reconnaissance of a portion of the southwest division of Western Australia. Western Australia Geol. Survey Bull. 44, 1912, pp. 21–34, 70. Describes geology of coal beds and gives several analyses.

Simpson, Edward. Analyses of western Australian rocks, meteorites, and natural waters. Geol. Survey, 1916, Bull. 67, pp. 108–114.

SIMPSON, E. S. Investigations into the composition and properties of coals from the Collie field. Western Australia Geol. Survey Bull. 48, Misc. Rpt. 16, 1912, pp. 66–81. Describes method of sampling and discusses moisture content and calorific value of the coals.

WOODWARD, H. P. The coal resources of Western Australia. Western Australia Geol. Survey Bull. 64, Misc. Rpt. 52, 1915, 12 pp. Describes character of the coals and presents ultimate analyses of mine samples.

PHILIPPINE ISLANDS.

BURRITT, C. H. The coal measures of the Philippines. Philippine Islands Min. Bur., 1901, 269 pp. Describes coal-mining industry; presents comparative analyses of Cardiff, Australian, and Wyoming coals.

DALBURG, F. A. Coal resources of the Philippines. Mineral resources of Philippine Islands for 1911, 1912, pp. 54–62. Describes extent and distribution of coal fields and the thickness of coal beds.

SMITH, W. D. The coal resources of the Philippine Islands. Mineral Resources of Philippine Islands for 1910, 1911, pp. 37–56. Discusses physical and chemical properties of the coals.

YCASIANO, F. R. Philippine coals and their use. Mineral Resources of Philippine Islands for 1915, 1916, pp. 32–39. Presents average analyses of East Batan coals.

INDEX.

This index gives the names of places at or near which samples of coal mentioned in this bulletin were collected. In addition, it gives the names of many coal beds, including names of geological significance, as well as some that are merely local, and the names of most of the mines.

Attention is called to the fact that many beds opened by prospect pits, country banks, or by mines, especially in the Rocky Mountain province, have no names, even local ones. Moreover, many such local names as "A," "B," "1," "2," "Upper," "Lower," have been omitted to reduce the length of the index and to avoid the confusion that would result from applying the same designation to different beds.

C.

D.

E.

Bulletin 198

DEPARTMENT OF THE INTERIOR
JOHN BARTON PAYNE, SECRETARY

BUREAU OF MINES
H. FOSTER BAIN, ACTING DIRECTOR

REGULATION OF EXPLOSIVES IN THE UNITED STATES

WITH ESPECIAL REFERENCE TO THE ADMINISTRATION OF THE

EXPLOSIVES ACT OF OCTOBER 6, 1917

BY THE

BUREAU OF MINES

BY

CHARLES E. MUNROE

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REGULATION OF EXPLOSIVES IN THE UNITED STATES, WITH ESPECIAL REFERENCE TO THE ADMINISTRATION OF THE EXPLOSIVES ACT OF OCTOBER 6, 1917, BY THE BUREAU OF MINES.

By CHARLES E. MUNROE.

ORIGIN OF FEDERAL EXPLOSIVES ACT, OCTOBER 6, 1917.

At the outset of the war the uncontrolled production and possession of explosives obviously became a serious menace to the safety of persons and property and the successful conduct of military operations. Even in the years immediately preceding the entrance of the United States into the Great War explosives were employed in attempts to wreck munitions plants as at Eddystone, Pa., or to interrupt transportation and conveyance by demolition of munition-laden cars as at Black Tom Island, N. Y., or by attacks on ships, bridges, and viaducts. Outrages with explosives, such as that which Holt inflicted on the Senate reception room, United States Capitol, were not infrequent, and often caused serious loss of life and injury to persons as well as destruction of property.

The regular manufacturers of explosives were keenly alive to this menace and early took such steps as lay within their power to meet it as is shown by the following letter:

CIRCULAR NO. 356-A.

NEW YORK, *March 8, 1917.*

To all division managers, salesmen, magazine keepers:

DEAR SIRS: Please refer to our circular No. 30, dated July 15, 1915, which reads as follows:

"From and after the receipt of this circular you are requested to use your utmost care in the sale and delivery of high explosives.

"You are required to satisfy yourself, either by actual knowledge or by information acquired from reliable sources, that the party buying from you has legitimate use of explosives: *And in no case will you deliver or sell such goods to parties unknown or unidentified.*"

I call your attention because this is a time when special attention should be paid to the sale and delivery of high explosives.

Yours, very truly,

(Signed) A. C. BLUM,
General Sales Agent.

Some of the States had no laws of any kind relative to explosives, and the laws were not alike in the States that had regulation. Therefore, to secure that uniform supervision and control which was essential, the law regulating explosives would have to be nation wide and nationally administered. The assumption of jurisdiction by the Federal Government was an invasion of the police powers of the States, but was justified by military necessity, and the right for such action at that time existed in the war powers of the Congress.

The necessity for Federal regulation was recognized by governors of the New England States who impressed it upon the War Department as an immediate and imperative need, and Brig. Gen. Joseph E. Kuhn, then Chief, War College Division, General Staff Corps, United States Army, was assigned to determine the best medium through which the desired action could be secured. Among the then existing divisions of the Government, the Bureau of Mines of the Department of the Interior, which was created in 1910, was charged with a measure of supervision over explosives used in mines where normally nearly 80 per cent of all explosives manufactured in time of peace was consumed. As a consequence the Bureau of Mines had a well-organized explosives division of experienced men who besides having had active contact with explosives as used in mine and field and at the testing station, made a study of the misuse of explosives and, by orders of the director, had visited when feasible, the scene of all accidents and outrages from explosives.

In addressing the House of Representatives Committee of Mines and Mining on this subject at a hearing on the bill, Gen. Kuhn, after referring to "one governor who submitted to the War Department, in writing, his fears and apprehensions over this question and the necessity for some sort of Federal supervision," said:[1]

We concluded there was a good deal in what he said, and the matter was brought to a head in that way, and the question arose as to what department or agency was best fitted for taking charge of this material. Naturally, we thought both of the War Department and of the Bureau of Mines, both of which have a great deal to do with explosives, but the Bureau of Mines seemed to us the more appropriate department for two reasons; first, because they were making a very intimate study of all classes of explosives used in mining and had laboratories and fairly well distributed agencies throughout the country; and, secondly, and primarily, that the War Department in these days of war is so overwhelmed with responsibility that the assumption of any additional burden is very much to be avoided if possible. In other words, in time of war the principle to be followed is not to load up the War Department with any additional work that can be taken care of by other departments or bureaus of the Government in the interest of saving them additional exertion and labor.

As a result Dr. Van H. Manning, then Director of the Bureau of Mines, was requested to bring this matter to the attention of the

[1] Regulation of the Use of Explosives. Hearings before the Committee on Mines and Mining of the House of Representatives. 1917. p. 8.

Congress and to assemble and present information essential to the proper consideration of the legislation sought. As the desired law would necessarily restrict the manufacturers, conveyers, dealers and consumers of explosives, Director Manning deemed it wise to secure their cooperation at the outset, especially as their experiences in the explosives industry would enable them to advise the form in which to draft an operative law and to furnish information by which such a law could be promptly carried into effect. He, therefore, at once commissioned the author of this paper to interview the more readily accessible representatives. Within one week of the time the project was entrusted to Director Manning a conference was held in Washington by representatives of those divisions of the Army and Navy most concerned with explosives, the more important manufacturers and consumers, the bureau of explosives of the American Railway Association, of several States and municipalities, and the Bureau of Mines, to consider the form for such a law and the means by which it might be enforced, and to determine the duties to be performed by the various parties interested.

A competent force from the Bureau of Mines was then assigned to study the laws and ordinances of countries, States, and municipalities in which laws and ordinances regulating explosives had been enacted, and especially to ascertain how these laws had been modified by the necessities of the existing state of war, and, also, wherein the proposed law might conflict with or overlap the jurisdiction of existing laws. By April 20, 1917, a bill had been drafted and introduced into the House of Representatives as H. R. 3633, and hearings were begun before the Committee on Mines and Mining of the House. At the hearing held April 20, Dr. Manning presented the following statement:[2]

JUSTIFICATION FOR THE ACT TO CONTROL THE MANUFACTURE, SALE, AND USE OF EXPLOSIVES.

Since the discovery and utilization of gunpowder no war has been conducted without the use of explosives, and just so far as these explosives have been perfected they have been utilized for war purposes. But explosives are equally important for use in times of peace. They are an essential instrument of our modern civilization and their use for utilitarian purposes in time of peace is extending as our knowledge of them improves and increases, and to be most efficiently used in times of peace they must be readily accessible to the users. As a result we find that they are widely distributed in commerce, as other general merchandise is, and, being thereby readily accessible for use, they may be secured by those who intend to misuse them or to abuse the community by their use of them. It is this problem that we now must meet. It is this problem which has been brought out by the War Department, for since explosives are generally accessible for peaceful uses thay can be secured by the enemies of our country for the purposes of demolition of our bridges, our ships, our aqueducts, our electric-light plants, and our other public utilities.

[2] Regulation of the use of explosives. Hearing before the Committee on Mines and Mining of the House of Representatives. 1917. pp. 35-36.

In view of the present dangers it is essential that the Government secure a complete record of every explosives factory in the United States, as regards its location, the kind of explosives it manufactures, the amount of its output of each explosive in a given time, the amount it could produce on a 24-hour run, the value of its products for military purposes, and the readiness with which its plant could be enlarged. A knowledge of location is of prime importance as looking to the use of the factory; first, as a source of supply of material for the defense of our harbors; second, as looking to the factory as a point to be defended (because of the aid it might supply) in case of foreign invasions or of internal uprisings.

Of all of the divisions of the Federal Government, the Bureau of Mines is that one which is best equipped and most directly organized to undertake this work, for it has already a well-trained and well-organized explosives division. It has, from its organization, given much attention to the subject of explosives. It, in times of peace, deals officially with a larger percentage of the explosives manufactured than all the other divisions of the Government, and from the nature of things it always will in times of peace.

All other civilized governments exercise a national supervision over the explosives manufactured within their confines and over the trade in explosives, for they have recognized not only the importance for the users of national supervision in order to promote safety in the use of these dangerous substances, but also that explosives are commodities of such concentrated energy that they may readily be misused.

In enacting legislation the effect a proposed form may produce must be ascertained in advance, so far as possible, for otherwise the attempt to correct an evil may seriously hamper essential industries and hurt the best interests of the people. This was especially true of laws regulating explosives. The industry was old and well established and explosives had become an essential of civilization. Explosives are used in mining coal, iron, copper, lead, zinc, and other metalliferous ores; in quarrying for the blasting out of limestone, sandstone, and fluorite with which to flux metalliferous ores when smelting them; in breaking out dimension stone from which to construct buildings, abutments, bridges, piers, sea walls, and docks; in throwing down broken stone for use as road metal and in the manufacture of phosphate rock for use as a fertilizer and of cement and concrete. They are used in engineering operations for driving tunnels, blasting out obstructions in building highways, throwing over earth in making fills, in building dams, in deepening channels, and in removing or demolishing obstacles to navigation. They are used in agriculture for breaking bowlders and blowing up stumps, for excavating in planting orchards, and for digging ditches in draining swampy land.

This incomplete enumeration of the peace-time uses of explosives shows that the quantity consumed is large. A more definite conception is given by the following statistics of production, to which is added statistics for exportation that disclose something of the effect of war on the explosives industry.

STATISTICS.

PRODUCTION OF EXPLOSIVES IN THE UNITED STATES.

For the past seven years the Bureau of Mines has undertaken the compilation of annual reports showing the production of explosives, excluding exports, in the United States.

The following statistics, in Table 1,[3] received from manufacturers, show the importance of the explosives industry:

TABLE 1.—*Production of explosives in the United States.*

Year.	Pounds.
1912	489,493,131
1913	500,011,845
1914	450,251,489
1915	460,900,796
1916	505,415,052
1917	582,475,327
1918	499,224,660

This production was of explosives used for domestic purposes only, and does not include the amounts manufactured for export by the various powder companies nor the munitions of war or explosives manufactured by the Government during the war.

EXPLOSIVES EXPORTED.

The total value of explosives exported from the United States[4] from 1913–1918 was as follows:

TABLE 2.—*United States exportation of explosives.*

1913	$5,525,077
1914	10,037,587
1915	188,969,893
1916	717,144,649
1917	633,183,574
1918	248,539,469

In peace time the mining industry used by far the largest amount of explosives manufactured. In 1915, of the total amount manufactured for domestic use, 72 per cent was used in coal and other mining; in 1916, 73.2 per cent, and in 1917, 76.4 per cent.

The United States in normal times has over 31,000 mines and quarries. About 55,000 wholesale and retail dealers handle explosives, and over 18,000 concerns engaged in the construction of railroads, highways, and waterways use explosives. This gives a total of over 100,000 concerns using such comparatively large quantities of

[3] Fay, A. H., Production of explosives in the United States, 1912 to 1917; Tech. Papers 69, 85, 107, 159, 175, 192; also Monthly statement of coal-mine fatalities in the United States, February, 1919.

[4] Compiled from Monthly summary of foreign commerce of the United States, published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

explosives that special magazines for their storage are an absolute necessity. These figures do not include the even greater army of individual consumers, numbering more than five times as many, as shown by the number of licenses issued, who use dynamite for clearing land and for many other purposes.

HISTORY OF THE ACT.

The proposed legislation was subjected to close scrutiny and to active and prolonged debate and two public hearings were held. The results of the first hearing, which was held on April 20 and 21, 1917, before the Committee on Mines and Mining of the House of Representatives, were issued in a pamphlet of sixty pages, and those of the second hearing held June 6, 1917, before the Committee on Mines and Mining of the United States Senate, were issued in a pamphlet of thirty-five pages, and they set forth the views and criticisms of representatives of all classes. The bill, as originally introduced by the Hon. Martin D. Foster, was numbered H. R. 3633, and it was this which was the subject of the first hearing, but this was so changed and confused by amendments that it was laid on the table and Mr. Foster introduced a second bill, numbered H. R. 3932, which he believed represented the views expressed in debate as to the proper means of accomplishing the object sought. This draft was the subject of the second hearing, and after debate and amendment it was passed by the Congress in the form presented below and became law, on the approval of the President, October 6, 1917, some seven months after the attempt to secure such legislation was begun. The act reads as follows:

[PUBLIC—NO. 68—65TH CONGRESS.]

[H. R. 3932.]

An Act To prohibit the manufacture, distribution, storage, use, and possession in time of war of explosives, providing regulations for the safe manufacture, distribution, storage, use, and possession of the same, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That when the United States is at war it shall be unlawful to manufacture, distribute, store, use, or possess powder, explosives, blasting supplies, or ingredients thereof, in such manner as to be detrimental to the public safety, except as in this Act provided.

SEC. 2. That the words "explosive" and "explosives" when used herein shall mean gunpowders, powders used for blasting, all forms of high explosives, blasting materials, fuses, detonators, and other detonating agents, smokeless powders, and any chemical compounds or mechanical mixture that contains any oxidizing and combustible units, or other ingredients, in such proportions, quantities or packing that ignition by fire, by friction, by concussion, by percussion, or by detonation of, or any part of the compound or mixture may cause such a sudden generation of highly heated gases that the resultant gaseous pressures are capable of producing destructive effects on contiguous objects, or of destroying life or limb, but shall not include small arms or shotgun cartridges: *Provided,* That nothing herein contained shall be construed to prevent the manufacture, under the authority of the Government, of explosives for, their sale to or their possession by, the military or naval service of the United States of America.

SEC. 3. That the word "ingredients" when used herein shall mean the materials and substances capable by combination of producing one or more of the explosives mentioned in section one hereof.

SEC. 4. That the word "person," when used herein, shall include States, Territories, the District of Columbia, Alaska, and other dependencies of the United States, and municipal subdivisions thereof, individual citizens, firms, associations, societies and corporations of the United States and of other countries at peace with the United States.

SEC. 5. That from and after forty days after the passage and approval of this Act no person shall have in his possession or purchase, accept, receive, sell, give, barter or otherwise dispose of or procure explosives, or ingredients, except as provided in this Act: *Provided*, That the purchase or possession of said ingredients when purchased or held in small quantities and not used or intended to be used in the manufacture of explosives, are not subject to the provisions of this Act: *Provided further*, That the superintendent, foreman, or other duly authorized employee at a mine, quarry, or other work, may *when licensed so to do*, sell or issue, to any workman under him, such an amount of explosives, or ingredients, as may be required by that workman in the performance of his duties, and the workman may purchase or accept the explosives, or ingredients, so sold or issued, but the person so selling or issuing same shall see that any unused explosives, or ingredients, are returned, and that no explosives, or ingredients, are taken by the workman to any point not necessary to the carrying on of his duties.

SEC. 6. That nothing contained herein shall apply to explosives or ingredients while being transported upon vessels or railroad cars in conformity with statutory law or Interstate Commerce Commission rules.

SEC. 7. That from and after forty days after the passage of this Act no person shall manufacture explosives unless licensed so to do, as hereinafter provided.

SEC. 8. That any licensee or applicant for license hereunder shall furnish such information regarding himself and his business, so far as such business relates to or is connected with explosives or ingredients at such time and in such manner as the Director of the Bureau of Mines, or his authorized representative, may request, excepting that those who have been or are at the time of the passage of this Act regularly engaged in the manufacture of explosives shall not be compelled to disclose secret processes, costs, or other data unrelated to the distribution of explosives.

SEC. 9. That from and after forty days after the passage and approval of this Act every person authorized to sell, issue, or dispose of explosives shall keep a complete itemized and accurate record, showing each person to whom explosives are sold, given, bartered, or to whom or how otherwise disposed of, and the quantity and kind of explosives, and the date of each such sale, gift, barter, or other disposition, and this record shall be sworn to and furnished to the Director of the Bureau of Mines, or his authorized representatives, whenever requested.

SEC. 10. That the Director of the Bureau of Mines is hereby authorized to issue licenses as follows:

(a) Manufacturer's license, authorizing the manufacture, possession, and sale of explosives and ingredients.

(b) Vendor's license, authorizing the purchase, possession, and sale of explosives or ingredients.

(c) Purchaser's license, authorizing the purchase and possession of explosives and ingredients.

(d) Foreman's license, authorizing the purchase and possession of explosives and ingredients, and the sale and issuance of explosives and ingredients to workmen under the proviso to section five above.

(e) Exporter's license, authorizing the licensee to export explosives, but no such license shall authorize exportation in violation of any proclamation of the President issued under any Act of Congress.

(f) Importer's license, authorizing the licensee to import explosives.

(g) Analyst's, educator's, inventor's, and investigator's licenses authorizing the purchase, manufacture, possession, testing, and disposal of explosives and ingredients.

SEC. 11. That the Director of the Bureau of Mines shall issue licenses, upon application duly made, but only to citizens of the United States of America, and to the subjects or citizens of nations that are at peace with them, and to corporations, firms, and associations thereof, and he may, in his discretion, refuse to issue a license, when he has reason to believe, from facts of which he has knowledge or reliable information, that the applicant is disloyal or hostile to the United States of America, or that, if the applicant is a firm, association, society, or corporation, its controlling stockholders or members are disloyal or hostile to the United States of America. The director may, when he has reason to believe on like grounds that any licensee is so disloyal or hostile, revoke any license issued to him. Any applicant to whom a license is refused or any licensee whose license is revoked by the said director, may at any time within thirty days after notification of the rejection of his application or revocation of his license, apply for such license or the cancellation of such revocation to the Council of National Defense, which shall make its order upon the director either to grant or to withhold the license.

SEC. 12. That any person desiring to manufacture, sell, export, import, store, or purchase explosives or ingredients, or to keep explosives or ingredients in his possession, shall make application for a license, which application shall state, under oath, the name of the applicant; the place of birth; whether native born or naturalized citizen of the United States of America; if a naturalized citizen, the date and place of naturalization; business in which engaged; the amount and kind of explosives or ingredients which during the past six months have been purchased, disposed of, or used by him; the amount and kind of explosives or ingredients now on hand; whether sales, if any, have been made to jobbers, wholesalers, retailers, or consumers; the kind of license to be issued, and the kind and amount of explosives or ingredients to be authorized by the license; and such further information as the Director of the Bureau of Mines may, by rule, from time to time require.

Applications for vendor's, purchaser's, or foreman's licenses shall be made to such officers of the State, Territory, or dependency having jurisdiction in the district within which the explosives or ingredients are to be sold or used, and having the power to administer oaths as may be designated by the Director of the Bureau of Mines, who shall issue the same in the name of such director. Such officers shall be entitled to receive from the applicant a fee of 25 cents for each license issued. They shall keep an accurate record of all licenses issued in manner and form to be prescribed by the Director of the Bureau of Mines, to whom they shall make reports from time to time as may be by rule issued by the director required. The necessary blanks and blank records shall be furnished to such officers by the said director. Licensing officers shall be subject to removal for cause by the Director of the Bureau of Mines, and all licenses issued by them shall be subject to revocation by the director as provided in section eleven.

SEC. 13. That the President, by and with the advice and consent of the Senate may appoint in each State and in Alaska an explosives inspector, whose duty it shall be, under the direction of the Director of the Bureau of Mines, to see that this Act is faithfully executed and observed. Each such inspector shall receive a salary of $2,400 per annum. He may at any time be detailed for service by said director in the District of Columbia or in any State, Territory, or dependency of the United States. All additional employees required in carrying out the provisions of this Act shall be appointed by the director of the Bureau of Mines, subject to the approval of the Secretary of the Interior.

SEC. 14. That it shall be unlawful for any person to represent himself as having a license issued under this Act, when he has not such a license, or as having a license different in form or in conditions from the one which he in fact has, or without proper authority make, cause to be made, issue or exhibit anything purporting or pretending to be such license, or intended to mislead any person into believing it is such a license, or to refuse to exhibit his license to any peace officer, Federal or State, or representative of the Bureau of Mines.

SEC. 15. That no inspector or other employee of the Bureau of Mines shall divulge any information obtained in the course of his duties under this Act regarding the business of any licensee, or applicant for license, without authority from the applicant for license or from the Director of the Bureau of Mines.

SEC. 16. That every person authorized under this Act to manufacture or store explosives or ingredients shall clearly mark and define the premises on which his plant or magazine may be and shall conspicuously display thereon the words "Explosives—Keep Off."

SEC. 17. That no person, without the consent of the owner or his authorized agents, except peace officers, the Director of the Bureau of Mines and persons designated by him in writing, shall be in or upon any plant or premises on which explosives are manufactured or stored, or be in or upon any magazine premises on which explosives are stored; nor shall any person discharge any firearms or throw or place any explosives or inflammable bombs at, on, or against any such plant or magazine premises, or cause the same to be done.

SEC. 18. That the Director of the Bureau of Mines is hereby authorized to make rules and regulations for carrying into effect this Act, subject to the approval of the Secretary of the Interior.

SEC. 19. That any person violating any of the provisions of this Act, or any rules or regulations made thereunder, shall be guilty of a misdemeanor and shall be punished by a fine of not more than $5,000 or by imprisonment not more than one year, or by both such fine and imprisonment.

SEC. 20. That the Director of the Bureau of Mines is hereby authorized to investigate all explosions and fires which may occur in mines, quarries, factories, warehouses, magazines, houses, cars, boats, conveyances, and all places in which explosives or the ingredients thereof are manufactured, transported, stored, or used, and shall, in his discretion, report his findings, in such manner as he may deem fit, to the proper Federal or State authorities, to the end that if such explosion has been brought about by a willful act the person or persons causing such act may be proceeded against and brought to justice; or, if said explosion has been brought about by accidental means, that precautions may be taken to prevent similar accidents from occurring. In the prosecution of such investigations the employees of the Bureau of Mines are hereby granted the authority to enter the premises where such explosion or fire has occurred, to examine plans, books, and papers, to administer oaths to, and to examine all witnesses and persons concerned, without let or hindrance on the part of the owner, lessee, operator, or agent thereof.

SEC. 21. That the Director of the Bureau of Mines, with the approval of the President, is hereby authorized to utilize such agents, agencies, and all officers of the United States and of the several States, Territories, dependencies, and municipalities thereof, and the District of Columbia, in the execution of this Act, and all agents, agencies, and all officers of the United States and of the several States and Territories, dependencies, and municipalities thereof, and the District of Columbia, shall hereby have full authority for all acts done by them in the execution of this Act when acting by the direction of the Bureau of Mines.

SEC. 22. That for the enforcement of the provisions of this Act, including personal services in the District of Columbia and elsewhere, and including supplies, equipment, expenses of traveling and subsistence, and for the purchase and hire of animal-drawn or motor-propelled passenger-carrying vehicles, and upkeep of same, and for every other expense incident to the enforcement of the provisions of this Act, there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $300,000, or so much thereof as may be necessary: *Provided*, That not to exceed $10,000 shall be expended in the purchase of motor-propelled passenger-carrying vehicles.

Approved, October 6, 1917.

With the approval of the act, the following proclamation was issued:

[Manufacture, etc., of explosives in time of war unlawful.]

A PROCLAMATION.

By the President of the United States of America.

Whereas, under and by virtue of an act of Congress entitled "An act to prohibit the manufacture, distribution, storage, use and possession in time of war of explosives, providing regulations for the safe manufacture, distribution, storage, use and possession of the same, and for other purposes," approved by the President on the 6th day of October, 1917, it is provided among other things that from and after forty days after the passage and approval of said act no person shall manufacture, distribute, store, use or possess explosives or ingredients thereof, not including explosives for the military or naval service of the United States of America under the authority of the Government or ingredients in small quantities not used or intended to be used in the manufacture of explosives, and not including small arms or shotgun cartridges, unless such person shall obtain a license issued in the name of the Director of the Bureau of Mines, except that any workman may purchase or accept explosives or ingredients thereof under prescribed conditions from a licensed superintendent or foreman.

And whereas, it is further provided in said act as follows:

"That the Director of the Bureau of Mines, with the approval of the President, is hereby authorized to utilize such agents, agencies, and all officers of the United States and of the several States, Territories, dependencies, and municipalities thereof, and the District of Columbia, in the execution of this act, and all agents, agencies, and all officers of the United States and of the several States and Territories, dependencies, and municipalities thereof, and the District of Columbia, shall hereby have full authority for all acts done by them in the execution of this act when acting by the direction of the Bureau of Mines."

Now, therefore, I, Woodrow Wilson, President of the United States of America, by this proclamation do announce the following:

That from and after the 15th day of November, 1917, and during the present war with Germany, it will be unlawful to manufacture, distribute, store, use, or possess explosives or ingredients thereof, except as provided in said act.

That the Director of the Bureau of Mines is hereby authorized to utilize, where necessary for the proper administration of said act, the services of all officers of the United States and of the several States, Territories, dependencies, and municipalities thereof, and of the District of Columbia, and such other agents and agencies as he may designate, who shall have full authority for all acts done by them in the execution of the said act when acting under his direction.

In witness whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

[SEAL.] Done in the District of Columbia, this twenty-sixth day of October, in the year of our Lord one thousand nine hundred and seventeen, and of the independence of the United States of America, the one hundred and forty-second.

WOODROW WILSON.

By the President,

ROBERT LANSING,

Secretary of State.

[No. 1404.]

The President's proclamation emphasizes the fact that from and after 40 days after the 6th day of October, 1917, "no person shall manufacture, distribute, store, use or possess explosives or ingredients thereof," giving due notice whereby all persons could qualify under the law by securing licenses, by ridding themselves of any of the forbidden articles in their possession and by refraining from committing any of the forbidden acts. This interval was also needed by the Bureau of Mines in making proper preparations for the enforcement of the law.

In order that the enactment of this law might be given the widest publicity a copy of the President's proclamation was sent to each post office with a request that it be posted in a conspicuous place. Copies were also forwarded to the governor and secretary of state of each State, county clerks, and licensing officers, United States attorneys, chiefs of police and fire departments; fire and safety commissions; manufacturers, importers and exporters of explosives; contractors known to have used explosives; railways, registered chemists and analysts; educational institutions; operators of metal mines and quarries; clay, brick and tile manufacturers; oil and gas operators; operators of coal mines, large and small; and blast furnaces; public road and work commissions; operators of munition plants; engineers and field men of the Bureau of Mines; and many others.

ADMINISTRATION OF THE ACT.

The Director of the Bureau of Mines, having been authorized, under section 18 of the act to make rules and regulations for carrying its provisions into effect, subject to the approval of the Secretary of the Interior, immediately organized the "Explosives Regulations Division" in the bureau and appointed committees to draft regulations and to advise what substances should be styled "ingredients" and be subject to license. The committee to draft the regulations was composed of Capt. E. B. Jones, representing the Institute of Makers of Explosives; Dr. Charles E. Munroe, consulting explosives chemist, Bureau of Mines; Col. W. S. Topping, acting chief inspector, Bureau of Explosives. The committee to determine the ingredients to be subject to license was composed of Maj. J. T. Crabbs, Ordnance Corps, United States Army; Dr. Charles E. Munroe, consulting explosives chemist, Bureau of Mines; Dr. Frank W. DeWolf, assistant director, Bureau of Mines; Mr. F. S. Peabody was appointed to the newly created office of assistant to the director in charge of explosives.

The selection of the ingredients which should be subject to license was difficult, for if the letter of the law had been absolutely followed some 1,200 to 1,500 substances must have been listed from such well known and commonly used substances as cotton, starch, and sulphur to substances known only to the expert chemist and rarely used even by him. The reading of the records of hearings on the bill and the debates in both Houses of Congress showed that the intent of the law as to ingredients was to prevent improper manufacture of explosives for criminal use and not to embarrass upright and loyal persons by unnecessary restrictions. Moreover, the greater the number of substances subject to license, the greater would be the difficulty in the enforcement of the law. The manufacture of an explosive requires more than one component, in general, a combustible and an oxidizing component, and clearly, if one was controlled the other might be free. Hence, as a rule, only oxidizing substances were listed as "ingredients" subject to license and at the outset only those more common and easily obtainable. The committee was guided in its decisions by a careful study of the code of ordinances of the city of New York as it related to explosives and combustibles and of the codes of other municipalities, and by the advice and suggestions received from many chemists to whom the problem was referred, among whom Dr. William Jay Schieffelin, president of the National Druggists' Association, and Dr. S. P. Sadtler, deserve especial mention. A list of "ingredients" containing but 45 items was finally adopted as subject to license, and in order that the proper use of these in pharmacy and medicine might not be impeded quantities of less than one ounce of these were exempt from license.

Director Manning called a conference at the bureau on October 16, 1917, of some 80 persons representing the manufacturers of explosives; operators of anthracite and bituminous coal mines; iron, copper, lead, and zinc mines, and of quarries; union and nonunion miners; officers of the several divisions of the Army and Navy; officials of States and municipalities and of all the divisions of our Federal Government in any degree concerned with the subject. The drafts of regulations prepared by the committees of the bureau named above were laid before this conference, and also a draft prepared at the director's request, by a committee from the Institute of Makers of Explosives. The discussion of these drafts and of issues raised relative to the administration of the law was full and to the point, and much valuable and constructive criticism and sound advice was subsequently submitted in writing by persons present at this conference. As a result of this the regulations were put into a final form and issued early in 1918 in a pamphlet of 44 pages entitled, "General information and rulings for the enforcement of the law regulating the manufacture, distribution, storage, use, or possession of explosives and their ingredients" (Public No. 68, 65th Cong; H. R. 3932) which began as follows:

FOREWORD.

The operation of this law will doubtless cause inconvenience to persons engaged in legitimate business; it may embarrass worthy citizens in the pursuit of their livelihood; it may necessitate the spending of money by bringing about changes in operating methods; but to all loyal citizens these hardships will be slight and temporary, and if we all cooperate in making it an efficient law disloyalty will suffer the penalty it deserves.

If you manufacture or sell explosives, see to it that they pass from you only to those who have lawful need of them. If you use them, make them produce coal or copper or wheat or corn, and protect them well from theft, in order that they may not be used for destructive purposes.

Our enemies are not all in Europe, and it was a weapon to be turned against those of them who are lurking here on our own soil that this law was created. They wear no uniform and do not fight us in the open; but they are here, plotting in various ways to prevent the products of our mines and our factories and our forests and our farms from clothing and feeding and arming our own fighting forces and those of our allies.

To each of us is given the duty of producing his or her share of these necessities, and on each of us falls a portion of the responsibility of counteracting the attempts of those who are working behind our backs to make our efforts ineffectual; and so, to each of us comes the chance of participation in the war. The part we can play may be an inconspicuous one, but it will be no less important because of that, and the things we will be fighting for will be the things our boys are dying for; and when success comes to our country, the end that will have been gained will be worth to the world all that it will have cost.

This pamphlet contained a copy of the explosives-regulation law; the President's proclamation; an announcement that "Any person violating any of these rules and regulations shall be guilty of a misdemeanor and shall be punished by a fine of not more than $5,000, or by imprisonment of not more than one year, or by both such fine and imprisonment"; a statement of the purpose of the law; definitions of "person," "explosives," and "ingredients" as they occurred in the law; list of commodities for which licenses were required; kinds of licenses; general rules on licenses; instructions to licensing agents; rules for licensees covering methods of applying for and obtaining licenses from local licensing agents or from the Bureau of Mines at Washington; use, protection, and lapse of licenses; special rules covering shipment of explosives or ingredients by common carriers; special rules for manufacturers of, vendors of, and industries using explosives and ingredients, and for licenses for various kinds of work; rules for the storage of explosives and ingredients; and instructions to United States explosives inspectors. As this pamphlet was published after the organization was effected, it contained also a list of United States explosives inspectors appointed by the President, with their addresses.

ORGANIZATION UNDER THE ACT.

Mr. F. S. Peabody was placed in charge of the division of explosives regulation, the chief branches of which, with their functions and heads, were:

1. Administration and questions of policy, under David D. Bush.

2. Investigation of applications for and issuance of manufacturer's, exporter's, and importer's licenses, under L. M. Meade.
3. Examination and appointment of field employees, under C. S. Eby.
4. Investigation and prosecution of violations of the act, under Edgar Priest.
5. Construction and location of magazines and proper storage of explosives and ingredients, under Gustavus N. Snow.

Mr. Peabody remained in charge of this division until May 17, 1918, when he was succeeded by Mr. Clarence Hall. On the resignation of Mr. Hall, August 1, 1919, Mr. F. J. Bailey, assistant to the director, was assigned this division and has remained in charge ever since. Mr. A. C. Yznaga succeeded Mr. Priest in charge of branch 4, and Capt. H. D. Trounce succeeded Mr. Snow in charge of branch 5.

For the enforcement of the act, under section 13, the President, by and with the advice and consent of the Senate, appointed an explosives inspector in each State and in Alaska. The duty of each inspector was "under the direction of the Director of the Bureau of Mines to see that this act is faithfully executed and observed." Therefore, as the duties of these officials were analogous to those of a sheriff they had to be loyal citizens of forceful character. Considerable knowledge of the properties, uses, and behavior of explosives would have been to their personal advantage, but persons possessing such knowledge were more efficiently employed in endeavoring to meet the enormous demand of our military program.

To prepare these inspectors for the performance of their duties they were assembled in conference at the Bureau of Mines in Washington, December 18, 1917, where they met Secretary Lane and were instructed in detail as to their duties by Director Manning, Chief Peabody, Maj. Crabbs, Mr. A. Bruce Bielaski, of the Department of Justice, Mr. Eby, and others. A second meeting was held in Chicago July 16, 1918, after all had had experience in the working of the act, in order that the inspectors might by conference and exchange of experiences facilitate operations and improve efficiency.

Under each explosives inspector was formed an advisory committee of representatives of those interested in the community most imperiled or of persons most qualified, such as members of the Council of National Defense, the Departments of Justice and Agriculture, the Bureau for the Safe Transportation of Explosives and Combustibles of the American Railway Association, a fire insurance company, a casualty company, and a manufacturer of, large dealer in, or consumer of explosives. The members of the advisory committees were appointed by the Director of the Bureau of Mines, with the approval of the Secretary of the Interior. They were designated assistant inspectors and they acted as deputies to the inspector and rendered him such assistance as lay within their powers.

Grateful acknowledgment is made of the valuable services of these members of the State advisory committees who largely assisted in the successful operation of the act.

LICENSES.

In planning the details of operation it was at first thought that one licensing agent for each county, making a total of 3,032, would suffice to handle the granting of the necessary permits to the dealers and users of explosives throughout the country. However, when the ingredients to be licensed were decided upon, they were found to be so widely distributed and used for so many different purposes that it became necessary to increase the number of licensors, because every druggist, doctor, butcher, and representative of many other professions and trades was forced to take out a license. Hence the number of agents was increased until it reached almost 16,000. The usual method of procedure in making these appointments was to obtain a list of the justices of the peace and notaries public in each State; locate on the map those points where, according to the size of the city or town and the transportation facilities, licensing agents would be needed; choose the man who had the longest term to run, investigate his standing in the Department of Justice files, and if this was found satisfactory mail him his appointment. Preference was given to county clerks when a county seat needed an agent. From November 14, 1918, after the signing of the armistice, when by an order (printed on p. 40) of the Director of the Bureau of Mines, approved by the Secretary of the Interior, the ingredients of explosives were struck from the list requiring a license, the number of licensors was gradually diminished by recalling the appointments beginning with the smaller towns.

On all surface operations, such as railroad and highway construction, where explosives were used, licenses were obtained by foremen and similar responsible parties, who in turn issued the explosives to powder men and others. This necessitated the keeping of a strict account of all explosives used, and not only produced markedly beneficial results, but resulted in a decrease in such accidents as are caused by carelessness in handling and storing explosives.

Through the licensing of users of explosives information and data could be procured which is helpful in safeguarding explosives in the future, not only against theft and possible misuse but also in making recommendation for safe and proper storage in populated districts, so that, if a magazine should explode, the terrific loss of life, limb, and property, which has heretofore resulted may be minimized or altogether prevented.

Furthermore, by the protection of explosives from the weather, danger and loss to the users from handling deteriorated goods should be greatly reduced.

The form of application issued was as follows:

FORM NO. 6—860

APPLICATION NO. ......
LICENSE NO. ....

UNITED STATES OF AMERICA.

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

APPLICATION FOR VENDOR'S, PURCHASER'S, ANALYST'S, OR FOREMAN'S EXPLOSIVES LICENSE.

This application should be sworn to before the licensing officer, and a single fee of twenty-five cents will include both the affidavit fee and the license fee.

An application for an analyst's license must be indorsed under oath by two responsible citizens acquainted with applicant and known by the licensing officer.

Mr. ....
Post office ....
County .... State ....

SIR: The undersigned hereby applies for a license under the provisions of the Act of Congress approved October 6, 1917 (Public, No. 68, 65th Congress).

1. (a) IF AN INDIVIDUAL.
Place of birth .... Date of birth ....Occupation ....
Are you a citizen of the United States?................If not, give name of country..............
If naturalized, date of naturalization............ Place of naturalization........................
Present address of applicant: City.............. County.............. State...................

(b) IF A FIRM, ASSOCIATION, OR SOCIETY.
Where organized ....
Present address of applicant: City.............. County.............. State...................

(c) IF A CORPORATION.
Place of incorporation.......................... Date of incorporation ....
Present address of applicant: City.............. County.............. State...................

2. Kind of license applied for..
(Vendor's, purchaser's, foreman's.)

3. (a) Nature of business in which now engaged..
(b) Principal place of business..
(c) Is business controlled by citizens of the United States?.....................................
If not, give name of country...
(d) Place and nature of business in foreign countries, if any......................................

4. Amount and kind of explosives or ingredients purchased, disposed of, or used by applicant during the six months next preceding date of this application: (See footnote.)

	Amount.	*Kind.*
Purchased..................	....	....
Used by applicant...........	....	....
Otherwise disposed of........	....	....
Remaining on hand..........	....	....

5. Have sales been made to jobbers?.................... Wholesalers?..............................
Retailers?... Consumers?...............................

6. Explosives and ingredients covered by this application. (See footnote.)
Kind.................. Amount......................... Intended use........................

7. If a license has been previously issued to you, state kind of license and by whom issued. ....
....

REMARKS..
....

....
(Signature of applicant.)

Subscribed and sworn to before me this..........day of.................., A. D. 191

....
(Licensing officer.)

IF ADDITIONAL SPACE IS REQUIRED, ATTACH A SEPARATE SHEET HERETO.

Up to July 1919 the number of licenses of all classes which had been issued was 500,625 of which 950 were manufacturers and exporters licenses. Sixty-two applications for such licenses were refused.

ENFORCEMENT OF PROVISIONS OF THE ACT.

GENERAL INVESTIGATIONS AND CONVICTIONS.

Ninety convictions were obtained under the Federal explosives law in 20 different States, California leading the list with 29. The number by States is as follows:

Convictions obtained by States.

California	29	Texas	4
Iowa	14	Alabama	3
Ohio	6	Arizona	3
Massachusetts	6	Michigan	3
Washington	5	Oklahoma	3
New York	4	Nevada	2

with the States of Georgia, Idaho, Illinois, Kansas, Minnesota, Missouri, New Mexico, and Pennsylvania each recording one conviction.

These figures are somewhat misleading as approximately double the above number of convictions were secured under State laws where the United States explosives inspectors actively assisted the State authorities in presenting and prosecuting violations. In many States, the number of convictions obtained and investigations made was an index of the energy and ability of the inspectors.

Many violations of the Federal explosives law that were brought to the attention of United States attorneys and State authorities were found upon examination to be violations of State laws, and the violators were proceeded against under the State's penal code, which usually provided a heavier penalty. In these cases the Federal explosives inspectors assisted greatly in securing the evidence necessary for conviction. It was not the policy of the Bureau of Mines to press many charges under this act, and in all instances magazine owners and others were previously advised as to the law on the subject and every attempt made to assist them in complying with its provisions.

Prosecution was undertaken only in extreme cases and usually only where the party had previously been carefully warned of the consequences to himself and the danger to the public, and had disregarded it.

Approximately 1,500 cases were investigated, which have been roughly classified as follows:

Investigations of reported violations of the law.

Improper storage	400
Discovery of explosives	51
Miscellaneous thefts of explosives	40
Thefts from magazines	251
Safe blowing	36
Dynamiting of fish	18
Blasting cap accidents	14
Destruction of dipping vats	120
Unlawful possession of explosives	72
Miscellaneous explosions	130
Army and navy explosions	6
Mine explosions	8
Explosions in powder company plants	30
Bomb outrages	42
License investigations	202
Careless handling of explosives	80
Total	1,500

These investigations were those of sufficient importance to have been reported to the Washington office. Many others, among them the less serious violations, were handled by the State inspectors.

IMPROPER STORAGE.

A carefully planned campaign of education was followed by the State inspectors. The Washington personnel constantly advised owners and occupiers by correspondence as to the different types of magazine construction that would be approved. Specifications were forwarded to all persons or firms interested in safely storing explosives, or improving the existing storage. No prosecutions for insufficient or unsafe storage were instituted until after many warnings had been issued as to the necessity of the owner's providing proper safeguards for his stock and protection for his employees and the public, and after ample time had been allowed for making the changes recommended. Some of these warnings went unheeded, with the result that a large number of the convictions obtained were on account of improper storage. Fines differing with the gravity of the offense, from $1 to $500 on each count, were levied on most of the convicted persons.

Unfortunately in many localities it was the general impression that the act, being a war measure, was designed only to prevent enemies and their sympathizers from obtaining explosives. With the signing of the armistice there was a marked tendency on the part of grand juries in many localities to return findings of "No bill" or "No indictment" against persons charged with improper storage, even where such storage was clearly proved. This procedure undermined to some extent the good effects that had been secured.

The State inspectors and the personnel engaged in enforcing the act required only a reasonable compliance with safety requirements and attempted to educate magazine owners and the public generally to the dangers of improperly housed and handled explosives, rather than to make exacting demands for improvements under penalty of the law.

On the whole, however, it was decidedly encouraging to note that numerous firms and persons, when convinced of the possible danger to which they were subjecting their employees and the public, not only complied with the regulations in force, but made such further alterations, often at heavy expense, as would eliminate every recognized source of danger.

The most flagrant cases of improper and dangerous storage were investigated. Conditions were uncovered which showed that many States had been entirely unaware of the dangers that existed. The apparent indifference or ignorance in many districts is inexplicable. The most serious and disastrous accidents had occurred, stirred people to indignation for a short time, and then were forgotten without any adequate steps having been taken to prevent a repetition.

THEFTS FROM MAGAZINES.

Numerous thefts from magazines were reported and doubtless many thefts occurred that were not detected. Such thefts occurred in almost every State. Many individual powder magazines were broken into and explosives stolen. One magazine in Oklahoma was robbed four times inside of three months, and at each time a quantity of nitroglycerin was stolen.

Large amounts of explosives were often taken, also blasting caps, fuse, and other explosives equipment. From one magazine in Nevada 1,300 pounds of powder was stolen. Almost coincident with news of unrest in different localities came reports of powder magazines being forced and their contents stolen. This happened in Nevada, Massachusetts, and in other States. The source of explosives used in outrages and in acts of violence was repeatedly traced to previous thefts from magazines nearby.

The Bureau of Mines has waged a constant campaign against careless or irresponsible magazine owners. Specifications and pamphlets covering types of construction have been sent to practically every magazine owner in the United States. These specifications provided for weather, fire, and theft-proof construction of all magazines for storage of high or low explosives, and in addition they provided for bullet-proof construction of high-explosive magazines.

Although many of the magazines broken into were provided with heavy, strong, well-made padlocks, these padlocks proved slight obstacles to the determined thief able to open or destroy any padlock in a few minutes with the aid of a small steel hacksaw or of a little "soup" (nitroglycerin).

ACCIDENTS TO CHILDREN.

Many accidents and deaths of children are attributable to the careless manner in which powder magazines are locked or secured. As representative of these unfortunate events, two cases are cited from a large number investigated. On August 4, 1919, at Philadelphia, Pa., three small boys were blown to bits when they accidentally exploded a quantity of dynamite while playing in an unguarded stone quarry. Parts of the body of one victim, aged 13, were found in a lot a block away. Both legs and an arm of another boy were ripped from his body, and the third lad was mangled beyond recognition. Persons living near the quarry declared the explosive was stored in a small tool house that was locked only by a hasp and a nail.

In May, 1918, sewer contractors engaged in the construction of a submain sewer in Tulsa, Okla., were using explosives for excavating. Part of their work was carried on near a school, and an 8-year-old boy in passing stole two boxes of dynamite detonators from the contractor's tool box, and distributed them amongst his playmates, who attempted to ignite or detonate them in different ways. A 10-year-old boy went into the yard, struck a match against a board, and placed the lighted match in the hollow end of the dynamite cap. "An explosion occurred which tore off the thumb and first finger of his right hand, and a portion of his third finger. A large number of particles of the cap were driven into one of his eyes in such a way that the sight of one eye was totally destroyed and the sight of the other eye was greatly impaired." A verdict of $25,000 damages was awarded to the boy by a jury against the contractors and the city of Tulsa.

DESTRUCTION OF DIPPING VATS.

During the year 1919 a very large number of cattle-dipping vats were destroyed in many of the southeastern States, particularly in Arkansas, Alabama, and Georgia, by the use of explosives, usually dynamite.

On account of the ravages of the tick and other vermin among the cattle of these States the Bureau of Animal Industry, Department of Agriculture, found it necessary to quarantine all stock not dipped. The following account from the Arkansas Democrat shows the extent to which these attacks on dipping vats were carried.

FORT SMITH, *May 30, 1919*.—Since the week commencing April 13 and up to the present, a period of 47 days, a total of 72 cattle-dipping vats has been destroyed by dynamite in Arkansas. The record of destruction is without equal in this State since the inauguration of the law requiring the dipping of cattle to free them of ticks. The number of vats destroyed is compiled from press dispatches, and it is reasonable to assume that the list does not include all of the vats that were destroyed.

It is stated there is more opposition to the dipping law in Arkansas at present than ever before. Although there has been spasmodic opposition to the law ever since it became effective, it has never before covered such a wide stretch of territory and has never been asserted so vigorously as at present. Not content with destroying vats opponents of the law have in several instances destroyed the charge or solution in the vats and have scattered poison over the ground in the vicinity of the dipping grounds.

Farmers and other law-abiding citizens have been forced to resort to the use of firearms in order to protect their dipping vats and to suppress these outrages.

A letter received from United States Explosives Inspector E. T. Reaves, under date of May 29, 1919, says that he

feels, as many others in this State feel, that the present Congress should pass some legislation that will make it more difficult to secure explosives, and that this work should be made permanent and given more latitude, with sufficient capable men from the Department of Justice to effectually suppress the lawless operations of those who have been responsible for outrages perpetrated in nearly every section of the State.

Again, on June 27, 1919, Inspector Reaves said:

I am still hopeful that Congress will yet take some action to continue this work for the sake of humanity if nothing more.

Despite the difficulties attending the apprehension and punishment of persons responsible for these acts, numerous arrests were made, and many prosecutions were pending (Nov. 11, 1919). As a result of the licensing of all persons handling and selling explosives, it was possible to trace the source of the explosives with which some of these dipping vats were destroyed.

With the aid of the local and State press, the Bureau of Mines and the Bureau of Animal Industry did much to educate the general public as to the benefits to be derived from dipping their cattle. Dr. R. M. Gow, State veterinarian of Arkansas, says:

Destroying of dipping vats simply delays operations in the particular community for a time and causes inconvenience to the intelligent farmers who are anxious to dip their cattle. It will be noticed that most of the vats destroyed in Arkansas this year have been in those remote sections of two counties that were strongholds of the draft resisters last summer.

Great difficulty was encountered in securing convictions on account of the reluctance of witnesses to testify.

Gov. Brough, of Arkansas, assured the ex-Federal explosives inspector, Mr. E. T. Reaves, Little Rock, Ark., that "he was giving and would continue to give his most active cooperation in suppressing dipping-vat violations, as well as dynamiting the waters in this State."

BOMB OUTRAGES.

Numerous and disastrous bomb outrages throughout the country aroused public opinion to such a degree that much thought and study was given to the problem of strictly enforcing existing law and of formulating new statutes or regulations to deal effectively with such crimes.

In compliance with the universal demand for such legislation, Secretary Franklin K. Lane, of the Department of the Interior, addressed a letter to Congress recommending that the Federal explosives act of October 6, 1917, be continued in operation in peace as well as war time. In this letter Secretary Lane stated that the legislation was "aimed to meet the need emphasized" by the Senate Judiciary Committee's report on German propaganda and Bolshevism, which declared "the Federal Statutes never have provided adequate security against an unlawful and promiscuous use of high explosives."

All well-informed persons are convinced that in the matter of handling explosives wide-sweeping reforms are needed that will safeguard life and property better than heretofore.

All possible means should be taken to protect the eminent citizens who have been or who might become the target of bomb outrages. Special agents, detectives, and policemen would not hesitate to risk their lives in an endeavor to prevent such attacks, but it is better to prevent the possibility of such attacks. With stringent State regulations, and with explosives closely controlled, there would be comparatively little difficulty in accounting for almost every pound of explosives manufactured or used, and in guaranteeing its safe storage where neither thieves, criminals, nor anarchists could obtain powder or dynamite.

On account of the enormously extended use of explosives during the war, thousands of persons acquired a knowledge of their uses and the ability to handle them with impunity. Previously explosives had been little known generally, and, as a psychological effect, no one cared to handle a stick of dynamite or explosive unless required to do so by his duties.

The necessarily close relations of labor unrest, Bolshevism, and anarchism, to the regulation of explosives is too obvious to require much comment.

A large number of bomb investigations have been made, but unfortunately few of the perpetrators have been apprehended. Many of these anarchists have perished in their attempts to destroy others, as was the assassin who bombed the house of Attorney General Palmer, who was blown to pieces as he placed his bomb on the doorstep of Mr. Palmer's residence. A similar fate attended four men in Franklin, Mass., who were plotting the destruction of the Ray mill of the American Woolen Co. of that city. These men were carrying dynamite to the mill one night with an evident purpose of destruction, when one, stumbling in the darkness, fell with the explosive.

The resulting detonation blew the four men to pieces, portions of their bodies being found several blocks away.

At the scene of this outrage, as well as at the houses of proposed victims, a copy of the following circular was left.

PLAIN WORDS.

The powers that be make no secret of their will to stop, here in America, the world-wide spread of revolution. The powers that must be reckon that they will have to accept the fight they have provoked.

A time has come when the social question's solution can be delayed no longer; class war is on and can not cease but with a complete victory for the international proletariat.

The challenge is an old one, oh "democratic" lords of the autocratic republic. We have been dreaming of freedom, we have talked of liberty, we have aspired to a better world, and you jailed us, you clubbed us, you deported us, you murdered us whenever you could.

Now that the great war, waged to replenish your purses and build a pedestal to your saints, is over, nothing better can you do to protect your stolen millions, and your usurped fame, than to direct all the power of the murderous institutions you created for your exclusive defense against the working multitudes rising to a more human conception of life.

The jails, the dungeons you reared to bury all protesting voices, are now replenished with languishing consciencious workers, and never satisfied, you increase their number every day.

It is history of yesterday that your gunmen were shooting and murdering unarmed masses by the wholesale; it has been the history of every day in your régime; and now all prospects are even worse.

Do not expect us to sit down and pray and cry. We accept your challenge and mean to stick to our war duties. We know that all you do is for your defense as a class; we know also that the proletariat has the same right to protect itself. Since their press has been suffocated, their mouths muzzled, we mean to speak for them the voice of dynamite through the mouth of guns.

Do not say we are acting cowardly because we keep in hiding, do not say it is abominable; it is war, class war, and you were the first to wage it under cover of the powerful institutions you call order, in the darkness of your laws, behind the guns of your boneheaded slave.

No liberty do you accept but yours; the working people also have a right to freedom, and their rights, our own rights, we have set ourselves to protect at any price.

We are not many, perhaps more than you dream of, though, but are all determined to fight to the last, till a man remains buried in your bastiles, till a hostage of the working class is left to the tortures of your police system, and will never rest till your fall is complete, and the laboring masses have taken possession of all that rightly belongs to them.

There will have to be bloodshed; we will not dodge; there will have to be murder; we will kill, because it is necessary; there will have to be destruction; we will destroy to rid the world of your tyrannical institutions.

We are ready to do anything and everything to suppress the capitalist class; just as you are doing anything and everything to suppress the proletarian revolution.

Our mutual position is pretty clear. What has been done by us so far is only a warning that there are friends of popular liberties still living. Only now we are getting into the fight; and you will have a chance to see what liberty-loving people can do.

Do not seek to believe that we are the Germans' or the devil's paid agents; you know well we are class-conscious men with strong determination and no vulgar liability. And never hope that your cops and your hounds will ever succeed in ridding the country of the anarchistic germ that pulses in our veins.

We know how we stand with you and know how to take care of ourselves.

Besides, you will never get all of us * * * and we multiply nowadays.

Just wait and resign to your fate, since privilege and riches have turned your heads.

Long live social revolution; down with tyranny.

THE ANARCHIST FIGHTERS.

TO THE WORKING PEOPLE OF AMERICA.

The war is over. Your exploiters have quickly placed the profits in safety.

You, the working slaves, will soon find yourselves on the streets, facing a hard winter, looking for work, for it is your only means to supply yourselves with the necessities of life, because you lack the courage to use other methods.

You have tolerated all the moral and physical slaveries during this war.

When you dared open your mouths to protest you were quickly railroaded to jail.

What were your profits out of this war? You lost all the little of the liberty you had and you gave your sons, brothers, and fathers to be shot down like dogs and left to rot on the fields of France.

For what?

For the glory of the American flag?

So that your masters may have bigger markets to sell their merchandise and exploit other people like you?

The workers of Russia, Germany, Austria, and other countries have risen and have overthrown their rulers.

Not by ballots but by arming yourselves, as it is your only means. You alone do not budge. Are you afraid to follow their example? Are you afraid to take by force what rightly belongs to you?

Will you be meek and slavish? Will you wallow under the iron heel of your masters?

Or will you tear your way by the revolution to a better and happier life? Which will you choose?

These investigations were made by the State inspectors and explosives engineers at headquarters in cooperation with the special agents of the Department of Justice and local and State police. In seeking the source of the explosives required in manufacturing these bombs, the active assistance and records of the 16,000 explosives licensing agents throughout the country were utilized to great advantage. Unfortunately the personnel at the disposal of the Bureau of Mines' Explosives Regulation at the Washington headquarters was very small, and it was impossible to give to these vitally important investigations the necessary time required.

On May 1, 1919, the most elaborate bomb plot in American history was disclosed in New York. Death devices addressed to 16 leaders in the Nation's political and business life were discovered in the mails; four others reached their destination. By the prompt action of an intelligent post-office clerk these bombs were discovered and terrible consequences averted. Inspector Egan, of the New York fire department, and engineers of the Bureau of Mines, and the

Bureau of Explosives of the Interstate Commerce Commission opened the bombs and assisted in the investigations of the police.

On June 2 attempts were made on the lives of eight prominent officials. The Department of Justice and other agencies have been devoting a great deal of their time to uncovering the source of these outrages. The sworn secrecy and often the total ignorance of the other plotters involved in these "death sentences" increase the difficulties of discovering the assassins. The numerous alien organizations, meetings, and foreign propaganda make the work increasingly difficult.

The theft of very small quantities of explosives, perhaps three or four pounds of dynamite or other high explosive, yields sufficient material to make charges for several small bombs, which have disastrous effects when detonated. As laborers connected with blasting on highways, railroads, and other construction projects can now easily secure a stick or two of dynamite, it is a comparatively simple matter to procure material for the charges of bombs. During the enforcement of the Federal explosives law, however, as all foremen on construction work and other foremen using explosives were obliged to have a license to use and issue explosives to workmen, as well as to keep careful and strict accounting of them, it was very difficult for evil-disposed persons to obtain dynamite.

EXPLOSIONS AND ACCIDENTS.

A large number of explosions, accidents, and fires, which have occurred in munition and other plants, have been reported to the Bureau of Mines, as follows:

TABLE 3.—*Explosions in munition and powder plants.*

Date.	Company.	Place.
1917.		
Nov. 7	G. R. McAbee Powder & Oil Co	Tunnelton, Pa.
22	American Zinc Co.	Mascot, Tenn.
Dec. 5	Aetna Chemical Co.	Heidelberg, Pa.
5	Aetna Explosives Co.	Carnegie, Pa.
12	Bethlehem Steel Co.	New Castle, Del.
22	Newark Rubber Co.	Newark, N. J.
1918.		
Jan. 10	Atlas Powder Co	Patterson, Okla.
22	Hercules Powder Co.	Kenvil, N. J.
31	.....do.	Valley Falls, N. Y.
31	E. I. du Pont de Nemours & Co.	Butte, Mont.
12	Aetna Explosives Co.	Goes, Ohio.
Feb. 20	E. I. du Pont de Nemours & Co.	Welpen, Minn.
21	.....do.	Repauno, N. J.
25	.....do.	Wayne, N. J.
Mar. 2	E. I. Du Pont de Nemours	Hopewell, Va.
18	Hercules Powder Co.	Gillespie, N. J.
26	Trojan Powder Co.	Iron Bridge, Pa.
26	Jarvis Warehouse	Jersey City, N. J.
28	International Explosives Co.	Swanton, Vt.
29	Atlas Powder Co.	Scottdale, Pa.
29	Aetna Explosives Co	Powder Plant.
Apr. 5	Hercules Powder Co	Gillespie, N. J.
16	National Chemical Mfg. Co.	Hunkers, Pa.
19	E. I. du Pont de Nemours & Co.	Carneys Point N. J.

TABLE 3.—*Explosions in munition and powder plants*—Continued.

Date.	Company.	Place.
1918.		
Apr. 22	Hercules Powder Co	Carthage, Mo.
25	....do	Hercules, Calif.
26	E. I. du Pont de Nemours & Co	Deepwater, N. J.
May 6	Hercules Powder Co	Bacchus, Utah
8	....do	Kenvil, N. J.
9	....do	Youngstown, Ohio.
11	....do	Marlow, Tenn.
17	E. I. du Pont de Nemours & Co	Jermyn, Pa.
18	Aetna Chemical Co	Oakdale, Pa.
31	Aetna Explosives Co	Emporium, Pa.
June 2	Hercules Powder Co	Kenvil, N. J.
10	....do	Do.
12	Aetna Explosives Co	Ishpeming, Mich.
14	Hercules Powder Co	Ferndale, Pa.
19	....do	Gillispie, N. J.
25	Grasselli Powder Co	New Castle, Pa.
July 2	Aetna Explosives Co	Mount Union, Pa.
2	Semet Solvay Co	Syracuse, N. Y.
2	Hercules Powder Co	Kenvil, N. J.
3	Newtons Cal. Mfg. Co	San Francisco, Calif.
5	Hercules Powder Co	Kenvil, N. J.
8	Aetna Explosives Co	Ishpeming, Mich.
10	E. I. du Pont de Nemours & Co	Carneys Point, N. J.
19	Aetna Explosives Co	Ishpeming, Mich.
20	....do	Goes, Ohio.
20	Bethlehem Steel Co	Redington, Pa.
21	Aetna Explosives Co	Mount Union, Pa.
23	Standard Powder Co	Pittsburgh, Pa.
28	Atlas Powder Co	Reynolds, Pa.
30	Aetna Explosives Co	Aetna, Ind.
31	American Glycerine Co	Wilmington, Del.
Aug. 1	E. I. du Pont de Nemours & Co	Carneys Point, N. J.
2	....do	Barksdale, Wis.
5	Grasselli Powder Co	New Castle, Pa.
7	Hercules Powder Co	Kenvil, N. J.
8	Illinois Powder Mfg. Co	Easton, Ill.
8	American Standard Metal Products Co	Paulsbury, N. Y.
10	G. R. McAbee Powder & Oil Co	Tunnelton, Pa.
14	Hercules Powder Co	Kenvil, N. J.
14	Trojan Powder Co	Seiple, Pa.
16	E. I. du Pont de Nemours & Co	Hopewell, Va.
19	Stauffer Chemical Co	Chauncey, N. Y.
8	Standard Powder Co	Pittsburgh, Pa.
Sept. 2	Aetna Explosives Co	Newton-Hamilton, Pa.
6	E. I. du Pont de Nemours & Co	Pompton Lakes, N. J.
11	Eddystone Munitions Co	Eddystone, Pa.
15	E. I. du Pont de Nemours & Co	Barksdale, Wis.
17	Aetna Chemical Co	Carnegie, Pa.
17	Barrett Chemical Co	Frankford, Pa.
17	Aetna Powder Co	North Birmingham, Ala.
22	E. I. du Pont de Nemours & Co	Wilmington, Del.
25	Unexcelled Mfg. Co	East St. Louis, Ill
27	Aetna Explosives Co	Emporium, Pa.
9	....do	Do.
15	....do	Do.
28	E. I. du Pont de Nemours & Co	Peckville, Pa.
26	Penn. Trojan Powder Co	Allentown, Pa.
Oct. 2	....do	Do.
6	Aetna Explosives Co	Emporium, Pa.
7	....do	Mount Union, Pa.
9	....do	Heidelberg, Pa.
9	Aetna Chemical Co	Carnegie, Pa.
9	Hercules Powder Co	Hercules, Calif.
10	E. I. du Pont de Nemours & Co	Pompton Lakes, N. J.
12	....do	Wilpen, Minn.
12	Aetna Explosives Co	Port Ewen, N. Y.
14	T. A. Gillespie Loading Co	Morgan, N. J.
19	Aetna Explosives Co	Near Duluth, Minn.
20	Dow Chemical Co	Midland, Mich.
28	Eddystone Munition Co	Eddystone, Pa.
29	Aetna Explosives Co	Mount Union, Pa.
Nov. 2	....do	Do.
7	....do	Emporium, Pa.
12	Western Powder Manufacturing Co	Edwards, Ill.
14-16	Aetna Explosives Co	Mount Union, Pa.
16	....do	Emporium, Pa.
18	....do	Do.
19	....do	Mt. Union, Pa.
25	Grasselli Powder Co	Quaker Falls, Pa.
26	Aetna Explosives Co	Mt. Union Pa.
30	....do	Do.

TABLE 3.—*Explosions in munition and powder plants*—Continued.

Date.	Company.	Place.
1918.		
Dec. 2	Aetna Explosives Co	Heidelberg, Pa.
5	E. I. Du Pont de Nemours Co	Pompton Lakes, N. J.
9	.....do	Carney's Point, N. H.
9	Aetna Explosives Co	Mt. Union, Pa.
7	E. I. du Pont de Nemours Co	Olivers Mills, Pa.
12	Aetna Explosives Co	Mount Union, Pa.
16	.....do	Brandywine, Md.
17	.....do	Mount Union, Pa.
18	.....do	Do.
18	.....do	Emporium, Pa.
19	E. I. Du Pont de Nemours Co	Moosic, Pa.
20	Aetna Explosives Co	Fayville, Ill.
22	.....do	Emporium, Pa.
27	.....do	Mount Union, Pa.
30	.....do	Goes, Ohio.
1919.		
Jan. 7	Hercules Powder Co	Hercules, Calif.
9	Aetna Explosives Co	Emporium, Pa.
10	E. I. Du Pont de Nemours Co	Deepwater Point, N. J.
19	Hercules Powder Co	Kenvil, N. J
Feb. 2	.....do	Do.
3	Grasselli Powder Co	New Castle, Pa.
10	Egyptian Powder Co	Pollard, Ill.
19	General Explosives Co	Joplin, Mo.
Mar. 1	Winchester Repeating Arms Co	New Haven, Conn.
2	Western Powder Co	Edwards, Ill.
4	E. I. Du Pont de Nemours Co	Olivers Mills, Pa.
5	Grasselli Powder Co	Wayside, Pa.
11	E. I. du Pont de Nemours & Co	Gibbstown, N. J.
11	Aetna Explosives Co	North Birmingham.
28	Ordnance Department, U. S. A	Aberdeen Proving Grounds, Md.
29	Aetna Explosives Co	Fayville, Ill.
Apr. 2	E. I. du Pont de Nemours & Co	Connable, Ala.
3	.....do	Wayne, N. J.
May 20	Hercules Powder Co	Turck, Kans.

As will be seen from the above list, the majority of these disasters occurred in powder and munition plants. The loss of life attending explosions has been heavy, and many persons have been injured. The damage to property alone has been enormous, in some disasters as high as several millions of dollars. The origin or cause of the explosion in many disasters was impossible to determine absolutely, despite the fact that the most experienced of the powder company's engineers and chemists, as well as the experts of the Bureau of Mines and Bureau of Explosives of the American Railway Association, have very carefully investigated the circumstances. In many of the accidents there were no survivors, a fact that added to the difficulty of determining the cause.

In justice to the owners of these plants it should be stated that in the majority of cases no expense or care had been allowed to stand in the way of making all the manifold and complicated operations of the manufacture of explosives as safe as circumstances would permit, and no criticism is made of the companies concerned. Although the numbers appear high, yet in view of the tremendous enlargement of munition plants and the increase in output of explosives consequent to the war, the casualties attending all operations have been remarkably low. On account of the pressure of the work involved in the investigations and in exercising general control of explosives by civilians during the war, it was possible for the Bureau of Mines to investigate only the most important accidents. Among the major disasters resulting from the war activities were those listed below:

On October 14, 1918, a series of explosions occurred at the loading plant of the T. A. Gillespie Loading Co., at Morgan, N. J., resulting in the loss of 11 lives.

At the Pompton Lakes, N. J., plant of the E. I. du Pont de Nemours & Co., a disaster occurred on September 6, 1918, which resulted in the death of four girls.

At the same plant on December 5, 1918, 14 persons were killed and 22 injured in another accident.

In 1918 several very large TNT plants of various powder companies were destroyed by fire or explosions. The TNT plant of the Semet-Solvay Co., at Syracuse, N. Y., was destroyed in this way on July 2, 1918. In this unfortunate catastrophe 52 persons were killed and 25 injured.

At the Kenvil, N. J., TNT plant of the Hercules Powder Co. an accident occurred on August 7, 1918, involving the death of 2 men and injury to 5 others; at the same plant a week later a fire broke out in which 2 persons lost their lives and 11 others were injured.

At Barksdale, Wis., TNT plant of the E. I. du Pont de Nemours & Co. an explosion occurred on August, 2, 1918, in which 6 persons were killed. Another one occurred on December 7, 1917, at the Carnegie TNT plant of the Aetna Explosives Co. in which 11 persons were killed.

Details of numerous other explosions might be cited, but space does not permit.

Numerous explosions of a miscellaneous nature have been brought to the attention of the bureau, but many have not been reported. Unfortunately it has been impossible to gather definite statistics covering these; investigation would doubtless prove that many could have been prevented.

One explosion of this nature, in the Laner Building, Pittsburgh, Pa., in the stock rooms of the Film Exchanges, caused the death of 10 persons and the injury of 20 others. The most disastrous of the mine accidents caused by explosives was that in the Baltimore Tunnel of the Delaware & Hudson Coal Co. near Wilkes-Barre, Pa., on June 5, 1919, which killed 93 men and injured 43. Many explosions and accidents in the United States have occurred during Army and Navy operations. The terms of the Federal explosives act exempted these departments from the control of the Bureau of Mines, though several major explosions were investigated.

In all important plants explosions in works engaged in war manufactures the military and naval authorities have cheerfully cooperated with the bureau in endeavoring to determine the origin of the accident, and as a result many improvements have been effected that will do much to reduce the hazards in the future.

MISCELLANEOUS CRIMES WITH EXPLOSIVES.

The miscellaneous crimes with explosives embrace a large category. Statisticians have estimated that approximately 70 per cent of the crimes committed in this country have been accomplished with the aid of explosives. Without doubt, the percentage is very high, and stringent regulations providing for a close control of all explosives are urgently demanded.

The dynamiting of fish continues to be practiced, especially in the Southeastern States, in spite of the State fish and game laws prohibiting it. Explosives for such use are often obtained by thefts from magazines.

Among the 1,500 investigations that this office has conducted, numerous cases have been recorded as "unlawful possession of explosives." Arrests on this charge, which legally implies the absence of a license to possess explosives, have led to the discovery that in practically every instance the persons arrested could not give a satisfactory account of their possession or use of explosives. Yeggs, or criminals of the safe-blowing type, have been thus brought to light, as described in the following clipping from an Arkansas newspaper of June 1, 1919:

HARTFORD, *June 1.*—William R. Ortigo, an Italian miner of Frogtown, near here is probably fatally wounded, another man is painfully shot, and two others are in jail here as a result of a battle about 11.45 o'clock last night with City Marshal Joe Hargis, who was fired upon at close range by the four men, but escaped with only a powder burn. The men refused to divulge their names, but Ortigo was identified by local citizens. Their automobile was filled with high explosives.

The men drove into town in a Hupmobile car about 11.30 o'clock last night and stopped in the business section. Marshal Hargis approached the car, he said, to arrest the men for joy riding. He saw a Colt's revolver hanging inside the automobile and attempted to take it, whereupon one of the passengers began firing. The marshal drew back, firing as he did so, and the four men jumped from the auto. Two of them fell, victims of the official bullets, a third ran down the street, firing as he ran, and the fourth man surrendered. Constable Lee Scrum came to the assistance of the marshal, and this morning captured the fourth man, who had run away. He was found asleep in the woods. Several revolvers were taken from the men.

Ortigo is shot through the lung and probably will die. Another of the men suffered a shattered bone in his leg from the officer's bullets. A full kit of burglar tools, nitroglycerine, drills, a cake of soap 6 inches square, and dynamite caps and fuses were found inside the auto. This leads officers to believe thay have captured a gang of bad men who have been operating in this section. The man who is shot in the leg appears to be an Italian, and the officers believe all are miners. The prisoners probably will be taken to the jail at Fort Smith for safe-keeping.

One of the many crimes committed with the aid of explosives is that of safe blowing. The usual plan of the experienced "yegg" or safe blower is to extract the dynamite with a solvent in order to obtain the liquid nitroglycerine or "soup" with which to blow the safe. Many crimes of this character have been investigated and the source of the dynamite has been sought.

MAGAZINE CONSTRUCTION.

Approximately 26,000 report blanks relating to magazine inspection have been mailed to owners of powder magazines, and about 8,000 of these reports have been filled out and returned to the Bureau of Mines. In the Eastern States, such as Pennsylvania, New York, and New Jersey, are a very large number of powder magazines, whereas in most of the Middle States, the number is comparatively small. In the West the States of California and Washington use large amounts of explosives. About 18,500 inspections of magazines were made and reports rendered.

Recommendations for safer construction for approximately 7,000 magazines have been made, and as a rule have been cheerfully followed; many reports have been approved and returned to the files of owners.

If unusual circumstances attended the construction or location of magazines much correspondence was necessary to obtain detailed information; in spite of the inconvenience involved owners generally have been very appreciative of suggestions regarding means of making their plants safer for employees and for the public. The larger companies have been particularly responsive; almost without exception they have voluntarily gone to much trouble and expense to remedy potentially unsafe conditions. Some firms have even abandoned costly magazines in consequence of having their attention called to the danger involved in the location of the buildings.

Thousands of reports have been received from persons using smaller quantities of explosives. A few of these have discontinued storage, but most of them have provided themselves with small portable magazines built according to the specifications of the Bureau of Mines.

The users of explosives who handle quantities sufficient to require facilities for proper and safe storage number, according to a conservative estimate, a little more than 100,000. A campaign of education in the proper storage and use of explosives was initiated at the outset. Standards of magazine construction of different types were submitted and specifications written for the storage of all kinds of explosives. The best possible opinion was invited. The engineers of the Bureau of Mines consulted engineers and chemists of the powder companies, and in several conferences proposed plans and specifications were carefully examined, discussed, and adopted.

With a few minor changes, the standard drawings and specifications of the Institute of Makers of Explosives for the construction of powder magazines were adopted by the Bureau of Mines. This institute is composed of the chief manufacturers of explosives in the United States, and their standards of construction are the result of many years of experience in manufacturing, storing, and handling explosives. With so many and such important changes, however, in the component character and the methods of manufacture of explosives, it is probable that some changes will be made from time to time in methods of storage.

JUSTIFICATION OF THE FEDERAL EXPLOSIVES ACT.

The United States is practically the only civilized government in the world that fails to exercise permanently a national supervision over the manufacture, storage, and use of explosives. A few of the States have laws that partly govern or control explosives, but many of these laws are not properly enforced.

Explosives are fundamental necessities; they are essential instruments of modern civilization, and their uses in industry as well as in war are so varied and extensive that the safe disposition and use of explosives is a matter of capital importance to every citizen.

For economy and efficiency in use it is imperative that explosives should be readily accessible. As a result they are distributed like other general merchandise, and in the absence of Governmental regulation and supervision may be obtained easily by those who intend to make improper use of them. This is the problem which the Bureau of Mines brings to the attention of the public. As explosives are so generally available, so often used improperly, and are such deadly agents of destruction in the hands of the careless and criminal, is it not wise that the Federal or State Governments should exercise a strict and uniform control over them? Explosives are substances of such concentrated energy that, improperly handled, they constitute a danger to the public that should no longer be tolerated.

This country faces the problems of reconstruction, and it is imperative that the class of people from whom trouble may be expected shall be recognized. As evidence of the state of affairs that obtained when the Federal Explosives Act of October 6, 1917, went into effect, an extract from a report by one of the Federal inspectors is quoted:

We have gathered up the explosives that were lying around in abandoned mines, among the wrecks in railroad cuts and tunnels, in barns, in cellars and houses. The convicts of the State have been using dynamite in their work on the State roads. They could leave it hidden and, when their terms expired, they could recover the dynamite and use it for safeblowing or other criminal purposes. One tramp who has reformed told me a story that was alarming. He said that he could stop at any water tank and find out where there was dynamite hidden in a dozen places.

The persons who were leaving explosives lying around carelessly did not seem to fear the State laws, as there was no State law under which they could be prosecuted. However, as soon as we made them understand that to be in possession of explosives that were not adequately protected meant trouble they began to get rid of them.

The result of energetic action in the enforcement of the law on the part of the inspectors and officers of the Explosives Regulation was soon manifested. For example, these facts were noticed by Director Manning: An enemy alien conceived the idea of getting rid of a man he disliked by blowing him up with a bomb. In manufacturing the death-dealing instrument he found it extremely difficult to buy the powder he needed, owing to the restrictions of the war regulation act. In order to get the explosive he went from store to store, purchasing at each a few small-arms cartridges, from which he extracted the powder Even working under these difficulties he was able to get enough explosives to fill his bomb, though the authorities captured it before he had a chance to use it.

After the armistice, the severity of the explosive regulation law was for some months relaxed, and simultaneously the activities of the anarchists and bomb throwers increased.

Preventive measures can not be too strongly advocated in order to check the increasingly serious Bolshevik-anarchist menace to life and property in the United States by making it difficult, if not impossible, for unauthorized persons to obtain explosives. Unless Federal or uniform State legislation comes to the rescue, an unfortunate situation will undoubtedly develop on account of the ease with which even tons of explosives may be procured by the anarchists when supervision is withdrawn. In urging prompt governmental measures Van. H. Manning, former Director of the Bureau of Mines, has pointed out that greater quantities of explosives are available in the United States than in any other country. Moreover, under peace-time conditions it is easier to obtain explosives in this country than in any other. The production of explosives has been enormous. In the calendar year 1917 alone there was manufactured 582,475,327 pounds, or considerably more than half a billion pounds. In view of the possible destructive effect on property, life, or limb of only 1 pound of dynamite, the possibilities for evil and disaster implied by such figures are tremendous.

In most of the States, as their laws now stand, a criminal can obtain any quantity of death-dealing explosives for any diabolical aim—with no questions asked him as to his purpose.

The following editorial from the Washington "Post" of June 12, 1919, sums up many of the arguments for comprehensive legislation:

Officials interested in the enactment of statutes calculated to suppress the activities of anarchists are convinced that it is important that Congress should pass a law which will make it more difficult for the advocates of violence to secure explosives for use in bombs. The explosives regulation law now in effect is a war-time measure, and will expire with the proclamation of peace. Since the close of hostilities its enforcement has been relaxed considerably in order that dynamite for use in industry might be obtained and utilized with less trouble. It has been noted that as the enforcement of this war statute has relaxed the activities of bomb planters have increased, which has convinced officials that in the interest of the public safety the procurement of explosives should be made as difficult as possible to those who wish to use them in their trade of assassination.

The Senate committee which had under investigation the pro-German propaganda in this country, and which is expected to suggest laws directed at violent radicalism, has given consideration to the explosives question. Van. H. Manning, Director of the Bureau of Mines, likewise has studied the subject and strongly recommends congressional action. Police officials have become convinced that the matter is of importance in suppressing anarchy, and they support the demand for repressive legislation.

With the expiration of the war-time explosives regulation law, unless a new statute is enacted to take its place, it will be comparatively easy for anarchists to secure all the dynamite, T. N. T. or powder they need for their nefarious purposes.

There may be a question as to the most efficacious way in which to proceed to regulate the traffic in explosives in times of peace, but it is generally conceded that some method can be devised which will be constitutional and at the same time effective. Licensing and taxing are the means most generally favored. It is by this method that the traffic in narcotic drugs is regulated by the Federal Government.

The public interest undoubtedly requires that Congress take some action along this line. Practically every city in the country regulates the sale of firearms with the object of protecting its citizens, and it is the same sort of protection upon a larger scale that it is proposed the Federal Government should extend to the people. During 1917 there were 582,475,327 pounds of explosives manufactured in the United States, and since that time the production has been increasing. With this tremendous output every possible means should be employed to prevent any portion of it getting into the hands of those who would use it to spread terror throughout the land.

The operation of the Federal explosive act, a war-time measure, has probably caused some inconvenience and expense to many owners of explosives magazines and to persons using and handling explosives throughout the country. To many this inconvenience and expense was only one of the many hardships and sacrifices incident to our participation in the war. The bill was not designed with the purpose of embarrassing the legitimate manufacturer, but to reach the man who compounded explosives in his back yard or cellar and then used them in destroying innocent men and women. The officers charged with the enforcement were relentless in their search for and tireless in their prosecution of this type of criminal.

Many of the urgent reasons that prompted the enactment of legislation to control the use, storage, and handling of explosives during war time continue. The danger is from another direction. In the attempt to readjust labor problems to the reconstruction period many disordered minds are advocating violence. The following extract (par. 5) from the report of the Senate Judiciary Committee on German propaganda and Bolshevism throws light on the situation:

Never have the Federal statutes provided adequate security against an unlawful and promiscuous use of high explosives. During the period of American neutrality, the representatives of the German Government, as well as many criminally inclined residents of our own country, resorted to the use of explosives for the destruction of life, property, and transportation facilities, and except for the provisions of the interstate-commerce act, which prohibited the shipping or carrying of explosives in interstate commerce, the offenses could not be reached by the Federal Government, and when reached under this act the penalties were entirely incommensurate with the offense. The act of Congress of October 6, 1917, entitled "An act to prohibit the manufacture, distribution, storage, use, and possession in time of war of explosives, providing regulations for the sale, manufacture, distribution, storage, use, and possession of same, and for other purposes," was enacted by Congress as a purely war statute, and becomes inoperative upon the restoration of peace. The efficacious effect of this legislation during the period of the war has not only justified its enactment as a war statute, but has impressed upon the people of the country the merit of its provision in times of peace as well as in times of war.

All law-abiding persons recognize the necessity of controlling and regulating the manufacture, distribution, and possession of the instruments of death and destruction relied upon by the criminal and lawless elements of society. The obligation of the Federal Government to protect the lives and property of its citizens would not fully be performed were Congress to permit the act of October 6, 1917, to die by limitation without enacting in its place a peace-time measure.

LEE S. OVERMAN, *Chairman.*
WILLIAM H. KING.
JOSIAH O. WOLCOTT.
KNUTE NELSON.
THOMAS STERLING.

In the United States with the repeal of the war-time Federal explosives act no Federal regulations remain to control the manufacture, transportation, use, storage, and possession of explosives with the exception of the provisions of the Interstate Commerce act, which prohibits the shipment or carrying of explosives except as authorized. In other words, our Federal laws cover only the transportation of explosives.

In England, France, Germany, Italy, Austria, Belgium, and other foreign countries national laws strictly govern the manufacture and handling of explosives. Our country is inadequately protected. Very few of our States have adequate laws or regulations dealing with this important matter.

During the enforcement of the Federal explosives act the numerous licensing agents appointed by the Bureau of Mines uncovered a most deplorable state of affairs. Great stores of explosives were found within the limits of cities and towns where an explosion would have caused tremendous loss of life, limb, and property. In hundreds of places explosives have been abandoned by the owners without any protection whatsoever; thousands of storage places were of such poor construction that any person could enter and obtain explosives to use for criminal purposes. This has been the usual course of procedure of safe blowers and other criminals who were unable to secure an explosives license.

As far as the miners of the country are concerned, and in them the Bureau of Mines has possibly the greatest interest, the enforcement of this act has brought about a notable reform which the bureau earnestly hopes will be made permanent. In the mining districts of many States the miners in the past have not only had free access to explosives, but have made it a common practice to carry the explosives to their homes, often in thickly populated mining towns. This was especially common practice in the winter, when the miners took frozen explosives home for the purpose of thawing them. It was not uncommon to find from 50 to 80 pounds of explosives in a single lodging house for miners and to have these houses blown up with all the occupants. Metal miners and coal miners purchased explosives, stored them in their homes in thickly settled districts, and carried them to the mines in any quantity or manner they saw fit. The accident reports show plainly the great loss of life resulting from such practices.

In Kansas, Alabama, Pennsylvania, and other States over 90 per cent of this pernicious practice has been eliminated under the explosives act through the cooperation of the coal operators in issuing and selling explosives to the men at the mines, thereby reducing the necessity of carrying this dangerous material to their lodging houses.

The possession of dangerous explosives by irresponsible and criminal persons constitutes a constant menace to the Nation. The facts uncovered in the enforcement of the explosives-regulation act during the war are such as would surprise and alarm every citizen.

Just as the enforcement of the explosives act has revealed this deplorable state of affairs throughout the country, it has also shown the manner by which such conditions may be remedied. In its brief active existence of less than two years, it developed an organization of over 16,000 persons, only 1 per cent of whom were salaried.

It is important for purposes of national defense, in view of the possibilities of future war, that the National Government should be provided with ample and complete records of every explosives and munition factory in the United States. These files should register the location; kind of explosive or munition manufactured; amount of daily and pressure output; readiness with which plants could be enlarged, and other facts which would be of great value in an emergency. The matter of location is of prime importance, especially with regard to railroads and harbors. It is of interest to note that many such records as have been described are now in the files of the Bureau of Mines. Additional data should be obtained in order to complete the records.

REMOVAL OF RESTRICTIONS.

With the cessation of hostilities the matter of the continuation of the operation of the act of October 6, 1917, which, by its preamble, was to be in force "when the United States is at war," was taken up for consideration and was held to operate until (1) the declaration of peace, or (2) the repeal of the law, or (3) the funds for its administration were exhausted.

The act of October 6, 1917, appropriated for its administration the sum of $300,000, and the sundry civil act of July 1, 1918, appropriated a like sum for the fiscal year 1919. But the sundry civil bill, approved July 19, 1919, directed that "the unexpended balance of appropriations heretofore made for the enforcement of the act * * * shall be covered into the Treasury immediately upon the approval of this act, with the exception of the sum of $15,000 which may be used for expenses incident to concluding the work under said act." Under the act of July 19, 1919, the sum of $118,335.25 was covered into the Treasury, and on November 17, 1920, a balance of $285.40 remained from the $15,000 appropriated "for expenses incident to concluding the work under said act."

The far-reaching effects of the act and more particularly in the application of the regulations to the control of "ingredients" was realized in advance by few, if any, but experience showed that such simple domestic operations as the home curing of pork products was subject to the regulations for licensing nitrates. During active military operations our loyal citizens submitted to these restrictions patiently, and with the cessation of active hostilities as much embarrassment as possible should be removed; hence, under section 18 of the act, the Director of the Bureau of Mines, with the approval of the Secretary of the Interior, issued the following orders curtailing the scope of explosive regulations:

NOVEMBER 14, 1918.

Because no longer required for the public safety the Director of the Bureau of Mines, in charge of explosives regulation, has made the following changes in the General Information and Rulings under the act of October 6, 1917 (40 Stat., 385), and as amended by the sundry civil act of July 1, 1918:

1. All regulations relating to ingredients not used or intended to be used in the manufacture of explosives are revoked and no further license of such ingredients will be required.

2. All regulations relating to fireworks are revoked and no further license of fireworks will be required.

3. All regulations relating to platinum, iridium, and palladium and compounds thereof are revoked and no further license of platinum, iridium, and palladium will be required.

Very truly, yours,

CLARENCE HALL,
Chief Explosive Engineer.

Approved:
VAN. H. MANNING,
Director.

Approved:
FRANKLIN K. LANE,
Secretary of the Interior.

JANUARY 9, 1919.

The Director of the Bureau of Mines in charge of explosives regulation, has made the following changes in the General Information and Rulings under the act of October 6, 1917 (40 Stat., 385), and as amended by the sundry civil act of July 1, 1918:

1. All regulations relating to ammonium nitrate, electric blasting machines, and flashlight powders are revoked and no further license of these commodities will be required.

2. Attention is called to the fact that all articles listed under explosives, page 13, General Information and Rulings for the enforcement of the act, with the exception of ammonium nitrate, electric blasting machines, flashlight powders and fireworks, still require a license.

3. The previous order of November 14, relative to ingredients when purchased for use in the manufacture of explosives still remains in effect.

Very truly, yours,

CLARENCE HALL,
Chief Explosives Engineer.

Approved:
VAN. H. MANNING,
Director.

Approved January 9, 1919.
FRANKLIN K. LANE,
Secretary of the Interior.

MARCH 15, 1919.

Because no longer required for the public safety the Director of the Bureau of Mines, in charge of explosives regulation, has made the following changes in the General Information and Rulings under the act of October 6, 1917 (40 Stat., 385), and as amended by the sundry civil act of July 1, 1918:

1. All regulations relating to the purchase, possesions, and use of explosives for reclaiming of land, stump blasting, ditching, and other agricultural purposes are revoked and no further license will be required.

2. These revocations do not allow enemy aliens or subjects of a country allied with an enemy of the United States to manufacture, purchase, or sell, use or possess explosives at any time.

Provided, That nothing in the above shall release any person whosoever from complying with the law in the matter of safeguarding and storing of explosives.

Very truly, yours,

CLARENCE HALL,
Chief Explosives Engineer.

Approved:
VAN. H. MANNING,
Director.

Approved:
ALEXANDER T. VOGELSANG,
Acting Secretary of the Interior.

NOTE.—In order that railroads will accept shipment of explosives without a license, it will be necessary for the shipper to state on bill of lading: "For agricultural purposes."

In anticipation of the effect of the passage of the sundry civil bill, which became law July 19, 1919, and which was the only existing legislation making appropriation for the administration of "Explosives Regulations," the Secretary of the Interior, by order of the President, canceled the commissions of each of the United States explosives inspectors on June 30, 1919; and the Director of the Bureau of Mines issued the order following on July 19, 1919.

JULY 19, 1919.

Notice is hereby given that, in accordance with the following provision of the sundry civil act, approved July 19, 1919,

"The unexpended balance of appropriations heretofore made for the enforcement of the act entitled "An act to prohibit the manufacture, distribution, storage, use, and possession in time of war of explosives, providing regulations for the safe manufacture, distribution, storage, use, and possession of the same, and for other purposes," approved October 6, 1917, shall be covered into the Treasury immediately upon the approval of this act, with the exception of the sum of $15,000 which may be used for expenses incident to concluding the work under said act,"

it will be impossible, because the funds appropriated are insufficient, to administer in full the act of October 6, 1917, and that, therefore, none of the following licenses under said act will be issued or required, and all such licenses heretofore issued are hereby canceled:

Vendor's license authorizing the purchase, possession, and sale of explosives or ingredients.

Purchaser's license authorizing the purchase and possession of explosives and ingredients.

Foreman's license authorizing the purchase and possession of explosives and ingredients, and the sale and issuance of explosives and ingredients to workmen under the proviso to section 5 of the act.

Analyst's, educator's, investor's, and investigator's licenses authorizing the purchase, manufacture, possession, testing, and disposal of explosives and ingredients.

The following licenses will remain in force and be required until a condition of peace is reached, the act repealed or the operating funds exhausted, when due notice will be given:

Manufacturer's license authorizing the manufacture, possession, and sale of explosives and ingredients.

Exporter's license authorizing the licensee to export explosives, but no such license shall authorize exportation in violation of any proclamation of the President issued under any act of Congress.

Importer's license authorizing the licensee to import explosives.

Applications for licenses under the last three mentioned categories will be made to the Director of the Bureau of Mines, Washington, D. C.

Very truly, yours,

VAN. H. MANNING,
Director.

Approved:
FRANKLIN K. LANE,
Secretary.

PROPOSED ACT TO REGULATE EXPLOSIVES.

The facts developed in the administration of the act of October 6, 1917, emphasize the need for close supervision over and control of the manufacture, storage, transportation, and use of explosives in order to properly protect the people of this country from accidents occurring from them or outrages committed with them.

As has been pointed out, this may be accomplished by the enactment of a uniform law by each of the States and by the United States to cover its Territories, the District of Columbia, and all other possessions, if such laws are uniformly administered, or, by a single Federal law operating throughout the land. The following is offered as a proposed form of peace-time legislation which if enacted into law would, when efficiently administered, go far toward securing the protection needed:

For investigations of explosions and fires caused by explosives in mines, quarries, factories, warehouses, magazines, houses, cars, boats, conveyances, and all places in which explosives or the ingredients thereof are manufactured, distributed, stored, or used, with a view to recommending safe methods for the manufacture, distribution, storage, and use of explosives to the end that precautions may be taken to prevent such explosions and fires, and including personal services in the District of Columbia and elsewhere, printing and binding, supplies and equipment, traveling and subsistence expenses, maintenance, repair, hire, and operation of motor-propelled passenger-carrying vehicles, $35,000 or so much thereof as may be required for expenses incurred in connection with the work during the fiscal year ....: *Provided*, That the Director of the Bureau of Mines shall, in his discretion, report his findings, in such manner as he may deem fit, to the proper Federal or State authorities, to the end that if such explosion or fire has been brought about by a willful act the person or persons causing such act may be proceeded against and brought to justice; or, if said explosion or fire has been brought about by accidental means, that precautions may be taken to prevent similar accidents from occurring.

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Bulletin 199

DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, Secretary

BUREAU OF MINES
H. FOSTER BAIN, Director

EXPERIMENTAL PRODUCTION OF ALLOY STEELS

BY

H. W. GILLETT and E. L. MACK

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By H. W. Gillett and E. L. Mack.

INTRODUCTION.

The production of small heats of alloy steels on an experimental scale is often desirable in beginning the study of new alloy steels before large amounts of expensive alloys are used in heats of commercial size. Such small heats can sometimes be made up at crucible-steel plants, but few crucible-steel makers care to undertake experimental heats for other firms. Small electric furnaces offer some advantages over crucible furnaces for experimental work.

Hansen [1] in 1909 described a small 100-kilowatt single-phase, direct-arc furnace with a capacity of 50 to 300 pounds of steel, and such furnaces, of 200 pounds capacity or larger, are being successfully used by various firms for experimental work. They have the advantage of using the same metallurgical procedure as is used in practice for larger electric furnaces. The very small sizes have the drawback of lack of precision in controlling the carbon content of the steel. Small Rennerfelt two-phase, indirect-arc furnaces of 40 to 60 kilowatts and small Industrial Electric Furnace Co. furnaces, single-phase with one electrode embedded in the hearth, of 25 to 50 kilowatts, are also in use by a few firms for experimental work or for production on a very small scale. Hoskins carbon-plate resistor crucible furnaces are also sometimes used. Little seems to have been published on the use of these furnaces in making experimental alloy steels.

Keeney [2] has given data on the making of uranium steels in a tilting Siemens furnace of 25 pounds capacity, and has described [3] a small stationary Siemens furnace.

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[1] Hansen, C. A., Small experimental Heroult furnace: Electrochem. and Met. Ind., vol. 7, 1909, p. 206.

[2] Keeney, R. M., Manufacture of ferro-alloys: Bull. Am. Inst. Min. Eng. Aug., 1918, p. 1821.

[3] Lyon, D. A., and Keeney, R. M., Melting copper ores in the electric furnace: Bull. 81, Bureau of Mines, 1915, p. 17.

More recently, two direct-arc furnaces for experimental use in the laboratory have been described,[4] and the Ajax Electrothermic Corporation[5] has brought out its high-frequency induction, eddy-current furnace, which has been developed mainly in small sizes, such as one to handle 25-pound charges of steel. This type should be well fitted for work on a very small scale and should allow satisfactory control of carbon, but is expensive.

The Bureau of Mines has recently made up experimental heats of alloy steels for the Army and the Navy.

The steels for the Army were desired for work on gun erosion, especially as regards the effect of nitrogen on the steel.[6] No physical tests of any of these steels were made by the Army.

The ingots made for the Navy were in two series, the first being rolled, heat-treated, and given physical tests by the Bureau of Standards. A report of the physical tests on these steels under definite heat treatment is given in Technologic Paper 207 of that bureau. Tests on steels of a similar type are also given by Johnson.[6a] The second series was made in larger ingots, which were rolled into plates, cut up into smaller plates, and heat-treated to different Brinell hardness numbers by the Halcomb Steel Co. Physical tests of this series under several heat treatments are being made by the Navy but are not yet finished.

Another series of alloy steels was made up in the course of cooperative work with the Vanadium Corporation of America and the Welsbach Co.; various impact and endurance tests are being made on these steels, the results to be given in a later publication. The present report deals only with the preparation of the ingots on any of the series of steels.

Some of the points brought out in preparing the steels, particularly as to the recovery of the alloying elements from the various ferro-alloys entering the steel, may, however, be of interest and are therefore put on record. The indirect-arc furnace finally used seems also to be a sufficiently useful piece of experimental apparatus to justify its description. There is, of course, nothing new about a furnace of this type, but it seems to fit in between the 25-pound high-frequency furnace and the 200-pound direct-arc furnace, being, in a 100-pound size, probably as satisfactory as either of the other types, and it can be constructed more cheaply than either of the other two. For a brief review of the ferro-alloy field, see Richards.[7]

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[4] Advisory Council of Science and Industry, Australia, Manufacture and uses of ferro-alloys and alloy steels: Bull. 9, 1918, pp. 36, 39.

[5] Northrup, E. F., High-frequency induction steel furnace: Chem. and Met. Eng., vol. 24, 1921, p. 309.

[6] Wheeler, H. E., Nitrogen in steel and the erosion of guns: Min. and Metal., April, 1920, No. 160, sec. 4.

[6a] Johnson, C. M., Some alloy steels of high elastic limit, their heat treatment and microstructure: Trans. Am. Soc. for Steel Treating, vol. 2, 1922, p. 501.

[7] Richards, J. W., Chem. and Met. Eng., vol. 19, 1918, p. 501.

SYMBOLS FOR FERRO-ALLOYS.

Inasmuch as repeated reference will be made to various ferro-alloys, they will hereafter frequently be abbreviated to the following chemical symbols:

FeMn = Ferromanganese.	FeZr = Ferrozirconium.
FeSi = Ferrosilicon.	FeTi = Ferrotitanium.
FeW = Ferrotungsten.	FeB = Ferroboron.
FeMo = Ferromolybdenum.	SiZr = Silicozirconium.
FeU = Ferrouranium.	SiZr = Silicozirconium.

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Acknowledgment is also made for courtesies extended by Mr. H. A. Neel, of the Michigan Steel Castings Co.; Dr. J. A. Mathews and Mr. H. J. Stagg, of the Halcomb Steel Co.; and Mr. F. M. Becket, of the Electro Metallurgical Co.

It should also be stated that part of the supplies, such as ferro-alloys required in the preparation of steels for the Navy were supplied by the Navy. Aside from this and from the services of men assigned to the work by the Army and the Navy, the expenses of the work done for these departments were paid from the Bureau of Mines appropriation.

REASONS FOR UNDERTAKING THE WORK.

In 1917 the Bureau of Mines received information from a creditable source that Germany was using uranium steel in the liners of some high-power naval guns. It was stated that uranium stiffens steel at high temperatures, and raises the softening point some 200° C., so that gun erosion is reduced. The fact that the German guns retained accuracy of fire at the end of the Jutland naval engagement was ascribed to the uranium-steel gun liners. The report agreed with previous less circumstantial reports. Somewhat similar reports had been received as to the use of molybdenum steel. Whether these reports had any foundation in fact is still unknown to the writers, but under the conditions existing in 1917 they seemed of sufficient importance to warrant an investigation.

The Bureau of Mines had some ferrouranium on hand from its work[8] on the production of that alloy, and because the Bureau of Mines had the use, at its Ithaca field office, of the electric-furnace equipment of Cornell University, which was suitable for the production of small experimental heats of steel, the bureau was requested by Col. T. C. Dickson, commanding the Watertown Arsenal, to prepare a series of uranium steels.

The series of uranium steels desired was to analyze as follows:

Desired composition of uranium steel.

	Per cent.
C	0.40 to 0.50
Mn	0.35 to 0.80
Si	0.15 to 0.35
S	Not over 0.05
P	Not over 0.05
U	0.5, 1, 1.5 per cent, etc., as far up as was feasible, in 0.50 per cent steps

The steel was to be supplied in ingots, from which a sound bar 1 inch in diameter and 15 pounds in weight could be forged, this being enough for physical test specimens and for a pressure plug for an erosion test by the method of Langenberg and Fay[9]—inserting the plug in the mushroom head of a large caliber gun. Forging as well as testing was to be done by the arsenal.

The arsenal later requested that similar series of tungsten and molybdenum steels be supplied, the other elements being the same as in the uranium series, one series to contain 1 to 15 per cent W by 1 per cent steps, the other to contain 1 to 15 per cent Mo by 1 per cent steps. After the delivery of the steels was begun, the arsenal found it impossible to forge the ingots, so the bulk of the steels sent to the arsenal were forged at Ithaca into about 1¼-inch diameter bars before shipment.

When the work was begun the arsenal regarded uranium steel as the most important and asked that the uranium series be prepared first. After some work on this series had been done the arsenal came to the conclusion that it was doubtful if uranium steel really had been

[8] Gillett, H. W., and Mack, E. L., Preparation of ferrouranium: Tech. Paper 177. Bureau of Mines, 1917, 46 pp.; Ferrouranium, Jour. Ind. Eng. Chem., vol. 9, 1917, p. 342.

[9] Fay, H., Erosion and hardening of large guns: Iron Age, vol. 98, 1916, p. 1290.

used by Germany and that the other series were more important. Work on the uranium series was therefore dropped, the tungsten series made, and the molybdenum series begun.

The arsenal then requested that work on the molybdenum series be stopped and another set of steels be made up, as the plan of attack upon the erosion problem had been changed, and these were desired in the study of another method of testing than the pressure-plug method. . These steels were to contain chromium, vanadium, titanium, nickel, and aluminum as alloying elements; some of the steels were to have but one, others up to four, of these elements.

All except two or three of these steels were shipped to the arsenal by November 8, 1918, but the armistice necessitated changes in the arsenal's plans for experimental work and no physical tests of the steels were made.

The Bureau of Mines has analyzed the Army steels for its own guidance only, for analysis of the steels for the arsenal was also scheduled to be made by the arsenal, though it was not, as it happened. Many analyses of the Navy steels for Zr, Ti, and Al were made by the Bureau of Standards. The analytical figures given herein on the first series of Navy steels are averaged from all the analyses by both bureaus. Analyses for Cr, Mo, and V in the third series of steels, except those also containing cerium, were made by the Vanadium Corporation.

STEELS MADE BY MICHIGAN STEEL CASTINGS CO.

After the first laboratory steel furnace was built, many difficulties developed in connection with its use, hence advantage was taken of the offer of the Michigan Steel Castings Co., of Detroit. to make up a few steels. This firm was interested in uranium steel and had made a trial heat previously, analyzing 0.20 C, 0.65 Mn, 0.31 U, which showed up well.

The Michigan Steel Castings Co. made the steels by pouring about 100 pounds (estimated) of steel from one of the Heroult furnaces into a heated hand ladle and feeding the crushed ferro into the stream of metal. On account of the chilling effect of large amounts of ferro no attempt was made to prepare steels very high in alloying element.

The steel was poured into a baked sand mold, making an ingot 3¾ inches in diameter by 15 inches high. The balance of the metal was poured into "Keelblock" test-bar molds in sand. Drillings for analysis were taken from the riser of the test bar. The liquid steel used ran from 0.04 to 0.05 per cent in S and P. A small pellet of aluminum was used in each ladle for deoxidation.

TABLE 1.—*Results on making uranium steels.*

M. S. C. test No.	Composition of liquid steel used.			No. of ferro.[a]	Composition of ferro used.			Ferro used.	Calculated composition of steel.				Composition of steel by analysis.				Apparent recovery of U.[b]	Remarks.
	C.	Si.	Mn.		U.	C.	Si.		C.	Si.	Mn.	U.	C.	Si.	Mn.	U.[b]		
	P. ct.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*Lbs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
11	0.28	0.28	0.58	34	33	4.8	0.8	1	0.33	0.29	0.57	0.33	0.33	0.26	0.48	0.30	91	Ferro was apparently completely dissolved.
12	.28	.28	.58	45	39	5.2	1.6	1.67	.36	.31	.56	.66	.32	.30	.39	.45	68	Some of the ferro seemed to be oxidized, as a scum formed on the metal.
13	.28	.28	.58	84 50	47.5 65	2.45 5.3	1.4 .5	1 .96	.36	.33	.55	1.1	.35	.27	.39	.56	51	Do.
14	.28	.28	.58	50 66 81	65 58 53.5	5.3 2.4 2.4	.5 1 1.2	.76 1 1.17	.38	.31	.54	1.7	.35	.35	.48	.93	55	Observers were not sure whether the ferro was completely dissolved or not.
15	.24	.20	.54	94 86	68.5 72	5 2.4	.3 .6	2.15 1.62	.37	.22	.52	2.63	.33	.37	.48	1.83	70	Ferro not completely dissolved.
16	.26	.21	.51	67 39	44.5 47.5	2.25 4.2	1 .3	6 [c]4.33	.56	.27	.46	4.72	c.70	.41	.27	3.49	74	(c).

[a] See Gillett, H. W., and Mack, E. L., Preparation of ferrouranium, Tech. Paper 177, Bureau of Mines, for details of the making of these ferros.

[b] These figures are not necessarily correct, as there was undoubtedly segregation, the U analysis not necessarily being representative of the average U content of the ingot.

[c] 90 pounds metal poured into hot crucible instead of ladle, onto 10¼ pounds ferro in bottom of crucible. Metal froze. Heated 4¼ hours in oil furnace. Metal still rather cold. Carbon probably taken up from crucible.

URANIUM STEELS.

The results on making uranium steels are shown in Table 1.

The Michigan Steel Castings Co. sent the test bars to the Standard Alloy Co. for determination of uranium and for physical tests. The uranium analysis by the Bureau of Mines on the sample taken from the riser and that by the Standard Alloy Co. on a sample taken from the test bar did not agree.

Analyses of steel samples.

No. of sample.	Composition, per cent.					Uranium, per cent.		
	C.	Si.	Mn.	P.	S.	Bureau of Mines analyses of riser.	Standard Alloy Co. analyses of test bar. First report, original method.	Standard Alloy Co. analyses of test bar. Second report, revised method.
11	0.33	0.25	0.34	0.035	0.011	{0.31, .30} Av. 0.30	0.26	0.49
12	.32	.30	.38	.036	.015	{.41, .49} Av. .45	.29	.78
13	.35	.27	.35	.032	.013	{.56, .57} Av. .56	.39	.45
14	.35	.30	.38	.036	.016	{.97, .89} Av. .93	.37	.87
15	.33	.37	.48	.033	.034	{1.81, 1.83} Av. 1.83	....	1.40
16	.70	.41	.35	....	....	{3.47, 3.51} Av. 3.49	....	n. d.

The methods of analysis were then compared by interchanging samples of test bar 15.

Analyses of sample 15.

Sample.	Bureau of Mines analysis.	Standard Alloy Co. analysis.	
	Per cent.	*Per cent.*	*Per cent.*
Bureau of Mines, original from riser	1.83	[a] 1.88	[b] 1.69
Standard Alloy Co., from one end of bar	....	1.40	....
Standard Alloy Co., from other end of bar	1.06	[a] 1.04	[b] 1.02

[a] Using Standard Alloy Co. revised method, precipitation as phosphate, which is reduced and titrated.
[b] Using Bureau of Mines method, precipitation as oxide, gravimetric method.

This comparison of results, compiled after a number of uranium steels had been made up and shipped, shows that there was material segregation of uranium in the uranium steels made by the Michigan Steel Castings Co.

The physical properties of the test bars were reported by the Standard Alloys Co. as follows: All samples quenched at 1,620° F. (883° C.), samples M drawn at 800° F. (427° C.), samples N drawn at 1,200° F. (647° C.). Standard 0.5-inch diameter, 2-inch length test bar used.

Physical properties of test bars.

No. of sample.	Tensile strength.	Yield point.	Elongation.	Reduction of area.	Fracture.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*	
11 M	121,800	89,750	9	34.4	Fine, silky half cup.
11 N	85,600	65,600	20.5	54.6	Fine, silky cup.
12 M	149,800	141,700	1.5	4	Coarse, granular, ragged.
12 N	93,800	79,300	13	21	Do.
13 M	148,000	100,800	8.5	29.2	Fine, silky half cup.
13 N	95,600	81,500	17.5	40.2	Do.
14 M	126,800	79,900	1.5	4	Coarse, granular, ragged.
14 N	90,000	76,000	10	14.2	Do.
15 M	96,400	None.	None.	None.	Coarse, granular, straight.
15 N	84,900	None.	1.5	1.2	Coarse, granular, ragged.

According to the Standard Alloys Co., the greatest benefit claimed for uranium in low-carbon steels is from the addition of not over 0.3 per cent U.

Several tungsten and molybdenum steels were made up at the Michigan Steel Castings Co. The ferro-alloy was preheated in a crucible furnace, molten steel then added, and the mixture heated in order to produce a molten rich W or Mo alloy that could be added to ladles of carbon steel taken from the Heroult furnaces; however the maximum temperature attainable in the oil-fired crucible furnace was too low to produce a sufficiently fluid rich alloy and this method had to be abandoned. A 1 per cent Mo steel was satisfactorily made up by adding the ferromolybdenum in the ladle, but the steels of higher Mo and W content desired by the arsenal could not be so made on account of the chilling of the steel when large amounts of solid ferro are added to the ladle.

The Michigan Steel Castings Co. made every effort to prepare these steels, but the futility of attempting to make laboratory-sized heats with equipment designed for large-scale production soon became apparent, and the additional work was done in the laboratory, starting with a small direct-arc furnace.

USE OF SMALL DIRECT-ARC FURNACE.

Since the arsenal required but 15 pounds of sound forged bar of each composition, it was thought that a 30-pound charge should allow for melting losses and for cropping the ingot free from pipe. A single-phase, direct-arc type of furnace was chosen. A rectangular shell 11½ by 15 inches by 13 inches high was mounted on trunnions and counterbalanced to tilt about the spout for direct pouring, since it was feared that with so small a charge it would not be practicable on account of too rapid chilling of the metal to pour first into a ladle and then into the mold.

Inasmuch as the water-cooled hearth of the furnace used for making ferrouranium had proved satisfactory, it was decided to test a thin refractory lining and to try to maintain this by water-cooling; therefore the furnace was lined with split magnesite brick 1¼ inches thick, save for the upper course, which was 2½ inches thick, making a chamber 12½ inches long by 9 inches wide and 13 inches high. The bottom was built up into hearth form by ramming magnesite, bonded with water glass, into the corners.

Two perforated spray pipes were placed about the furnace, one at the top and one about halfway up, so that the sides and bottom were covered with a uniform film of flowing water which dripped off the bottom into an open tank placed beneath the furnace, from which it was led to the sewer. A shell was welded about the spout to prevent water from getting into the mold when the furnace was tilted to pour. A pouring spout measuring 2 by 4 inches after it had been lined with split brick was provided. The roof was made of split zirkite brick held in an iron frame set on top of the furnace body. Holes were ground out in the zirkite brick for passage of the two 2-inch diameter graphite electrodes, which were on the center line of the furnace about 2 inches apart. The electrodes were thus 3½ inches from the side walls. The water coolers through which the electrodes passed with one-sixteenth-inch clearance were large enough to cover nearly all of the roof and to cool it as well as the electrodes.

The electrodes were supported by masts attached to the furnace and were adjusted by handwheels. Connection was made to the flexible leads by electrode holders, which were uncooled as the roof coolers were sufficient.

The furnace took a current of 500 to 700 amperes at 75 to 90 volts. The average load was about 40 kilowatts at a power factor of about 0.90.

The split cast-iron ingot mold gave an ingot 2½ by 2½ inches at the butt, 3 by 3 inches at the top, and about 16 inches tall. As a 30-pound charge scarcely filled this and the furnace would not hold much over 30 pounds, a hot-top brick could not be used.

When the metal was poured direct from furnace to mold it was poured through a conical alundum-lined funnel with a one-half inch hole in the bottom, set on the mold, to direct the stream.

Experiments were tried with making up the series of tungsten steels in 30-pound heats, charging iron, ferrotungsten, and washed metal with part of the ferrosilicon and ferromanganese at the start, plus about 1¼ pounds of a mixture of 75 per cent CaO, 20 per cent SiO_2, 5 per cent CaF_2 for slag, and adding the balance of the ferrosilicon and ferromanganese, after the charge was fully melted, and later, just before pouring. After the slag was skimmed off, the metal was poured, at first without allowing time for the metal to cool and give up dissolved gases, which produced unsound ingots at any of the high pouring temperatures tried, even though as much as 0.05 per cent aluminum was added just before pouring. The metal was, in later runs, poured into a preheated ladle, thence to the mold. By using lower pouring temperatures sound ingots were obtained.

CONTROL OF CARBON CONTENT.

The main trouble, however, was in controlling the carbon content of the steel. One charge calculated for 0.35 per cent C gave 0.7 per cent C, two each calculated for 0.7 per cent C gave 0.36 per cent and 0.97 per cent C, and one calculated for 0.61 per cent C gave 0.32 per cent C.

On account of the necessary clearance between electrodes and the electrode coolers in the roof, the furnace could not be tightly closed against the entrance of air. For this reason, as well as for the presence of a little scale on the iron used, some decrease in the carbon found from that calculated was to be expected. In the great majority of melts, however, there was a decided pick-up of carbon, which came, of course, from the electrodes. It soon became evident that the carbon pick-up was related to the way the arcs held during the melting-down period, when the charge was still solid, and before a sufficient pool of metal and slag had formed beneath the electrode to sustain the arc. If the charge happened to be piled so that, as it melted down, the arc broke often and was "snappy," contact had to be made often with the charge to restart the arc. During each contact carbon was absorbed from the electrode. If, on the other hand, the charge happened to lie so that the arc was smoother and broke less often, less carbon was absorbed. In a furnace of commercial size, variations in the amount of carbon so absorbed would be negligible in comparison with the whole charge, but on a 30-pound charge they were not. The electrode loss varied from one-half to 1½ inches per electrode per heat—that is, 0.2 to 0.6 pound graphite. Attempts were made to control the carbon content by sampling, after the charge was melted, making a rapid carbon analysis, and readjusting the composition of the charge, but the time was so short and the difficulty of readjusting the charge so great that this method appeared impractical.

Such a tiny direct-arc furnace might be useful for university instruction, to show the way that type works, but it seemed obvious that to be of service in preparing steels of definite analysis the size of the furnace would have to be increased. The use of this furnace was therefore finally abandoned. While the next furnace was being constructed, however, work was continued with the direct-arc furnace, a few molybdenum and uranium steels being made.

REFRACTORIES.

Various refractories were tried in the side walls above the slag line. Magnesite brick spalled rather badly, as would be expected in a furnace used intermittently, with one face of a 1¼-inch split brick at steel-melting temperature and the other face against the water-cooled shell. Zirkite did better, lasting 14 heats, but melted away a little and went into the slag. A purer zirconia refractory than that of zirkite, which was made from the natural unpurified ore, might be expected to do better. Bauxite brick melted away rapidly. Carborundum brick stood up well, but spattered globules of steel shot up against them and the C and Si content of the steel was thereby slightly raised. If used where such spatter can not reach them, they should give good service.

Considering the nearness of the arcs to the side walls, it appeared that the water-cooling gave the thin zirkite lining a much better life than would have been expected from a thicker lining not water-cooled.

The magnesite hearth stood up well enough with occasional patching, while hot, with crushed magnesite moistened with dilute water-glass. The zirkite roof bricks stood up satisfactorily, showing little tendency to soften or to crack.

The recovery of W and Mo was found to be quantitative, all that was added being recovered in the steel. The recovery of uranium was not quantitative.

Recovery of uranium.

Analysis of ferrouranium.			Per cent U—		
C.	Si.	U.	Added.	Found.	Apparently recovered.
Per cent.	*Per cent.*	*Per cent.*			
5	0.6	49.5	1.1	0.7	63
5	.6	49.5	1.1	.7	63
5.8	.5	52	1.55	.72	46
2.1	1.8	48	1.05	.31	30
2.1	1.8	48	1.05	.52	50

About one and a half minutes elapsed in these runs between the addition of ferrouranium, crushed to pea size, to the charge in the furnace, and pouring the melt into the mold direct from the furnace for the first three tests, or into the ladle for the last two tests. The slag was thoroughly skimmed off before the ferro was added and the ferro stirred in at once. The melt was held in the ladle about two minutes.

The samples for analysis were taken from the top of the ingots, and as previously stated but ascertained after these were shipped, segregation is to be expected, so that the recovery figures are not necessarily correct.

USE OF INDIRECT-ARC FURNACE.

Since it was necessary to discard the small direct-arc furnace and either to build a larger one that would take a large charge and a longer time per heat, or to utilize a type in which there would be less contamination by the electrodes, it was decided to try an indirect-arc furnace, in which no slag need be used (thus tending toward better refractory life) and in which the charge could be melted down without contact with slag or electrodes. The metallurgy of the process would then be similar to that of crucible-steel melting, though done in an electric furnace.

For these reasons it was decided to try a few heats in the laboratory rocking brass-furnace.[10] A facing of magnesite cemented with water glass was put in after some of the regular brass furnace lining was chipped out and all brass shot were removed. A lining so put in could not be expected to wear well, but was hoped to show how the furnace would handle steel. Charges of 35 to 45 pounds were used instead of the 28 to 30 pound charges used in the direct-arc furnace.

The molds, which were washed over smoothly with thin alundum paste, dried, baked by playing a large gas flame on them and smoothed with fine sandpaper, were thereafter lightly smoked with a smoky kerosene flame.

URANIUM STEELS IN RELINED ROCKING BRASS FURNACE.

In heat 1044 the furnace was preheated with 15 kilowatt hours, then all the 35-pound charge added except the ferrouranium, 50 grams of FeSi, and 5 grams of Al. After 27 kilowatt hours the metal was skimmed of the fallen pieces of magnesite lining, 400 grams of pea-size FeU (No. 77) containing 45½ per cent U, 2 per cent C, 4 per cent Si, and the FeSi, were added, 1 minute 10 seconds elapsing after adding the ferro and stirring it in before pouring into the ladle. Aluminum was added in the ladle. The metal was cold and skulled a good deal. The ingot was sound and forged well.

Analysis of product of heat 1044.

Constituent.	Calculated.	Found.
C	0.76	0.52
Si	.45	.18
Mn	.94	.62
U	1.15	.44
Al	.03	n. d.

[10] Gillett, H. W., and Rhoads, A. E., Melting brass in a rocking electric furnace: Bull. 171, Bureau of Mines, 1918, p. 25.

Heat 1045 was run about the same, but as 600 grams of No. 77 FeU was to be used, the furnace was heated seven minutes after the FeU was added and before pouring. As the metal was too cold on the previous heat, 20 kilowatt hours were used on the preheat, 24 kilowatt hours before adding the FeU, 5 kilowatt hours after adding it, 49 in all. The ingot was satisfactory.

Analysis of product of heat 1045.

Constituent.	Calculated.	Found.
C	0.72	0.53
Si	.44	.29
Mn	.94	.63
U	1.69	.04
Al	.03	n. d.

In heat 1046 a 44-pound charge was used, 20 kilowatt hours preheat, 34½ kilowatt hours before adding FeU, when 665 grams No. 77 FeU were added together with a little FeSi and FeMn, 6 kilowatt hours more then used in about 10 minutes, and a further addition of 225 grams No. 28 FeU (35.5 per cent U, 4.9 per cent C, 0.5 per cent Si) made before pouring into the ladle. The ingot was sound.

Analysis of product of heat 1046.

Constituent.	Calculated.	Found.
C	0.68	0.60
Si	.50	.40
Mn	.96	.77
U	2.1	.85
Al	.03	n. d.

In these three heats the furnace was rocked by hand during the heat, starting with a small rocking arc as soon as the metal started to melt and steadily increasing the angle through which the furnace was rocked until when all the metal was melted, the whole lining, save the ends and the portion close to the charging door lining, was washed by the metal.

In the direct-arc furnace an apparent recovery of 30 to 60 per cent of the U added was made; in heat 1044, a 58 per cent recovery. In both tests the FeU was added just before pouring. In heat 1045 the ferro was allowed to remain in the furnace seven minutes before pouring, with an almost total loss of U. In heat 1046 FeU was added both before the heat was finished and at the very end. On the basis of the total U added, the apparent recovery was only 17 per cent, while if it be assumed that the U added before the heat was over was lost, as in heat 1045, the apparent recovery on the U added at the end is 70 per cent. The term "apparent recovery" is used because the liability to segregation of U in U steels was not established until these ingots had been forged and shipped.

The magnesite lining did not adhere well to the old lining, and no additional runs were made in this furnace shell. The loss of C, Si, and Mn, while not entirely uniform, showed a much better approach to it than in the direct-arc furnace and it was felt that for the purpose in hand the indirect-arc furnace was better fitted than the direct-arc type, hence an indirect-arc furnace was built. At this time it was not expected that any steels other than the U, Mo, and W series would be made, for the arsenal had not yet requested the others; therefore the furnace was built up as cheaply as possible, and designed for a charge of about 40 pounds.

DESCRIPTION OF INDIRECT-ARC FURNACE.

A cylindrical sheet-iron shell 30 inches long by 30 inches diameter was bought at a junk shop. Two hoops of one-half by one-half inch stock were made, slipped over the shell while hot, and riveted thereto about 2 inches from each end, thus forming the rings supporting the shell. Each ring rested on two rollers held in a framework forming the base of the furnace. (See Pl. I, *A* and *B*.)

The shell was a horizontal cylinder, resting on four rollers beneath it. The braces on the base were so spaced and bent as to allow the shank of the pouring ladle to pass beneath the furnace. The furnace was raised enough on the supports to allow the metal to drain completely from the spout into a crucible used as a ladle.

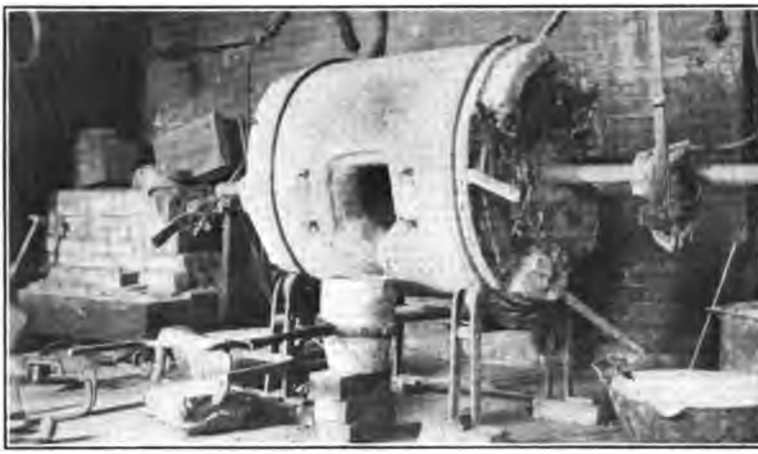
A hole 12 by 12 inches was cut in the shell for a combined charging door and pouring spout.

Four handles extending from the end of the shell at 45°, equally spaced, tilted the furnace.

At one end, braces projecting from the end of the shell held an alberene slab 1 inch thick, through which a $2\frac{1}{16}$-inch hole was bored. This slab, 6 inches from the end of the furnace, supported a long electrode and took the bending strain. The 2-inch diameter round graphite electrode rested in this support as well as in the electrode hole in the end wall.

ELECTRODES.

Two electrodes 40 to 48 inches long were used, one entering the furnace horizontally from each end, an electrode being started in service on the end with the alberene support. When it had worn off to a length of about 30 inches, it was transferred to the other end of the furnace, on which no other support than the refractory wall was provided, the shorter electrode being balanced well enough in and supported by the end wall alone. It could then be used until it had worn down to a length of about 20 inches and was then put in stock, as the short electrodes are useful in other work. The alberene



A. LABORATORY INDIRECT-ARC STEEL FURNACE, OPEN FOR CHARGING.

B. LABORATORY INDIRECT-ARC STEEL FURNACE, CLOSED FOR OPERATION.

support could be removed when it was desired to use short electrodes in both ends. These supports were finally abandoned in favor of a thick end wall, 15 to 18 inches, which supports even a very long electrode without any other support than the furnace. Jointed electrodes were used when the longer electrodes were not obtainable, but were far more likely to break; therefore, even had there been no use for the discarded butt, the long electrodes were no more expensive to use in the long run than jointed electrodes, with far less danger of spoiling a heat through breakage.

Flexible copper leads were bolted to split bronze electrode holders, fitting the electrodes tightly. The holders were not water-cooled, as they would have been more expensive to make, heavier, and more likely to cause breakage of the horizontal electrodes. Little or no cooling was needed on long electrodes, since the C^2R heating was not great, as care was taken to make good contact between holder and electrode with copper gauze. When an electrode had worn down very short, the conducted heat made it desirable to cool the holder. In such cases, the holder was wrapped in asbestos cloth and water was dropped on it slowly from a hose whose end was suspended over the holder. The drip was caught in a large pan set on the floor and emptied when necessary. This cheap and crude method of cooling was entirely adequate for the purpose.

A hole was bored in the outer end of the electrode and an iron rod stuck through the hole to form a handle for the adjustment of the electrode. The length of the arc was thus controlled by hand, the electrode staying where it was put, as it fitted snugly into its hole. After the first few minutes' heating of a cold furnace, the arc requires little adjustment.

Since the electrodes became pointed by oxidation, due largely to the removal of the electrodes at the end of a heat to allow skimming before pouring, and since the alundum lining softened somewhat, it was necessary to punch out the electrode holes with a 2½-inch diameter steel bar immediately after pouring. This bar had a handle on one end like that used on the electrodes, and could readily be forced in and turned around to keep the electrode holes smooth and true. When this was done, very little patching of the electrode holes was needed.

The furnace lining consisted of 2½ inches of corundite fire brick next to the shell and at the ends, then of 4 inches of refractory brick, zirkite at the start, magnesite later, the latter being brought out clear to the shell about the combined charging door and pouring spout. Since the zirkite brick were made from crude zirkite ore and were plastic at the temperature attained, and since magnesite spalls badly when used intermittently at these temperatures, it was necessary to protect both with an inner layer of albundum cement.

ROOF OF FURNACE.

A roof of magnesite bricks spalled so much as to require frequent patching. A zirkite brick lining made from natural zirconia ore softened much more than alundum and made too heavy a slag. A partial lining of refined zirconium oxide (about 99.5 per cent ZrO_2) bonded with a little water-glass was tried, and might perhaps have been satisfactory had it been used exclusively, but when in contact with alundum it fluxed down and was far less refractory than the impure zirkite. Aluminum oxide therefore appears to lower the melting point of zirconium oxide appreciably. The carborundum (Carbofrax) brick used as a door stood up so remarkably well, that the 4-inch magnesite backing to the inner alundum lining over the upper half of the furnace was replaced with 1¼ inches of magnesite, next the corundite and 2½ inches of carborundum (Refrax) brick over the magnesite when the second series of zirconium steels was made. The lower half of the furnace was left as before, the carborundum being used only in the upper part of the furnace where the lining never came in contact with the steel, since a crack in the alundum lining might have allowed the charge to come in contact with the carborundum. For fear that the Refrax brick might spall and allow carborundum to drop into the melt, a coating of alundum was maintained over the carborundum bricks, but this had to be patched often to maintain it at required efficiency.

When carborundum was used in the roof, all heats were made on the hearth proper. When magnesite or zirkite was used, less patching was required if the furnace was turned over between heats, making the roof for one heat the hearth for the next.

The Refrax (pure carborundum) brick were absolutely unharmed after some 40 heats when they were replaced by Carbofrax (clay-bonded carborundum) brick which had lower heat conductivity. These were put directly against the corundite backing, allowing the roof to be brought a little farther from the arc. After about 40 heats, the Carbofrax bricks appear unaffected, as far as can be seen without taking them out of the furnace, which is still in service. When the Carbofrax bricks were put in the roof and upper side walls, an attempt was made to coat them with a layer of pure electrically sintered, finely ground magnesite, bonded with a little dextrin. The magnesia lining, baked down to a solid mass of about the texture of an ordinary brick, showed only a slight tendency to crack. It did crack a little, yet that little was sufficient to make the lining come off, because it did not adhere to the Carbofrax brick back of it. It seems possible that a very thin layer of ordinary fire clay over the Carbofrax, followed by the magnesia layer, might fuse and stick the magnesia layer to the Carbofrax layer without reducing the refractoriness of the magnesia layer. The magnesia was sufficiently coherent, but failed to adhere to the Carbofrax.

The alundum coating was therefore used over the Carbofrax to prevent possible contamination of the charge by spalling of the brick or spatter of the steel against it.

From the behavior of the bare Carbofrax door, which is still in good condition after 200 heats, notwithstanding some rough treatment, the alundum layer over the roof may be a needless precaution. It was used because little more time was needed to patch the roof as well as the hearth when patching was required.

SATISFACTORY FURNACE LINING.

The most satisfactory lining for such a furnace would appear to be as follows: Outside layer, Sil-o-cel or some similar reliable low-temperature insulator; second layer, high-grade fire brick, preferably one high in alumina, such as corundite; third layer, magnesite brick in the lower or hearth half, bare Carbofrax in the upper or roof half; and, as the inner layer in the hearth, electrically sintered, dextrin-bonded magnesia, if slags are to be taken off. If, as in the present tests, no refining is to be done, the hearth can be lined with alundum, which, although less refractory than the magnesia, softening a good deal at operating temperatures and requiring continual repair, is nevertheless not so likely to crack and let the steel work down into the hearth. If the furnace is to be used on steels of similar composition, so that metal retained in the hearth from one heat does not introduce contaminating elements into the next heat, a magnesia hearth would be preferable, but when, as in this work, successive heats of different composition have to be made, alundum appears, on the whole, to be better. This alundum lining, 1 to 2 inches thick, was rammed over the whole inner surface in layers when a fresh lining was put in, each layer being dried thoroughly with a gas flame, then moistened with a thin wash of alundum before a fresh layer is placed and dried. The corners were filled up with alundum and care taken to shape the hearth and pouring spout so that metal would drain completely. The furnace chamber proper then had an approximately spherical form of about 14 inches diameter.

When larger charges were required for later work the magnesite-brick backing to the hearth was made a little thinner, and by scraping out all slag immediately after pouring, and by filling up the hearth to its normal position only when patching, it was found possible to handle 100-pound charges without trouble if the charge was compact. "Armco" iron cut into 2 by 4 inch pieces from one-half-inch plate formed a sufficiently compact charge to be piled in the furnace without touching the electrodes.

At first the electrodes were mounted with their centers 2 inches below the center line of the furnace, bringing the 2-inch electrode 5 inches from the hearth and 7 inches from the roof to protect the roof somewhat and to bring the arc nearer the charge. This arrangement was satisfactory when very heavy scrap, such as crop ends of ingots, formed a large part of the charge, but made it hard to pile the charge in without touching the electrodes when light material only was used. This arrangement was retained during the manufacture of most of the steels which were cropped and forged at Ithaca for the arsenal and the crop ends utilized. When the steels for the Navy that were shipped without cropping were made, these larger heats being made up from new metal, it was necessary to locate the electrodes centrally to avoid piling the charge so near the electrodes that there was danger of pieces falling against them as the charge melted down, with a consequent pick-up of carbon due to this contact.

It was hoped that the furnace might be rocked when in operation, thus washing the refractories with the metal and thus increasing their life; however, the furnace was so heavy when lined up that without going to the expense of installing a motor-driven rocking mechanism, or at least providing ball-bearing rollers, it could not be rocked by hand without too great exertion, although it could be tilted by hand for pouring. Had it been expected that the furnace would be stationary when operated it would have been designed with a larger diameter to bring the arc farther away from the roof.

REPAIRING FURNACE.

So small a furnace, with the refractories so close to the arc, used at extremely high temperatures, as it had to be, was known to require constant patching. The temperatures often used were decidedly higher than those of a large commercial steel furnace. First, it was necessary to get a small charge hot enough to pour from a ladle, which, though preheated, was nevertheless at a much lower temperature than the metal and chilled it a good deal. Second, when steels are made with such ferro-alloys as ferrouranium and ferrozirconium, where the recovery of alloying element is too low unless the ferro is added to superheated metal at the end of the heat, the steel must be very hot, especially when steels high in the alloying element are to be made up. Since there is grave danger of oxidation when these alloys are preheated, they were normally added cold and in attempting to make steels high in U or Zr under these conditions as much as 5 or 6 pounds of ferro was sometimes used in a total charge of 40 to 50 pounds.

When used in the production of plain carbon steels, or of such alloy steels as nickel, tungsten, chromium, or molybdenum, when the alloying element or the ferro-alloy can be added with the rest of the charge at the beginning of the heat without loss, the furnace, even as built, required only a very reasonable amount of patching to the alundum coating,[11] such as any laboratory furnace might be expected to require. Hansen states that he used alundum as a lining for a steel furnace (probably a direct-arc furnace, using a slag) with "disastrous results." It should therefore be emphasized that alundum is suitable only when simple melting, without refining, is to be done. Under the service conditions, extremely hot metal being required on perhaps half of the heats to take large alloy additions into solution, and the lining being chiseled free from adhering metal from the previous heat whenever a change of composition was made in the steels being produced, the refractory brick lining, whether zirkite or magnesite, had to be replaced about every 100 heats.

Inasmuch as continuous operation was not required, it was seldom that more than two heats were made without allowing the furnace to cool and making such repairs to the lining as were needed to keep the lining from serious injury. In the early part of the work it was especially necessary to know the analysis of each heat or each short series of heats in order to be able to calculate the next charges from the results of earlier ones as to losses of the various elements. More heats could be made with the furnace in a given time, even on intermittent operation, than the analytical staff could handle in the period.

Since intermittent operation only was contemplated, no heat-insulating brick such as infusorial earth brick were used. The hand could, nevertheless, be held on the shell at the end of a second heat; so although the furnace would not serve in the dimensions given for continuous operation it was fairly satisfactory, if continuous patching was done, for the conditions that had to be met.

USES OF ALUNDUM CEMENT.

The charging door of the furnace was closed by a 9 by 10 inch plug-type door, made up of carborundum brick cemented together by and coated with alundum cement, and held in an iron frame and by a large clamp serving as a handle. The door was set in place and a bar thrust through two wire loops, one on each side of the door. The loops were held by eyebolts passing through the shell, and the door was tightened by putting an iron plate on the back of it to protect the bricks and then driving an iron wedge between this plate and the bar. The door was then luted in place with alundum

[11] Hansen, C. A., Discussion: Trans. Am. Electrochem. Soc., vol. 17, 1910, p. 134.

cement in order that, after the furnace had become heated up sufficiently to hold the arc without breaking, a little thin alundum wash brushed over any cracks that developed in the luting and over the edges of the electrode holes (if any light from the arc showed between electrode and hole) served to keep the furnace tight, without any flame coming from any part of the furnace.

The door only entered the charging opening for about half its thickness, its inner face being thus about a foot from the arc. There was some heat loss from a door made of so good a conductor of heat as carborundum and the door became red hot at the end of a heat, but its brightness served as a fairly accurate indication of the temperature of the furnace.

The door was removed and set aside while pouring, and was thus subject to violent changes in temperature as well as to being accidentally dropped. The durability of the doors was nevertheless remarkable, one giving over 100 heats and then failing only because it had been dropped too often, and another being still good after about 275 heats. The efficiency of carborundum for this purpose, as well as its showing in the direct-arc furnace, make it seem well worth a trial in the roof of a commercial steel furnace.

Alundum cement was indispensable as a material for the inner lining. Various magnesite-alundum and zirkite-alundum mixtures were tried for lining and patching, but nothing adhered so well as the plain alundum, nor did additions appear to improve the refractoriness. If care was taken to paint the places to be patched with a thin wash before ramming in thick cement after steel shot and badly slagged lining were cleaned out, quite large patches could be successfully made; especially could this be done if the furnace was so warm from the previous run that a person's hand could barely be kept inside it, and provided that, in preheating the furnace to operating temperature before charging, any large patch was baked in, with the furnace so placed that the patched spot was on the bottom.

The cylindrical form of the furnace makes this easy, for if there is a bad place in the roof to be patched that spot can be put at the bottom and the patch held in place by gravity until it is thoroughly baked, whereas if the same place had to be patched in the roof of a furnace not capable of being rolled completely over, the patch could not be made to stick.

Alundum cement was used for painting the molds before they were smoked. In early runs of the direct-arc furnace some of the molds were quite deeply eroded by the stream of metal striking the side. By filling up these rough spots with alundum cement and baking it in, the molds were kept in service. The crucible used as a pouring ladle was lined with a quarter-inch layer of alundum cement to prevent the steel from taking up carbon from the ladle, to allow a better retention of heat by the ladle than would have been possible with the bare crucible, and to form a layer that could be chipped out to free a skull that could not have been removed without breaking the crucible if there had not been such a lining. The alundum-lined ladle was preheated by directing inside of it a large gas flame or one from a Hauck kerosene burner. This preheat usually was started simultaneously with the steel furnace. At the time of pouring, the ladle was ordinarily at about 800° C. An iron ladle lined with alundum would perhaps have been better than the crucible.

Alundum cement was used for luting the door in place. Fire clay was sufficiently refractory for this, but if in removing the door some of the luting fell in, it melted at once to an inconveniently thin slag, one from which silicon could be reduced into the metal.

When the stock of alundum ran low, attempts were made to substitute ordinary dead burned magnesite bonded with water-glass, but with very poor results. Plenty of alundum was almost as essential to the making of these experimental heats of steel as the charge itself; nevertheless, after the alundum lining had been in use some time and small globules of steel held in rough spots had become so oxidized between heats that some iron oxide was present, the lining would soften somewhat, and when the highest temperatures were being used to add large amounts of refractory ferro-alloys to very hot steel at the end of the heat, some of the lining would actually fuse and form a thickly fluid slag on the steel.

Had the furnace been used as a refining furnace, with refining slags, the lining would probably have given much more trouble.

RECOMMENDED CHANGES IN FURNACE DESIGN.

Although the furnace as built operated satisfactorily, it became evident that slight changes in the design would give at once somewhat increased capacity and better refractory life. These changes principally involve increasing the shell diameter to 32½ inches and the shell length to 32 inches. With the same number of lining courses this would allow the hearth to be increased 3 inches in diameter and 2 inches in length. This would bring the arc farther from the walls and undoubtedly tend toward better refractory performance. The power required by this altered design would not differ greatly from that actually used.

If continuous operation of the furnace was desired, it would be better to increase still further the shell dimensions in order to provide for a single outer course of heat insulating brick, such as

Sil-o-cel or Armstrong Cork. This provision would cut down the radiation heat losses which would be met and tend to lower the power demands of the furnace on continuous operation.

OPERATION OF INDIRECT-ARC FURNACE.

The procedure on a typical heat in the indirect-arc furnace was as follows: After the furnace was thoroughly cleaned out from the previous run, it was patched and dried, any large patch being in the lowest part of the furnace ready for preheating. The charge was then weighed out and both the ladle and the hot-top or "dozzler" preheated. The coated. dried, and smoked mold was prepared for use and placed where the waste heat from the ladle heater would heat it sufficiently to dry out any moisture. Tools, such as skimmers and stirrers, made from Armco iron so that if they melted in there would be no contamination, were cleaned and made ready, the furnace was luted up, and the arc started.

This furnace took a current of 500 to 750 amperes at 60 to 90 volts under load. had a power factor of about 90. and was run at 40 to 50 kilowatts, the rate of power input depending on the size of the charge.

Upon starting with a cold furnace the arc is unsteady, breaking from time to time for about 20 minutes. If the electrodes are not rounded off on the tips with reasonable smoothness, or if the electrodes do not enter the furnace on exactly the same center line, the period of unsteadiness may be 10 minutes longer. Any leak in the furnace at door or electrode holes will also accentuate the unsteadiness while it lasts. During this period the power input ranges from zero for the instant between the breaking of the arc to its restarting by the operator, to about 65 kilowatts the instant the arc is made. the average power input for the unsteady period being 30 to 35 kilowatts. After the furnace has reached a certain critical temperature the arc holds steadily, its length can be adjusted, and the power input thereby controlled.

CHARGING FURNACE.

After heating for about an hour, using 40 to 45 kilowatt hours. the originally cold furnace is approximately up to running temperature when lined up without any carborundum brick and with the hearth of suitable size for a 50-pound charge. With the carborundum lining and the hearth large enough to hold 100 pounds the preheating of the cold furnace takes about one and one-quarter hours. using 60 kilowatt hours. The arc is broken, the door is taken out, the furnace drained and scraped free from any metal left in from the previous heat and from any slag soft enough to flow or to be scraped out, and the charge put in, taking care to pile it so that it does not touch the electrodes and is not likely to do so as it melts. All the iron, washed metal, any alloyed scrap such as ingot crops or "over metal" left after pouring the ingot (this scrap having, of course, been analyzed), the nickel, ferrotungsten, ferromolybdenum, ferrochromium, or other alloy called for which does not suffer loss when charged at the start, together with part of the ferromanganese and ferrosilicon, are charged. Since manganese and silicon might both be volatilized if placed directly under the arc, these are placed at the ends of the furnace, and preferably charged in large lumps rather than in crushed or powdered form.

The door is then replaced and luted in and the arc again started. Ten minutes is the average time from the breaking of the arc on the preheat to starting it again.

The furnace is then run at about 40 to 50 kilowatts, depending on the weight of the charges, until a calculated kilowatt hour's input has been reached. This depends on the kilowatt hours used in the preheat, on the time the door is open in charging, on the rate of power input, that is, whether the furnace is run at 40 or at 50 kilowatts, on the weight of the charge, and on the temperature desired for the steel at the end, which in turn depends on the amount of ferro-alloy to be added at the end and the ease with which it is taken up. For example, on a steel requiring only half a pound of readily absorbed ferro-alloys such as FeV, FeB, FeSi, or FeMn, 40 kilowatt hours on the heat proper after the preheat of the cold furnace will heat 50 pounds enough. On one requiring, say, 3 pounds of FeZr, FeU, or FeTi, 45 or even 47½ kilowatt hours may be used. The higher figures will usually result in the melting down of some and the spalling of some of the lining and the formation of a thickly fluid or crusty slag over the metal.

ADDITION OF FERRO-ALLOYS.

When the scheduled kilowatt hour input has been reached, the heated ladle is set in the shank, the furnace opened, the electrodes taken out to give room to skim the metal, all slag or floating chunks of fallen lining skimmed off, the crushed or powdered ferro-alloys required, or if none are required save FeSi and FeMn, one-fourth to one-half pound of either of these, or a mixture of them according to what the charge calls for, is placed on the clean metal with a shovel, and at once thoroughly stirred in with an Armco iron rod. This portion of FeSi and FeMn is reserved until the end because such an addition appears to aid either in deoxidation or in "swamping" the dissolved gas and to be a desirable step in the production of sound ingots.

On the other hand this precaution may not be necessary, since in heat 1066 (Table 2, p. 28) the FeSi and FeMn reserved for the final addition were left out by mistake and the ingot was sound. If the steel was not hot enough or the amount of added ferro is more than can be taken up without chilling the steel too much, one or two of the small Thermit "Little Devil" cans for heating up dull iron or steel is plunged in on the end of an iron rod, the metal stirred with rod as soon as the reaction is over, the metal again hastily skimmed, the ladle put in place below the spout, and the charge poured.

Thermit cans are used only when the amount of ferro-alloy to be added is so great and so difficultly taken up that to heat the steel sufficiently to take up the ferro-alloy would ruin the lining or at least come dangerously near ruining it. They were required only on some of the heats in which large amounts of ferrouranium or ferrozirconium were used.

DEOXIDIZING AGENT.

Unless the steel contains a very active deoxidizer, such as vanadium, uranium, or cerium, 0.01 to 0.005 per cent aluminum is thrown into the ladle just before the steel is poured. This is of course a larger percentage of aluminum than is used in commercial practice on electric furnace steel poured from large ladles, but amounts of this order of magnitude appear to be generally used as a final addition in crucible steel practice, as well as when pouring electric furnace steel from small hand ladles in foundries making electric steel castings. Moore[12] gives, however, a typical electric furnace charge as 0.025 per cent aluminum. The arsenal allowed 0.05 per cent Al in their specifications, and since this was the case no extended investigations were made to see if the use of Al could be avoided.

Since the stream of metal comes into contact with the air twice, once in pouring from furnace to ladle and once from ladle to mold, and the surface of the small stream necessary in handling a 50 or 100 pound charge is greater in proportion to the weight of metal than is the case of large heats, the use of Al was considered desirable, and was the regular practice unless other strong deoxidizers were present or unless aluminum was carried in by ferro-alloys made by reduction with aluminum. If it had been possible to heat the ladle hotter and then allow more time for degasification in the ladle before pouring into the mold, the use of aluminum could probably have been avoided.

POURING METAL.

The ladle was normally allowed to stand until the metal was absolutely quiet and until it had cooled to the point where it would either

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[12] Moore, W. E., Electric furnaces for steel foundries: Elect. Jour., vol. 16, 1919, p. 365.

pour clean or leave only a thin skull in the ladle. The best pouring temperature seemed to be about 1,600° C., determined by an optical pyrometer. The 1,600° C. figure is corrected[18] for deviation from black body temperature, the observed temperature being 1,470° C. Of course in some tests the addition of large amounts of ferro-alloy chilled the metal so that it had to be poured at once into the mold and even then might leave a rather heavy skull, but usually it was possible to hold the metal in the ladle from one to two minutes before it was poured into the mold.

In pouring, care was taken to skim back any slag, oxide skin, or other floating impurities, to pour steadily, and to keep the stream from hitting the sides of the mold. When the mold had filled within about an inch of the top, pouring was interrupted, the hot-top brick inserted and held from floating up, and pouring again started slowly until the metal had frozen about the inserted part of the hot-top brick and then the hot-top filled to the top. The hot-tops were 6½ inches tall, with a 2 inch diameter hole. The ingot molds finally used were of the usual split form, the ingot being about 22 inches long, 2½ by 2½ inches near the butt (rounding off below this) and 3 by 3 inches at the top. In the second series of zirconium steels, 6 by 3 inch molds were used, with the usual hot-tops for that size. Unless the hot-top was heated hotter than could be done with the apparatus at hand, however, it was not sufficient, as the ingots piped below the hot-top. The cropped ingots gave more metal below the pipe when no hot-top was used on this size, than when one was used that was too cool.

The 3 by 3 inch mold plus the extension made by the hot-top held about 44 to 47 pounds of steel, hence the regular charge was made up to a total of 46½ to 50 pounds when one of these molds was used.

All the steels made piped very deeply when no hot-top was used, but by using one and cropping the 3 by 3 inch ingot about 1 inch below the bottom of the hot-top, the pipe was all removed and sound metal reached. After cropping about 38 to 40 pounds of sound metal was left. In many cases the bottom of the ingot was drilled for analysis for the study of possible segregation between the bottom and the top, the other sample being taken by drilling just below the pipe. In these cases the balance of the ingot, ready for forging or rolling, was reduced to 35 to 37 pounds.

After the hot-top had been filled the top was kept open by poking it with an iron rod to prevent bridging over with frozen metal and to allow the escape of any gas released while freezing. Just as soon as the metal had set the ingot was taken from the mold, the piped por-

[18] Burgess, G. K., Temperature measurements in Bessemer and open hearth practice: Bureau of Standards, Tech. Paper 91, 1917, pp. 9, 16.

tion that was inside the hot-top was knocked off and the ingot at once buried in fine lime, for slow cooling, in order to soften it for drilling the sample and for cropping. It usually took 36 hours for the ingot to cool enough to be handled.

While the ingot was being poured the furnace operator poked out the electrode holes, scraped the furnace free from all plastic slag, and drained it from any steel that had remained in pockets in the lining, charged the next heat, replaced the electrodes, having jarred them to shake off any loosely adhering graphite powder that may be on them, replaced and luted the door, and started the second heat.

When the furnace is hot from the first run, of course no preheating is required. The arc may fluctuate a trifle for, say, five minutes, but seldom breaks, and has soon settled down so as to require no attention.

RUNNING ADDITIONAL HEATS.

The power input required on the second heat is reduced from the 40 to 47½ kilowatt hours required on the run proper of the first heat to from 30 to 38 kilowatt hours on a 50-pound charge, and, were it wise to continue taking off heats without patching the lining, the power required would continue to fall, as the furnace does not appear to have reached a thermal equilibrium through its walls even at the end of the second heat.

In calculating a charge, one must allow for losses of C, Si, and Mn, as well as of the still more readily oxidizable elements such as U and Zr. The loss of Si is a fairly constant factor and no very great difficulty is found in coming reasonably close to the desired Si content. If the charge comes in contact with fire clay or fire brick, it may reduce Si therefrom, with a loss of C or Mn, and the Si in the steel may rise even above the amount charged. Barring such a case, which may occur if the lining becomes very badly damaged in the course of a heat so that the steel gets back to the fire-brick layer of the lining, the Si in the steel is lower than that charged. Mn always shows a loss, and a rather variable one, but it can usually be predicted with a fair degree of accuracy.

CONTROL OF CARBON.

Carbon is still the hardest variable to control, the greatest danger being with a bulky charge, which may have to be piled higher than the electrodes in some places and as the charge melts it may fall down and part of it rest against an electrode, thus absorbing carbon. Another source of carbon acquisition is the powdering or flaking off of the electrodes, which may occur to a variable extent, thus dropping a variable amount of graphite into the bath.

It is fairly easy to bring out duplicate heats, of which, say, 80 per cent will be within a range of 10 points of carbon. If the charge is made up to calculate 0.50 per cent C, the steels will run mostly between 0.35 and 0.45 per cent C. Backert[14] gives 0.30 to 0.40 as the range that must be allowed in crucible steel when 0.35 is desired. If it is calculated for 0.30, they will run mostly between 0.25 and 0.30 per cent, while if calculated for 0.15 or below, what few steels have been made with this low carbon content persist in coming 0.15 to 0.20 per cent. This shows the effect of the graphite that drops off the electrodes, the adventitious carbon from this source more than making up for that lost by oxidation in the latter case, almost balancing it in the case of steels calculated for 0.30 per cent C but being overbalanced by the oxidation loss on those calculated for 0.50 per cent C.

When the furnace is enlarged to a capacity of 100 pounds, the adventitious graphite from the electrodes plays a less important rôle and the carbon content of the product can be more closely predicted.

Although the lack of complete certainty of carbon control is a disadvantage, it is perhaps no worse in the experimental electric furnace than in crucible practice. Figures from the Watertown Arsenal show that in making up some experimental steels in their crucible-steel foundry in about 100-pound heats, the following figures for carbon were obtained:

Per cent of carbon aimed for and obtained in 17 heats in crucible furnaces.

Per cent of C aimed for.	Per cent of C obtained.	Per cent of C aimed for.	Per cent of C obtained.
0.40	0.46	0.30	0.20
.40	.49	.30	.20
.40	.29	.30	.36
.30	.38	.30	.42
.50	.55	.30	.45
.40	.44	.30	.35
.40	.43	.30	.32
.40	.38	.40	.48
.30	.26		

This shows a range of —11 to +15 points from that aimed at.

In one series in particular, in which the specifications were C, 0.40 to 0.50 per cent; Si, 0.15 to 0.35 per cent; Mn, 0.35 to 0.80 per cent; and W, 1 to 15 per cent in 1 per cent steps, the results obtained in the indirect-arc furnace are shown in Table 2.

[14] Backert, A. O., A. B. C. of iron and steel, 1915, p. 117.

TABLE 2.—*Results of series of heats in indirect-arc furnace.*

Number of heats.	Per cent calculated.				Per cent obtained.				Per cent of change.			
	C.	Si.	Mn.	W.	C.	Si.	Mn.	W.	C.	Si.	Mn.	W.
1058	0.55	0.38	0.07	1.8	0.49	0.26	0.54	1.70	−0.06	−0.12	−0.33	−0.10
1059	.57	.40	.90	2.5	.49	.32	.59	2.20	− .08	− .08	− .31	+ .30
1060	.54	.38	.87	1.2	.48	.20	.60	1.15	− .06	− .18	− .27	− .05
1061	.54	.37	.87	3.1	.41	.24	.61	3.05	− .13	− .13	− .26	− .25
1062	.54	.37	.87	4.2	.41	.28	.51	3.95	− .13	− .05	− .36	− .25
1063	.54	.37	.87	5.3	.42	.27	.58	4.70	− .12	− .10	− .29	− .60
1064	.54	.39	.88	6.15	.49	.21	.62	6.25	− .05	− .18	− .28	+ .10
1065	.56	.39	.88	7.15	.47	.20	.68	7.35	− .09	− .19	− .20	+ .20
1066	.54	.26	.57	8.2	.42	.13	.40	8.45	− .12	− .13	− .17	+ .25
1067	.54	.38	.83	9.25	.45	.19	.63	9.70	− .09	− .19	− .20	+ .45
1068	.54	.38	.84	8.15	.42	.23	.64	8.50	− .12	− .15	− .20	+ .35
1069	.54	.37	.84	10.0	.42	.20	.62	10.00	− .12	− .17	− .20	± .00
1070	.54	.35	.76	11.1	.38	.33	.50	11.00	− .16	− .02	− .26	− .10
1071	.54	.38	.84	12.0	.40	.29	.53	11.80	− .14	− .11	− .31	− .20
1072	.54	.39	.84	13.1	.37	.27	.63	12.80	− .17	− .12	− .21	− .30
1073	.54	.40	.85	14.1	.46	.30	.65	13.80	− .08	− .10	− .20	− .30
1074	.54	.38	.84	15.1	.42	.24	.73	15.20	− .12	− .14	− .11	+ .10
1075	.54	.39	.84	7.05	.42	.25	.74	7.15	− .12	− .14	− .10	+ .10
Average									− .10	− .13	− .23	± .0

At the beginning of the series, 0.05 per cent Al was used in the ladle and cut to 0.03 per cent by the middle of it. On later runs it was cut to 0.01 to 0.005 per cent. The Armco iron used contained 0.02 per cent S, and 0.004 per cent P, the washed metal below 0.02 per cent each of S and P, while the FeW contained 85 per cent W, 0.9 per cent Si, 0.13 per cent C, 0.05 per cent P, 0.01 per cent S. The FeSi was ordinary 50 per cent Si ferro, and the FeMn ordinary 80 per cent Mn ferro with 6 per cent C and about 0.25 per cent P. Small amounts of skeleton scrap steel from the punch presses of a local airplane factory containing 0.1 per cent C, 0.45 per cent Mn, and below 0.04 per cent each of S and P were also used, and crop ends of ingots were remelted in most of the heats. Since the S could not run over 0.03 or the P over 0.02 in the finished steels, no analysis was made for these elements. Analysis for W was made only for routine control, no correction being made for iron oxide carried down with the WO_3, nor were special precautions taken for the precipitation of the last traces of W. The average results indicate that the tungsten, which was charged at the start of the heat, was quantitatively recovered. According to Tyler [15], in British crucible tool-steel melting, 20 per cent tungsten powder has to be added to give 18 per cent W in the steel. The powder is stated to contain 98 to 98 per cent W.

In one series of high-silicon steels (2 per cent Si or more), with 65 to 70 pound heats with and without zirconium, the charge being calculated to 0.52 per cent C and 0.36 to 0.43 per cent C being aimed at, 26 out of 34 steels were in that range, 1 was 0.35 per cent, and 7 from 0.46 to 0.5 per cent C.

In another series of 34 plain, molybdenum, vanadium, and cerium steels, in which steels of 0.38 to 0.41 per cent C were desired, 17 were

[15] Tyler, P. M., High-speed steel manufacture in Sheffield: Iron Age, vol. 107, 1921, p. 370.

obtained in that range, 5 from 0.35 to 0.37 per cent C and 6 from 0.42 to 0.44 per cent C and one each of 0.45, 0.46, 0.47, 0.50, 0.53, and 0.54 per cent C. The charges weighed 75 to 95 pounds and were calculated for 0.46 per cent C. The percentage loss of carbon is slightly lower as the size of the heat is increased.

Although less uniform results than the above were obtained in some melts, these series were the only long ones made in which the operator was not continually faced with new variables in having to add different ferro-alloys of unknown behavior, and this series probably shows the capabilities of the furnace fairly. It would appear that the indirect-arc electric furnace is at least as likely to give the carbon composition desired on an experimental heat as is the crucible furnace.

SILICON AND MANGANESE STEELS.

Table 2 shows the loss of Si and Mn on steels of fairly normal Si and Mn content for castings and forgings. The losses when steels of higher Si and Mn content are aimed at are shown below, the figures being taken at random from a larger number.

Loss of silicon and manganese on steels of high Si and Mn content.

No. of heat.	Per cent calculated.		Per cent found.		Difference between per cent calculated and found.	
	Si.	Mn.	Si.	Mn.	Si.	Mn.
1102	1.41	0.80	1.15	0.65	0.26	0.15
1104	.72	.82	.66	.58	.06	.24
1113	1.42	.89	1.17	.76	.25	.13
1114	.71	.89	.52	.65	.19	.14
1120	1.35	1.23	1.00	.97	.35	.26
1128	1.49	.95	1.08	.87	.41	.08
1135	1.50	.90	1.44	.83	.06	.07
1136	2.20	.90	1.78	.83	.32	.07
1147	1.55	.91	1.04	.81	.41	.10
1163	1.55	.90	1.38	.81	.17	.09
1164	1.55	.90	1.48	.80	.07	.10
1165	1.55	.90	1.48	.76	.07	.14
1166	1.55	.90	1.33	.80	.22	.10
1167	1.55	.90	1.26	.75	.29	.15
1168	1.55	.90	1.36	.77	.19	.13
1169	1.55	.90	1.33	.82	.22	.08
1170	1.55	.90	1.27	.79	.28	.11
1171	1.55	.90	1.34	.78	.21	.12
1172	1.55	.90	1.32	.76	.23	.14
1173	1.55	.90	1.36	.79	.19	.11
1198	1.43	.92	1.08	.71	.35	.21
1199	1.44	.92	1.12	.75	.32	.17
1200	1.45	.93	1.18	.74	.27	.19
1201	1.45	.93	1.26	.84	.19	.09
1206	1.40	.95	1.25	.80	.15	.15
1207	1.40	.95	1.30	.80	.10	.15
1208	1.40	1.30	1.25	1.00	.15	.30
1209	1.40	1.30	1.20	1.15	.20	.15
1214	1.82	.95	1.40	.80	.42	.15
1226	1.91	1.00	1.60	.90	.31	.10
1227	1.91	1.00	1.45	.85	.46	.15
1236	1.50	1.50	1.45	1.10	.05	.35
1237	2.31	1.01	2.18	.94	.13	.07
1238	1.40	2.18	1.25	2.00	.15	.18
1251	1.66	1.89	1.25	1.46	.31	.43
1300	2.50	.87	2.31	.83	.19	.04
1303	2.50	.87	2.33	.81	.17	.06
1325	2.50	.87	2.47	.70	.03	.17
Average					.20	.15

The greatest deviations from the average loss are: Si, + 0.15 and —0.27 per cent; Mn, + 0.07 and —0.28 per cent.

About 75 per cent of these steels come within limits of 0.10 per cent Si either side of the average loss of Si, and about 90 per cent of them come within limits of 0.10 per cent Mn either side of the average loss of Mn.

In the steels listed above, all the Si and Mn were added at the start save about 100 grams each of FeSi and FeMn added at the end to help "swamp" occluded gases. Slightly different results are obtained when most of the Si for a high Si steel is added at the end of the heat as SiZr alloy. Only the difference between the total to be added and that carried by the SiZr is put in at the start, all the Mn save about 50 grams of FeMn, which is added at the end to help control gases, being charged at the start. Under these conditions, the bulk of the work of deoxidation during the melting of the steel falls on the Mn, the loss of Si being less and that of Mn greater, as the following figures show:

Per cent of silicon and manganese calculated and found in 18 heats.

No. of heat.	Per cent calculated.		Per cent found.		Difference between per cent calculated and found.	
	Si.	Mn.	Si.	Mn.	Si.	Mn.
1180	1.60	0.95	1.55	0.63	0.05	0.32
1182	1.60	.95	1.55	.76	.05	.19
1184	1.50	.90	1.20	.61	.20	.29
1185	1.50	.90	1.37	.71	.13	.19
1186	1.50	.90	1.37	.74	.13	.16
1187	1.50	.90	1.40	.67	.10	.23
1188	1.50	.90	1.38	.74	.12	.16
1189	1.50	.90	1.50	.73	.00	.17
1191	1.45	.90	1.40	.77	.05	.13
1192	1.46	.90	1.45	.76	.01	.14
1193	1.46	.90	1.45	.67	.01	.23
1194	1.45	.90	1.42	.65	.03	.25
1195	1.45	.90	1.52	.65	+ .07	.25
1196	1.46	.90	1.50	.65	+ .04	.25
1197	1.46	.90	1.50	.60	+ .04	.30
1212	.90	.95	.80	.70	.10	.25
1213	.90	.95	.80	.65	.10	.30
1289	1.65	1.13	1.57	.83	.08	.30
Average					.06	.23

No difference was found in the action of ordinary 80 per cent Mn, 6 per cent C ferromanganese and 50 per cent ferrosilicon as against siliconmanganese alloys of 75 per cent Mn, 6 per cent Si, 4.3 per cent C; 73 per cent Mn, 10 per cent Si, and 3 per cent C; or 72.5 per cent Mn, 16.5 per cent Si, and 1.5 per cent C made in another investigation.[16]

[16] Gillett, H. W., and Williams, C. E., Electric smelting of domestic manganese ores: Bull. 173, Bureau of Mines, 1920, chap. 10, pp. 151–186.

MOLYBDENUM STEELS.

With ferromolybdenum of 50 per cent Mo, 2.2 per cent C, 1.2 per cent Si, 0.12 per cent Mn, 0.57 per cent S, 0.18 per cent P, or 42.4 per cent Mo, 0.08 per cent C, 7.2 per cent Si, 0.2 per cent S, added at the start of the heat, the recovery of Mo was practically quantitative, as is shown below:

Per cent of molybdenum calculated and found.

No. of heat.	Per cent of Mo calculated.	Per cent of Mo found.	No. of heat.	Per cent of Mo calculated.	Per cent of Mo found.
1097	3.02	3.00	1358	.75	.75
1092	2.25	2.05	1360	.75	.73
1089	2.21	1.90	1366	.75	.75
1096	2.09	1.90	1369	.75	.76
1088	1.23	1.15	1337	.35	.37
1091	1.10	1.05	1342	.35	.34
1135	.81	.78	1345	.35	.36
1136	.81	.77	1350	.35	.31
1336 [a]	.75	.67	1355	.35	.35
1341	.75	.73	1361	.35	.35
1344	.75	.68	1367	.35	.34
1340	.75	.83	1371	.35	.37

[a] Mo analyses on Nos. 1336 to 1371 by Vanadium Corporation of America.

CHROMIUM STEELS.

Using low-carbon ferrochrome of about 65 per cent Cr, and 0.40 per cent C, added at the start, the following recoveries were obtained:

Recoveries of chromium calculated and found.

No. of heat.	Per cent of Cr calculated.	Per cent of Cr found.	No. of heat.	Per cent of Cr calculated.	Per cent of Cr found.
1124	1.02	0.96	1355	.92	.88
1125	2.03	1.99	1356	.92	.84
1126	3.5	3.61	1357	.92	.95
1127	3	2.77	1358	.92	.86
1177	2	1.95	1364	.92	.83
1178	2	1.98	1366	.92	.78
1343 [a]	1	.94	1367	.92	.83
1344	1	.95	1368	.92	.82
1345	1	.89	1369	.92	.79
1346	1	.93	1370	.92	.92
1347	1	.98	1348	.75	.65
1359	1	.92	1349	.75	.67
1360	1	.93	1350	.75	.68
1361	1	.84	1351	.75	.74
1362	1	.97	1365	.75	.77
1353	.92	.83	1374	.75	.84

[a] Cr analyses on Nos. 1348 to 1374 by Vanadium Corporation of America.

VANADIUM STEELS.

Using ferrovanadium of 36 per cent V, 0.26 per cent C, 2.3 per cent Si, 0.13 per cent P, 0.15 per cent Mn, 0.13 per cent Cu, S trace, the following results were obtained:

Recoveries of vanadium calculated and found.

No. of heat.	Per cent V—		When ferro added.	Size of ferro.
	Calculated.	Found.		
1121	1.03	0.98	At start	Hickory nut.
1122	5.38	3.00	Near end [a]	Do.
1123	2.22	1.95	do. [a]	Do.
1173	.26	.29	At end	Pea and smaller.
1207	.31	.32	do	Do.
1273	.35	.33	do	Do.
1346 [b]	.25	.20	do	Do.
1351	.25	.24	do	Do.
1356	.25	.20	do	Do.
1362	.25	.24	do	Do.
1368	.25	.19	do	Do.

[a] Furnace opened after rest of charge was melted, FeV added, furnace closed and run 5 to 10 kilowatt hours more.
[b] Analyses 1346 to 1368 by Vanadium Corporation of America.

Up to 1 per cent there appeared to be a practically quantitative recovery of V, but on heat 1223 there was a notable loss and on 1222 a great one. In these heats a slag or scum formed continually on the steel as it was held in the ladle for degasification, the scum forming again as fast as it was skimmed off.

NICKEL STEELS.

The recovery of nickel added at the start with the rest of the charge is quantitative, as is shown by the following representative figures.

Per cent of nickel calculated and found.

No. of heat.	Per cent of Ni—				No. of heat.	Per cent of Ni—			
	Calculated.	Found.				Calculated.	Found.		
		Top.	Butt.	Average.			Top.	Butt.	Average.
1299	3	2.96	2.96	2.96	1308	3	2.96	2.98	2.97
1300	3	2.94	2.96	2.95	1309	3	2.96	2.92	2.94
1302	3	3.01	3.04	3.02	1310	3	2.96	2.90	2.93
1303	3	3.02	3.00	3.01	1322	3	3.03	2.97	3.00
1304	3	2.91	2.95	2.92	1323	3	2.97	2.90	2.94
1305	3	3.03	3.05	3.04	1324	3	2.95	2.97	2.96
1306	3	3.00	3.00	3.00	1325	3	3.02	2.97	3.00
1307	3	2.98	2.98	2.98					

COPPER-NICKEL STEELS.[18]

Copper added at the start with the rest of the charge, in steels carrying nickel also, and from 0.8 to 1 per cent Mn gave the following:

Per cent of copper and nickel charged and found in copper-nickel steels.

No. of heat.	Charged.		Found by analysis.			
	Ni, per cent.	Cu, per cent.	Ni, per cent.	Per cent Cu.		
				Top.	Butt.	Average.
1279	2.43	0.6	2.46	0.63	0.60	0.61
1280	2.43	.6	2.45	.58	.53	.55
1283	2.60	.4	2.60	.35	.37	.36
1284	2.60	.6	2.58	.56	.54	.55
1285	2.43	.6	2.53	.61	.63	.62
1286	2.43	.6	2.56	.65	.63	.64

ALUMINUM STEELS.

The recovery of aluminum was fairly high, as is shown by the following:

Recovery of aluminum.

No. of heat.	Per cent Al—		
	Charged.	Found.	Lost.
1090	5.25	4.90	0.35
1147	.38	.30	.08
1206	.43	.23	.20
1270	.60	.45	.15
1329	.40	.20	.20

In these runs, the aluminum was added at the end of the heat, being placed on the metal in the furnace just before pouring, and thoroughly stirred in. In heat 1090 and several others in which 5 per cent and 2 per cent Al were added, but on which no analysis was made, as the exact percentage of aluminum was not important, an oxide skin continually formed in the ladle, and in pouring a skin tended to form about the stream of metal. The metal seemed to hold some oxide on the heats highest in aluminum, and acted slushy in pouring, even though it was fully as hot as usual.

URANIUM STEELS.

The data on the production of uranium steels in the indirect-arc furnace are shown in Table 3.

[18] Compare Clamer, G. H., Cupronickel steel: Metal Ind., vol. 8, 1910, p. 303.
Escard, J., Les ferro-alliages complexes: Jour. du four Électrique, vol. 29, 1920, p. 36.
Metal Industry (London), Copper in steel, vol. 16, 1920, p. 435.

TABLE 3.—*Production of uranium*

No. of heat.	Total weight of charge.	FeU added, analysis.					Total kw.h. used.[a]	1st or 2d heat.	FeU added at—		Size FeU.	Per cent of U.		
		Lbs.	No. of sample.	U.	C.	Si.			Kw. h.	Start or end.		Calculated.	Analysis. Top.	Analysis. Butt.
	Lbs.			*P. ct.*	*P. ct.*	*P. ct.*								
1049	43	2 1	[b]78 97	46 43	2.1 2.15	1.8 .7	40	1st..	40	End	Pea and smaller.	3.2	0.75	......
1051	39	2.5	78	46	2.1	1.8	45	1st..	45	End	Hickory nut and smaller.[c]	3+ .2	1.09	......
1052	38.5	2.5 1	95 74	58.5 60	3.65 2.4	1.2 2.4	[c]45	2d...	45	End	.....do.......	[c]5.4+ .1	.18	......
1053	39.5	2 2	47 74	.....	......	.....	41	1st..	41	End	Pea...........	5.85	[c]2.5	......
1054	39.5	3.8 .8	85 72B	64 61	3.25 1.7	.4 .3	[c]39	2d...	39	End	.....do........	7.45	[c]3.65	......
1056	39.3	6	75	51.5	2.05	.4	45	1st..	45	End	Hickorynut and smaller.	7.78	7.75	......
1076	50	3.75	35	40	4.1	1.8	44	1st..	45	End	Egg and smaller.	3	1.92	......
1077	50	3.9 2	35 40	40 42.5	4.1 4.5	1.8 .3	40	1st..	0	Start	.....do........	4.78	1.66	1.76
1078	50	1.4 2.8 2 1.1 3.5	40 97 71 64 87	42.5 43 36.5 35 65.5	4.5 2.15 .9 3.9 1.5	.3 .7 4.7 1.4 .5	28	2d...	0	Start	Egg to pea and smaller.	10.5	1.5	1.75
1079	49.5	.5 .9 .6 .7 .5 2.4 5.5	33 40 43 50 78 83 88	39.5 42.5 49.5 65 46 56 59	4 4.5 5 5.3 2.1 1.7 1.3	.4 .3 .6 .5 1.8 1.6 .6	42.5	1st..	0	Start	.....do........	12.5	1	1.09
1080	50	1 1.4	86 41	68.5 45	5 4.2	.3 .4	37.5	1st..	0	Start	Butternut and smaller.	4.6	.3	.35
1081	50	4.9	41	45	4.2	.4	41	1st..	0	Start	Hickory nut and smaller.	4.42	1.53	.16
1082	50	3.25 1.6 .2	80 75 74	67 51.5 60	1.1 2.05 2.4	.9 2.5 2.4	47	1st..	41	Near end.	....do........	7.05	.17	.04
1083	50	1.5 1.7 .5	73 57 69	70 33 37.5	1.7 2.7 1.75	3.8 1.4 2	40	1st..	35	Near end.	....do........	4.4	.05	......
1084	46	2 4	61 91	45 66	3.7 1.8	.3 .8	40	1st..	0 40	Start End	Hickory..... Pea..........	[d]2.25 [e]5.75 8	1.89	2.32

[a] Preheat not included.
[b] See Gillett, H. W., and Mack, E. L. Preparation of Ferrouranium, Tech Paper 177, Bureau of Mines, 1917, for preparation of these samples of FeU.
[c] See note.
[d] Start.
[e] End.

steels in indirect-arc furnace.

Remarks.

Metal was too cold to take all FeU into solution. In forging, the first blow smashed the end of the ingot struck. Forging was probably attempted with metal too hot. Balance of ingot forged well at a lower temperature.

0.2 per cent U in charge at start—crop end from heat 1049; 3.0 per cent U in ferrouranium was added at end.

0.1 per cent U in crop end at start, 5.4 per cent in FeU at end. This was a second heat; that is, it was made after heat 1051, not after a preheat of the empty furnace. The metal was very hot. A little slag, such as had been used in the direct-arc furnace (75 gr. CaO, 20 gr. SiO_2, 5 gr. CaF_2) was used on heats 1049, 1051, and 1052, the first in the indirect-arc furnace, in the hope of protecting the steel from oxidation. On heat 1052, the slag was so thin all could not be skimmed off before the FeU was added as it was on the two previous heats. When the FeU was added through the slag and stirred in, the slag foamed up to a large volume, and was finally skimmed off. The metal was so hot that it was left to cool in the ladle about four minutes before it was poured and was, moreover, cooled by thrusting part way in, and then withdrawing a small ingot of "over metal" from the previous heat, which did not melt in, but did chill the metal. No slag formers were added on later heats.

Sample taken from crop gave 2.5 per cent U. Samples from sound metal of both ends of forged bar, after cropping ragged end off bar, gave 3.39 per cent and 3.57 per cent U.

Both ends of the bar shattered in forging so that only about 1 foot of bar (1 inch diameter) was obtained. Samples from the two ends of this bar gave 4.61 per cent U and 0.68 per cent U.

Metal was very hot, but addition of 6 pounds of cold ferro to 33.3 pounds of molten metal chilled it so that not all could be poured from the furnace and a large skull was left in the ladle, though the metal was poured at once. This bar smashed completely when attempt was made to forge it.

Metal was very hot, but large chunks of ferro (which were added to see if the previous additions of finer material had caused loss of U by oxidation of the surface of the ferro while charging) did not dissolve well and the metal was slushy, as though carrying undissolved particles, although it was very hot. The metal acted dead, and the ingot showed a deep pipe, but the ingot surface was full of holes.

Although the analysis shows a high loss of U, there was very little slag on the metal when the furnace was opened. The FeU was put in at the start with the rest of the charge.

FeU was charged at start in this heat also, but some of ferros 87 and 97 were in pieces covered with a coating of uranium oxide, having been spilled when the FeU was poured in preparing the ferros. Some of these pieces went through the steel furnace without melting, about 4 pounds of such material being scraped from the bottom of the steel furnace.

Out of 11 pounds of FeU charged at the start, about 4 pounds (samples 83 and 88) was spilled material covered with an oxide skin. A few chunks of FeU went through the steel furnace unfused. There was a good deal of loose dross on the metal, some pieces of lining having fallen off, and much uranium oxide was found in this dross after it was skimmed and cooled.

All the FeU charged at the start was good clean metal. Twelve and one-half pounds of heat 1056 ingot (calculated to contain 7.75 per cent U on basis of analysis of drillings from top) was also charged. About one-half pound of undissolved FeU was scraped from the bottom of the furnace after it had cooled, together with much black powder, which was mainly uranium oxide. The steel was not slushy.

All the FeU was clean. Metal was very hot, but acted as if it contained undissolved particles. No unfused FeU was found in the furnace after cooling, but a considerable amount of black powder, mostly uranium oxide, was found.

The ferrouranium (good clean metal) was added after the steel was fully molten; then the furnace was closed and heated 15 minutes (using 6 kw. h.) and rocked back and forth to mix the ferro with the steel during this 15 minutes. In addition to the FeU thus added near the end, there was added 23 pounds of crop and skull from heat 1076, calculated as containing 1.92 per cent U. The metal was very hot, poured well, and did not act slushy or pasty. The usual black powder was found in the furnace, but no unfused ferro.

Procedure was similar to that of preceding heat. Clean ferro was added after steel was melted and the furnace heated 8 minutes, with continual rocking, using 5 kw. h. Twenty and one-half pounds of heat 1076 was charged at the start also, and its U content was included in the calculation. Considerable lining fell during the heat, the floating material being skimmed before the ferrouranium was added. The metal was very hot and appeared dead both in furnace and ladle. No aluminum was added. The metal rose in the mold and the ingot was unsound. Much black powder, largely uranium oxide, was taken from the furnace after cooling.

In this heat, part of the ferrouranium was added at the start, plus 18 pounds of crop and skull from heat 1081, the balance at the end. The metal wa hot, but poured rather slushy, as if carrying some material in suspension. An oxide skin formed continually in the ladle and while pouring. About 2¼ pounds of black powder, mostly uranium oxide, was taken from the furnace after cooling, as well as a few small pea-sized chunks of ferrouranium which had sharp corners, had not been fused, and were identified by their pyrophoric behavior.

TABLE 3.—*Production of uranium*

No. of heat.	Total weight of charge.	FeU added, analysis.					Total kw.h. used.	1st or 2d heat.	FeU added at—		Size FeU.	Per cent of U.		
		Lbs.	No. of sample.	U.	C.	Si.			Kw. h.	Start or end.		Calculated.	Analysis. Top.	Analysis. Butt.
	Lbs.			*P. ct.*	*P. ct.*	*P. ct.*								
1085	46	1.75 2.75	41 724	45 43	4.2 2.5	.4 2.5	30	2d...	0 40	Start End	Hickory..... Pea..........	[d]2.15 [e]2.6 4.75	1.4	1.75
1086	49	3	41	45	4.2	.4	37.5	......	37.5	In ladle at end.	Below pea....	[d].45 [e]2.75 3.2	1.23	.91
1087	49.5	2	91	68.5	5	.3	40	1st..	40	In ladle at end.	....do........	[d].7 [e]2.7 3.4	.12	.7
1228	50	1.6	69	37.5	1.75	2	40	1st..	40	End	....do........	1.19	.54	.51
1229	50	1	96	63	2.15	.8	37.5	2d...	37.5	End	.....do........	1.21	.38	.34
1244	52.5	1.3	92	63.5	2.15	.7	35	2d...	35	End	Below 8 mesh.	[d].5 [e]1.6 2.1	.36	.32
1327	70.5	2	68-69	37.5	2.8	2	55	1st..	55	End	8 to 30 meshes, no fines.	1.05	.36	.38

[d] Start.
[e] End.

RECOVERY OF URANIUM.

The only really concordant feature of the runs on uranium steel is that the percentage recovery of uranium is low, especially when attempts are made to add much uranium, say 5 per cent or more.

It is also noteworthy that when such attempts are made there is a marked segregation of uranium between the top and the bottom of the ingot. Metallic uranium has a specific gravity of almost 18.5; that is, it is over twice as heavy a material as iron. This alone need not cause segregation, since tungsten, with an even higher specific gravity, does not give trouble from segregation. Uranium and its ferro-alloys oxidize very readily, and in runs 1078 and 1079, when part of the ferro charged at the start was covered with a thick film of oxide, pieces of ferros fairly low in carbon went through the steel furnace without melting or being dissolved.

In heat 1085 some of a clean high-carbon ferro charged at the start also went through unmelted and undissolved. These pieces may readily have acquired an oxide film coating on being charged into the hot furnace before they were covered by molten steel. Even when the ferro is charged into molten steel it may possibly require a surface coating of oxide before it can be submerged under the steel merely by passing through the hot furnace atmosphere, which is *steels in indirect-arc furnace*—Continued.

Remarks.
Procedure was similar to that of preceding heat, part of the FeU (and 13.3 pounds of heat 1078 crop) being charged at the start, the rest at the end. Metal was not so hot as preceding but less slushy. In addition to the usual black powder, some unfused chunks of ferrouranium were found in the bottom of the furnace. These, by the characteristic fracture of a high-carbon ferrouranium, were recognized as being sample 41, which was added at the start and hence went through the whole heat unfused. None of the lower carbon ferro, 72A, was detected in the material left in the furnace.
Aside from 15 pounds of heat 1085 crop charged at the start, the uranium was added as finely crushed ferro in the following manner: The steel was very hot at the start. Half the steel was poured into the ladle, half the ferro added to the ladle, the rest of the steel poured, the rest of the ferro added, the metal stirred, and the whole poured back into the furnace, to mix by pouring, then at once into the ladle again, then immeditately into the mold, since it had become quite cold. The small residue in the bottom of the ladle burnt in the air, throwing off sparks. No uranium oxide or unfused ferro was detected in the furnace.
Nineteen pounds heat 1084 crop was charged at the start. The very hot metal was poured into the ladle all the ferrouranium being thrown in when half the steel had been poured, the rest of the steel poured, the ladle stirred, the metal poured back into the furnace, into the ladle, and then into the mold. The metal was still fluid enough for pouring, though it showed signs of a tendency toward slushiness. Some black powder was found in the furnace after cooling.
This steel contained 3 per cent Ni. and 1.2 per cent Si. The metal was very hot, the FeU was added in the furnace after the metal was thoroughly skimmed, one "Little Devil" Thermit being used. The metal was fluid and not at all slushy.
This steel was similar to the preceding and the procedure was the same.
This steel was similar to the two preceding ones, 5 per cent U was contained in the 49 pounds of crop ends of ingots previously made, which were charged at the start, the ferrouranium being added just before pouring. The metal was hot. The ferro was only slowly taken up, but by long and thorough stirring it was apparently taken into solution. No Thermit can was used.
Metal was hot. Ferro was readily taken up. This ingot, analyzing 0.45 per cent C, 2.42 per cent Si, 0.70 per cent Mn, 2.92 per cent Ni, 0.37 per cent U, broke up in rolling.

oxidizing when the furnace is open for charging. Very fine powder, so charged, could be seen to burn before it could be stirred into the metal, and all such very fine material is quite plainly lost. Rather large pieces of ferro were used in the earlier tests for this reason.

The prevalence of slushy heats in which the steel though at a temperature at which W or Mo steels would be fluid as milk, indicates either the probability of the presence of suspended material not in true solution, or of a very wide range between liquidus and solidus in the presence of U. Of the heats which were plainly not slushy—1080, 1082, 1228, 1229, 1244, 1327—only one, 1082, showed appreciable segregation. These contained not over 0.55 per cent U.

Segregation might at first thought always be expected to give more U in the bottom of the ingot than the top, due to the high specific gravity of U, but this need only occur when the steel is poured so hot that the steel remained fluid in the mold long enough to allow settling of U. If the steel is allowed to stand in the ladle for degasification long enough for settling to take place, there would be more U at the bottom of the ladle than at the top. If the steel is then poured into the mold so cold that it freezes before settling can again take place, the top of the ingot, which receives the metal from the bottom of the ladle, might be higher in U.

Savage[19] shows a radiophotograph of a uranium steel containing 7.74 per cent U which has radioluminous patches scattered through the steel in a decidedly nonuniform manner.

Keeney[20] states that steel makers using ferrouranium containing 15 to 30 per cent uranium could not make the uranium stay in high-speed steel, getting from zero to 50 per cent recovery, and that when commercial uranium (a mixture of metallic U and uranium carbide, U_2C_3) was used, no better recoveries were made. Experiments were then run in which from 1.42 to 5.45 per cent U was added in 25-pound heats of steel, using ferrouranium ranging from 20 to 40 per cent U, which showed from 9 to 118 per cent recovery of U. He summarizes his results as follows:

Recovery of uranium.

	Per cent recovery.
Average of all tests	54.7
Steel with less than 2 per cent U	67.8
FeU added after skimming slag	70.7
FeU added before skimming slag	48.3
Poured at once after adding FeU	60.2
Poured one-quarter minute after adding FeU	45.3
Poured one-half to one minute after adding FeU	56.7

There was no greater variation in the recovery between the use of 20 and 40 per cent U alloys than between two different lots of 25 per cent alloy.

The 9 per cent recovery was obtained when 6.2 pounds of ferro of 20 per cent U was added to about 20 pounds of steel.

In all these runs the ferros were added, in pea or one-half-inch size, either in the furnace just before pouring or in the ladle.

Six tests on 100 to 110 pound heats of crucible tool steel are cited, in which FeU of 50 to 53 per cent U content and 4.7 to 5 per cent C content was used, which show from 16 to 55 per cent recovery of U, averaging 40 per cent.

Nothing is said as to segregation of U, but two of Keeney's tests show, respectively, 100 and 118 per cent recovery by analysis, which makes it appear at least possible that the steels may not have been so sampled that the samples were truly representative if any segregation did occur. If there was segregation the calculated recoveries may not be accurate.

Matthews[21] states that while uranium has been advocated for use in high-speed tool steel, it is difficult to handle, owing to the ease

[19] Savage, W., Radioactive luminous materials: Chem. and Met. Eng., vol. 19, 1918, p. 515.

[20] Keeney, R. M., The manufacture of ferro-alloys in the electric furnace: Bull. Am. Inst. Min. Eng., August, 1918, p. 1358 and following.

[21] Matthews, J. A., Modern high-speed steel: Proc. Am. Soc. Test. Mat., vol. 19, pt. 2, 1919, p. 13.

with which it is oxidized, and that steel to which it is added has been more apt to show seams and defects than steel from which it is absent. Microscopic examination, he states, shows the presence of considerable amounts of a material which is probably uranium oxide, since, on account of its specific gravity, the elimination of such oxide is improbable. He says that further experience is needed to allow the introduction of uranium into steel without great loss of the expensive material and without the formation of detrimental impurities. A footnote states that a low-carbon high-uranium ferro recently put on the market should be more successful than the former high-carbon ferro.

TESTS OF SILICON-NICKEL-URANIUM STEELS.

Several Si-Ni-U steels were made in 1919 and analyzed as follows:

Analyses of silicon-nickel-uranium steels.

No. of heat.	C.	Si.	Mn.	Ni.	U.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1228	0.63	1.20	0.84	3.00	0.52
1229	.45	1.05	.75	3.00	.36
1244	.43	1.30	.90	3.00	34

Foote[22] has since recommended such steels as giving a combination of great static and dynamic strength, hardness, and ductility, and as being suitable for auto gears, light armor, and rivet sets.

Poluskin[23] states that on heats of 400 pounds in an electric furnace, when ferrouranium was added in the furnace at the end of the heat or in the ladle (the latter being preferable), he sometimes got 70 to 75 per cent recovery of U, but that in general the recovery is irregular and under 50 per cent. He states that U oxidizes too readily to allow the addition of ferrouranium to the charge at the beginning of the heat. Poluskin dealt with steels up to about 4 per cent U and with one of 7 per cent. He does not state whether segregation of U was found or if it was looked for, but says that the chemical analyses often had to be repeated several times and the average taken. He finds that there is no advantage in having over 0.5 to 0.6 per cent U in steel, and that any advantage in using U is confined to steels of less than 0.6 per cent C. In a plain U steel of 0.25 to 0.45 per cent C he concludes that U increases the tensile strength and elastic limit without decreasing the ductility, but that it does nothing that can not be accomplished with other alloying elements. He finds no advan-

[22] Foote, H. S., U. S. Pat. 1366254: Jan. 18, 1921 (application Sept. 29, 1920).
[23] Poluskin, E., Les aciers à l' uranium: Rev. de Met., vol. 17, 1920, p. 421. Abstracted in Iron Trade Rev., vol. 68, 1921, p. 413, and Iron Age, vol. 106, 1920, p. 1512.

tage in adding U to Ni or Cr steels. He finds U of no advantage as regards shock tests or repeated impact tests. He states that much of the U in a steel is present as oxide.

Foote[24] agrees with Poluskin that over 0.6 per cent U gives no advantage, but is more optimistic over the value of small amounts.

The main object in making up the uranium steels listed in Table 3 was to get, if possible, a few steels with at least more than 1 per cent U and as much higher as possible, in order to be able to ascertain what properties fairly large amounts of U confer on steel. Some of the steels should serve for this purpose, although most of them show too much segregation of U to give anything better than a general indication of the properties.

METHODS OF ADDING URANIUM TO STEEL.

Only tentative conclusions can be drawn as to the most desirable methods of adding U to steel in order to get a good recovery of U and to avoid segregation of U in the steel. It seems probable, however, that at least in making up steels to contain up to about 0.5 per cent U the best results will be obtained by using ferrouranium containing 40 to 65 per cent U with carbon as low as possible, certainly not over 2.5 per cent. It is reasonable to suppose that the presence of, say, 15 per cent silicon in the FeU would be of value in reducing the carbon content of the ferro, though if one assumes a recovery of 40 per cent of the U and 100 per cent of the Si in a ferrouranium of 60 per cent U, 15 per cent Si, 1.5 per cent C, and 22.5 per cent Fe, the addition necessary to give 0.5 per cent U in the steel would raise the silicon by about 0.3 per cent, so that such an alloy could only be used in such types of steel as admit of the presence of a considerable amount of Si. It seems likely, since uranium, like vanadium, forms a carbide with great ease, that further development of ferrouranium and of uranium steels may show that a low-carbon ferro is necessary in order to get the full benefit of the alloying element (if any benefit is conferred by it) as is claimed to be the case with vanadium.[25]

The ferro should probably be crushed to about pea size and the very fine dust screened out, since this is likely to oxidize so readily that it will reach the steel as oxide rather than as metal. On account of the ready oxidation, preheating the ferro appears inadvisable.

In order to get the greatest recovery of U from the ferro, it should be added in the furnace just before pouring or to the stream of metal

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[24] Foote, H. S., Uranium as structural steel alloy: Railway Mech. Eng., vol. 94, 1920, p. 695.

[25] Keeney, R. M., The manufacture of ferro-alloys in the electric furnace: Bull. Am. Inst. Min. Eng., 1918, p. 1342.

while pouring, and the steel should be free from slag. While the steel should be given a little time to allow dissemination of the uranium, the shortest time which is compatible with avoidance of segregation between adding the ferro and pouring the steel into the molds will doubtless give the highest recovery of U in the steel.

ZIRCONIUM STEELS.

The zirconium series of alloy steels was the longest made in the experimental indirect-arc furnace. The use of zirconium steel was brought to the attention of the Navy by W. H. Smith, of the Ford Motor Co.

The Krupp works at Essen were reported[26] to be investigating zirconium steel before the war, and it is known that in 1913, just prior to the war, over 1,000 tons of zirconium ore were shipped from Brazil to Germany, while only about 40 tons were shipped in 1912. Since zirconium oxide began to show its potential value as a refractory about this time, such statistics do not necessarily prove that the ore was intended for the production of zirconium steel. There was also a report[27] in a Brazilian newspaper that the long-range gun that bombarded Paris had a zirconium steel liner.

Ludwig Weiss, of Barmen, Germany, in German Patent 231002, English 29376 of 1910, and U. S. Patent 982326 of January 24, 1911, claims that the disadvantages of titanium in steel—that it is not a sufficiently energetic deoxidizer, that its specific gravity is too low, and that Ti alloys with more than 2 to 3 per cent Ti are difficult to work in the hot state—can be avoided by using zirconium instead of titanium. He claims that zirconium carbide silicide, ferrozirconium, or cuprozirconium can be used for adding Zr to iron, gun metal, brass, copper, aluminum bronze, and the like, and are totally dissolved in them. He advocates alloys of 10 to 25 per cent Zr, and the use of these alloys in such amounts as will add less than 1 per cent Zr (but the patent claims cover adding Zr in minimum amount of 1 per cent, if sound castings are desired, such additions greatly increasing the strength and tenacity of the metal and greater additions further increasing the strength and toughness.

Garcon[28] cites experiments made by the Ford Motor Co. indicating that a steel of 0.42 per cent C, 1 per cent Mn, 1.5 per cent Si, 3 per cent Ni, 0.34 per cent Zr, annealed at 875° C. and air-cooled,

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[26] Meyer, H. C., Zirconia, its occurrence and application: Mineral Footnotes, March–April, 1919, p. 11.

[27] Metal Industry (London), Notes of the week: Vol. 13, 1918, p. 91.

[28] Garcon, J., Aciers au zirconium: Bull. Soc. encour. ind. nat., vol. 13, 1919, p. 148. See also Iron Age, Zirconium in steel: Vol. 103, 1919, p. 1015; Foundry, vol. 48, 1920, p. 76.

reheated to 840° C. and oil-quenched, and drawn in oil at 180° C. for three hours, had a tensile strength of 281,000 pounds, an elastic limit of 240,000 pounds, and a Brinell hardness of 470. The optimum zirconium content is given as one-third of 1 per cent Zr, and it is stated that at above one-half of 1 per cent Zr the quality of the steel is poorer.

Tone[29] says, "We hear whispers about a zirconium steel of 300,000 pounds tensile strength and 30 per cent elongation."

It is pointed out[30] that while the combination of high strength, high elastic ratio, high Brinell hardness, and high ductility reported for zirconium steel is unusual, a nickel steel with high silicon and high manganese possesses remarkable quantities in itself, and the action of the zirconium may be merely as an intensifying agent, increasing toughness somewhat as vanadium acts as an intensifying agent on some steels in developing certain properties.

Ramsen[31] states that the value of zirconium steel is probably chiefly as a scavenger. Lantsberry states that it produces a cutting steel of great hardness, but not one possessing any outstanding properties for cutting tools.

Wood[32] states that NiSiZr steel is strongly recommended for parts where extreme hardness and toughness are essential and that it has been used with excellent results for balls and races for large thrust bearings, special heavy duty punches, and rivet sets. He states that the possibilities of this alloy are great.

It is stated[33] that 0.02 per cent Zr may be used as a scavenger in steel, and that zirconium steels have been used in Germany for various purposes.

COOPERATIVE PRODUCTION OF ZIRCONIUM STEELS.

At the request of the Navy, cooperative work on zirconium steel was undertaken in which the Bureau of Mines was to produce a series of zirconium and other similar steels, which were to be rolled, heat-treated, and subjected to physical tests by the Bureau of Standards. Production of these began in September, 1918, and about 165 steels

[29] Tone, F. J., Electrochemistry in its human relations, Presidential address: Trans. Am. Electrochem. Soc., vol. 35, 1919, p. 265.

[30] Iron Age: Vol. 103, 1919, p. 1030. Compare also Johnson, C. M., U. S. Pat. 1342911, for a chrome-vanadium-silico-nickel steel.

[31] Ramsen, —, Discussion of paper by Lantsberry, F. C. A. H., Zirconia in relation to the metal industry: Met. Ind., London, vol. 16, 1920, p. 3.

[32] Wood, H. F., Progress in metallurgy of alloy steel: Amer. Drop Forger, Jan., 1920, p. 25.

[33] Jour. du four electrique, Ferro-zirconium: Vol. 29, 1920, p. 157.

were made for the Navy. A second series of about 35 steels was later requested and prepared.

According to reports from the Ford Motor Co. it appears that, although zirconium may have a beneficial effect on some steels, it has so far been unable to control the introduction of Zr so as to make steel consistently with the properties which are ascribed to zirconium. That is, three steels may be similarly made and handled and may analyze exactly the same, yet one may not show any changes in physical properties from those given by a similar steel without zirconium, another may show decidedly poorer properties, while a third may have some of its physical properties materially enhanced. It is asserted that the properties can be predicted, before test, from the microstructure, which is claimed to be characteristic when the zirconium has entered the steel in the manner that will give superior physical properties, but that no such prediction can be made without microscopic examination; that is, if zirconium is responsible for the improvement in properties claimed, it gives this improvement only in so-called "freak" heats, which as yet can not be reproduced at will.

At the beginning of this work there seemed reason to hope that zirconium, as well as uranium, might repeat the history of vanadium, which, when first tried out in steel was thought to be useless and condemned by some early investigators; indeed, its value was not apparent until considerable time had elapsed and many trials had been made, through which the correct composition of ferrovanadium, the ways of adding it, the amounts to use, and the other alloying elements in connection with which it is of greatest value were finally found out.

Since the recovery of Zr from ferrozirconium to steel is an important factor in the development of zirconium steel, the experience of the Bureau of Mines in handling various ferros is given below in some detail. (See Table 4.) The only ferros available at first were some made for the Navy by the Thermit reaction (reduction with aluminum) by the Metal and Thermit Co., which gave poor recoveries of Zr.

TABLE 4.—*Recovery of zirconium*

No. of heat.	Total weight charge pounds.	Weight FeZr. pounds.	Total kw.h. used.	1st or 2d heat.	FeZr added—	Size FeZr.	No. Thermit heating cans used.	Per cent Zr— Calculated.	Per cent Zr— By analysis. Top.	Butt.	Average.	Recovery.
						USING THERMIT FeZr OF ABOUT 21 PER CENT Zr, 0.8 PER						
1134	46.5	2.2	37½	2d..	After 30 kw.h.	Pea..........	0	0.95	0.12	0.15	0.14	0.13
1145	46.5	1.4	35	2d..	At end.......	.....do.......	0	.61	.14	.13	.14	.23
1222	47.5	2.2	39	1st..	.....do.......	Under 8 mesh	2	.95	.11	.07	.07	.08
1223	47.5	2.2	39	1st..	.....do.......	.....do.......	2	.95	.07	.07	.07	.08
Av...												.13
						USING THERMIT FeZr OF ABOUT 16.1 PER CENT Zr, 0.7 PER						
1101	50	6	40	1st..	At start......	Hickory nut.	0	2	0.09	0.1	0.1	5
1103	50	3	40	1st..	.....do.......	.....do.......	0	1	.02	.02	.02	2
1105	45	5.4	37	1st..	.....do.......	Pea[a]........	0	2	.07	.09	.08	4
1109	50	6	45	1st..	After 40 kw. h.	Pea..........	0	2	.07	.13	.1	5
1117	50	2	45	1st..	After 37½ kw.h.	.....do.......	0	.7	.09	.06	.07	10
1119	50	3	35	2d..	At start......	Hickory nut to pea.	0	1	.04	.07	.06	6
Av...												5
						USING THERMIT FeZr OF ABOUT 25 PER CENT						
1231	50	2.2	35	2d..	At end.......	Under 8-mesh	0	1.1	0.15	0.15	0.15	0.14
1241	50	2.2	40	1st..	.....do.......	.....do.......	0	1.1	.1	.1	.1	0.09
Av...												.11
						USING THERMIT FeZr OF ABOUT 28.5 PER CENT Zr, 0.5 PER						
1131	45.5	1.8	40	1st..	After 35 kw. h.	Pea..........	0	1	0.12	0.11	0.12	12
1132	45.5	1.8	37½	2d..	After 32½ kw.h.	.....do.......	0	1	.22	.19	.2	20
1146	46.5	1	37½	1st..	At end.......	.....do.......	0	.6	.05	.05	.05	12
1155	46.5	1.5	40	1st..	.....do.......	.....do.......	1	.9	.11	.08	.1	11
1157	46.5	3.6	42½	1st..	.....do.......	4 to 8 mesh[a].	2	2	.09	.1	.1	5
1160	48.5	1.8	39	1st..	.....do.......	Under 8-mesh	0	1	.1	.1	.1	.1
1161	48.5	1.8	39	1st..	.....do.......	.....do.......	0	1	.06	.09	.08	8
1162	48.5	1.8	37½	1st..	.....do.......	.....do.......	1	1	.14	.08	.11	11
1175	50	3.6	42½	1st..	After 35 kw. h.	.....do.......	0	2	.1	.11	.1	5
1176	50	3.6	37	1st..	At end.......	.....do.......	2	2	.13	.16	.14	7
1177	50	2.2	34	2d..	.....do.......	.....do.......	1	1.3	.13	.09	.1	.8
Av...												10
						USING ELECTRO-METALLURGICAL CO.'S FeZr OF 36.3 PER CENT Zr, 0.6 PER						
1232	50	1.8	40	1st..	At end.......	Under 8-mesh	0	1.25	.11	.11	.11	9
1233	50	1.8	40	1st..	.....do.......	.....do.......	0	1.25	.16	.17	.16	1
1240	52	1.8	37½	1st..	.....do.......	.....do.......	0	1.2	.12	.14	.13	11
1243	52	1.8	45	1st..	.....do.......	.....do.......	1	1.2	.14	.14	.14	12
Av...												11
						USING ELECTRO-METALLURGICAL CO.'S NiZr of 54.9 PER CENT Ni. 25.3 PER CENT						
1249	50	2.8	37½	1st..	At end.......	Under 8-mesh	0	1.4	0.56	0.64	0.6	43
1290	50	1.6	40	1st..	.....do.......	4 to 8 mesh...	0	.8	.39	.4	.4	50
1291	50	1.4	37½	1st..	.....do.......	Under 8-mesh	1	.7	.23	.23	.23	33
1248	50	{ [a]2+ .7 }	43	1st..	.....do.......	.....do.......	0	1.3	.54	.61	.57	43
Av...												41

from ferrozirconium to steel.

CENT Ti, 10 PER CENT Si, 6 PER CENT Al, 0.2 PER CENT C.

Notes.
Furnace was opened after metal melted, FeZr was charged and stirred in, then furnace was closed and run 7½ kw. h. more. Metal was hot enough but FeZr did not go in readily on stirring.

CENT Ti, 12 PER CENT Si, 3.4 PER CENT Al, 0.7 PER CENT C.

FeZr was heated just to redness before adding, furnace was closed, and 5 kw. h. more run after adding FeZr. Final steel was rather cool. FeZr was added cold. Final steel was hot. Final steel was very hot.

Zr, Ti n. d. 10 PER CENT, Si, 9 PER CENT Al C. n. d.

CENT Ti, 8 PER CENT Si, 3 PER CENT Al, 0.2 PER CENT C.

Steel was hot, but FeZr did not dissolve readily when stirred. FeZr was preheated to dull redness; steel was very hot. FeZr did not dissolve readily on stirring. FeZr was added cold, steel hot. Some dross was found at end, apparently from FeZr. Final steel was rather cool. Final steel was hot enough.

CENT Ti, 7.5 PER CENT Si, 14.6 PER CENT Al, 1.6 PER CENT Cr, 0.1 PER CENT C.

Zr, 0.7PER CENT Ti, 5.2 PER CENT Si, 7.3 PER CENT Al, 0.1 PER CENT Cr, 0.07 PER CENT C.

All the Ni was added as NiZr. The steel was very hot and the NiZr well stirred in, but not all was taken up, since the calculated per cent Ni was 3, and that found 1.73 per cent top, 1.73 per cent butt; that is, 58 per cent recovery of Ni. 1.5 per cent Ni was added at start, 1.7 per cent Ni added at end as NiZr; total, 3.2 per cent. Found, 2.97 per cent; that is, 0.23 per cent loss, or a recovery of Ni from that added at the end of 80 per cent. 1.7 per cent Ni was added at start, 1.5 per cent was added at end as NiZr; total, 3.2 per cent. Found, 2.92 per cent; that is, 0.28 per cent loss, or a recovery of Ni from that added at end, of 81 per cent. Besides NiZr, 0.7 pound of SiZr in heat 1250 was also charged. Metal was very hot. NiZr seemed to go in fairly well. All the Ni charged was carried by the NiZr added at the end, 2.2 per cent Ni being thus added. There was found by analysis 1.62 per cent Ni top, and 1.61 per cent Ni butt, or a recovery of 73 per cent of the Ni.

TABLE 4.—*Recovery of zirconium*

No. of heat.	Total weight charge pounds.	Weight FeZr. pounds.	Total kw.h. used.	1st or 2d heat.	FeZr added—	Size FeZr.	No. Thermit heating cans used.	Per cent Zr— Calculated.	Per cent Zr— By analysis. Top.	Butt.	Average.	Recovery.
USING SOUTHERN MANGANESE CO.'S FeZr OF 44.5 PER CENT Zr, 3.2 PER												
1292	50	1.1	40	1st..	At end.......	All below 4-mesh, mostly below 8-mesh.	0	1	0.05	0.05	0.05	5
1293	50	1.1	40	1st..	.....do.......	.....do.......	2	1	.02	.08	.05	5
Av...	....	....	.....	....	....	....	.....	.....	.....	.....	.....	5
USING FeZr MADE BY BUREAU OF MINES, OF ABOUT 53 PER												
1108	50	1	42	1st..	At end.......	Pea..........	0	1	0.03	......	0.03	3
USING ALLOY MADE BY BUREAU OF MINES, OF ABOUT 64 PER CENT Zr,												
1138	46.5	0.9	40	1st..	After 35 kw.h.	Pea..........	0	1.3	0.04	0.05	0.05	4
USING SiZr MADE BY BUREAU OF MINES, OF ABOUT 24 PER CENT Zr, 0.												
1133	46.5	1.8	40	1st..	After 35 kw.h.	Pea..........	0	0.9	0.7	0.3	0.5	56
1134	46.5	1.1	37½	1st..	At end.......	.....do.......	0	.6	.13	.16	.15	58
USING SiZr MADE BY BUREAU OF MINES, OF ABOUT 36.6 PER												
1247	52	1.8	42	1st..	At end.......	Under 8-mesh	0	1.3	0.86	0.71	0.78	60
USING SiZr. MADE BY BUREAU OF MINES OF ABOUT 18.9 PER												
1250	50	2.2	38	1st..	At end.......	Under 8-mesh	0	0.8	0.65	0.35	0.50	63
USING SiZr MADE BY BUREAU OF MINES OF ABOUT												
1285	50	1.6	42	1st..	At end.......	Under 8-mesh	0	0.9	0.71	0.76	0.73	81
1289	50	[a]1.6	40	1st..	.....do.......	.....do.......	0	.7	.46	.35	.40	57
Av...	....	....	......	....	....	....	0	......	......	......	......	69

from ferrozirconium to steel—Continued.

CENT Ti, 8.7 PER CENT Si, 0.5 PER CENT Al, 3 PER CENT C, 0.36 PER CENT P.

Notes.
Metal was very hot, but FeZr did not seem to go in very well on stirring.
Metal was very hot, but FeZr did not seem to go in very well on stirring, and seemed to be mostly dissolved after Thermit heating cans were used.

CENT Zr, 0.7 PER CENT Ti, 6 PER CENT Si, 7.7 PER CENT C.

Metal was hot, but became rather slushy after FeZr was stirred in. FeZr was not readily dissolved About 0.05 per cent Al was present, so in the crop ends charged at the start no aluminum was added in the ladle. As the metal was slushy it was poured at once without holding it in the ladle to degasify. Metal rose in mold and ingot was unsound.

1 PER CENT Ti, 3.6 PER CENT Si, 8.6 PER CENT Ni, 6.4 PER CENT C.

Furnace was opened and alloy added and stirred in, but alloy was not readily dissolved; furnace was closed and ran 5 kw. h. more. Final metal was very hot, so was held longer than usual in ladle.

PER CENT Ti 40 PER CENT Si, 0.4 PER CENT Al, 0.1 PER CENT C.

Same procedure was followed as on heat 1138, but SiZr was very readily dissolved.
SiZr was very readily dissolved.

CENT Zr, 1.3 PER CENT Ti, 44.5 PER CENT Si, 0.7 PER CENT Al.

CENT Zr, 0.8 PER CENT Ti, 34.2 PER CENT Si, 1.6 PER CENT Al.

20 PER CENT Zr, 0.3 PER CENT Ti, 40 PER CENT Si.

SiZr was made up mainly of that of heats 1285 and 1289, with small amounts of SiZr alloys of heats 1247 and 1250.

TABLE 4.—*Recovery of zirconium*

USING ELECTRO-METALLURGICAL CO.'S SiZr OF 29.8 PER

No. of heat.	Total weight charge pounds.	Weight FeZr. pounds.	Total kw.h. used.	1st or 2d heat.	FeZr added—	Size FeZr.	No. Thermit heating cans used.	Per cent Zr— Calculated.	Per cent Zr— By analysis. Top.	Butt.	Average.	Recovery.
1180	48.5	1.6	37	1st..	At end.......	Under 8-mesh	0	1	0.48	0.48	0.48	48
1181	48.5	1.6	35	1st..	.....do.......	4 to 8 mesh...	0	1	.61	.6	.6	60
1182	48.5	1.6	32½	2d..	At start......	Egg..........	0	1	None.	.03	.02	2
1183	48.5	1.6	37½	1st..	After 32½ kw.h.	.....do.......	0	1	.23	.22	.23	23
1184	48.5	1.1	34	2d..	At end.......	Under 8-mesh	0	.7	.29	.24	.27	47
1185	48.5	1.1	35	1st..	.....do.......	.....do.......	0	.7	.5	.3	.4	57
1186	48.5	1.1	34	2d..	.....do.......	.....do.......	0	.7	.24	.26	.25	36
1187	48.5	1.1	35	1st..	.....do.......	.....do.......	0	.7	.38	.27	.33	33
1188	48.5	1.1	35	1st..	.....do.......	.....do.......	0	.7	.33	.31	.32	46
1189	48.5	1.1	35	1st..	.....do.......	.....do.......	0	.7	.15	.25	.2	29
1190	48.5	1.4	33	2d..	.....do.......	.....do.......	0	.9	.47	.44	.46	51
1191	48.5	1.4	35	1st..	.....do.......	.....do.......	0	.9	.4	.38	.39	43
1192	48.5	a1.4	33	2d..	.....do.......	.....do.......	0	.9	.8	.35	.58	65
1193	48.5	a1.4	35	1st..	.....do.......	.....do.......	1	.9	.3	.34	.3	33
1194	48.5	1.4	33	2d..	.....do.......	.....do.......	0	.9	.45	.45	.45	50
1195	48.5	1.4	35	1st..	.....do.......	.....do.......	0	.9	.51	.5	.5	56
1196	48.5	1.4	35	1st..	.....do.......	.....do.......	0	.9	.6	.48	.54	60
1197	48.5	a1.4	33	2d..	.....do.......	.....do.......	0	.9	.32	.34	.33	38
1210	48.5	1.3	32½	2d..	.....do.......	Under 4-mesh	0	.8	.55	.55	.55	69
1211	48.5	1.3	35	1st..	.....do.......	.....do.......	0	.8	.8	.3	.55	69
1212	48.5	.9	33	2d..	.....do.......	.....do.......	0	.55	.4	.2	.3	55
1213	48.5	.9	31	1st..	.....do.......	.....do.......	0	.55	.31	.33	.32	58
1218	48.5	a1.3	40	1st..	.....do.......	Under 8-mesh	2	.8	.8	.3	.55	69
1219	48.5	a1.3	37½	1st..	.....do.......	.....do.......	1	.8	.71	.72	.72	90
1220	48.5	a.65	35½	2d..	.....do.......	.....do.......	1	.4	.22	.18	.2	50
1221	48.5	a.65	37½	2d..	.....do.......	.....do.......	2	.4	.17	.17	.17	43
1224	48.5	a1.3	37½	2d..	.....do.......	.....do.......	0	.8	.18	.23	.2	25
1225	48.5	a1.3	37½	1st..	.....do.......	.....do.......	0	.8	.18	.22	.2	25
Av......												56

a See note.

b Average, omitting Nos. 1182 and 1183.

RECOVERY OF ZIRCONIUM.

Table 4 (see p. 44) indicates that alloys ranging from 16 to 36 per cent Zr, 0.5 to 0.7 per cent Ti, 7.5 to 12 per cent Si, 3.5 to 14.5 per cent Al, and 0.1 to 0.7 per cent C, made from the ore by reduction with aluminum by the Thermit reaction, not in an electric furnace, all gave low recoveries of Zr, averaging only 10 per cent, no matter how they were added. These ferros would lie on top of a cleanly skimmed bath of very hot steel without going into solution readily, even when vigorously stirred, and would bob back to the surface, doubtless becoming oxidized while remaining on the surface, since the alloys took on a surface film of oxide when attempts were made to preheat them, as in run 1157 (see note, p. 45, Table 4).

Table 4 (see p. 44) shows that the recovery of Zr when a FeZr high in carbon is used was still lower, under 5 per cent. This might be expected from the analogy with ferro-carbon-titanium (16 per cent Ti, 7.5 per cent C) with which it is said to be almost impossible to make more than traces of Ti remain in the steel, the alloy being used only as a scavenger.

from ferozirconium to steel—Continued.

CENT Zr, 3.1 PER CENT Ti, 46.7 PER CENT Si, 0.03 PER CENT C.

Notes.
Surface of ingot was rather poor.
FeTi as well as SiZr was added to these heats (see Table 5).
Do.
Do.
Metal was rather cold.
FeTi as well as SiZr was added to these heats (see Table 5).
Do.
Do.
Do.
Do.
Do.

On the other hand, when a FeZr of 13 per cent Zr, 1 per cent Ti, 4 per cent Si, 5 per cent C, 0.9 per cent Al is used for addition to the ladle, the following recoveries were said to have been made by the Ford Motor Co.

Recoveries of zirconium in three heats.

Heat No.	Zr added.	Zr found.	Recovery of Zr.
	Per cent.	*Per cent.*	*Per cent.*
901-2......	0.25	0.20	80
901-3......	.50	.35	70
901-4......	1	.54	54

Table 4 (see p. 44) shows that a NiZr alloy (made by reduction with Al in an electric furnace), although similar in composition (save that Fe was mostly replaced by Ni) to the FeZr's made by Al reduction, gave a distinctly better recovery of Zr. That only a 60 to 80 per cent recovery of the Ni contained in the alloy was made (see notes 12 to 15) shows that there is a mechanical loss of alloy. This may possibly be due to some of the alloy floating on the steel before it goes into solution, being pushed to the edges of the furnace in stirring, and there sticking to the rim of slag which remains after skimming, and being then either scraped out with the slag or part of it left in the furnace until the next heat. This is quite possible, in heat 1249 at least, as the following figures show:

Per cent of nickel calculated and found in two consecutive heats.

No. of heat.	Per cent Ni—		Loss.	Gain.
	Calculated.	Found.		
1249.....	3	1.73	1.27	....
1250.....	3	3.57	....	0.57

Mechanical loss may also occur through the presence of extremely fine powder, which if not sifted out after the ferro is crushed down to the desired size would float more readily than the larger particles and would thus be on the surface longer before being stirred in, and would have more surface area in comparison with its weight, so that oxidation of the surface is quite probable. If the surface does become oxidized, such small particles would be relatively slow to coalesce with the main mass of metal, even if they should melt; if they should not melt there may not be enough agitation in stirring to break through the oxide film and expose a clean metal surface to the dissolving action of the bath of steel.

Table 4 shows that silicozirconium alloys were readily taken into the bath and gave an average recovery of 50 to 60 per cent. These alloys go into the steel as readily, as far as the eye can tell, as the same amount of ferrosilicon. Since silicon is so very readily soluble in a hot bath of steel, the steel may have first dissolved the silicon, thus disintegrating the alloy and wetting it at the same time, so that the suspension of clean particles of alloy higher in Zr and lower in Si may occur as soon as the solution of Si has well started.

The differences in the solubility of the various alloys in steel may be closely related to the melting point. The Bureau of Standards has planned an investigation of the melting points of various ferro-alloys used for making alloy steels, and at the request of that bureau samples of representative alloys used in making the steels cited in this report have been sent to it for study. When the Bureau of Standards issues a report on its melting-point work, it will probably throw a good deal of light on the question of recovery of the various elements from their ferro-alloys into steel.

A better recovery can probably be made in pouring steel in commercial quantities into large ladles by throwing the crushed ferro into the stream of metal as it flows from furnace to ladle, as the pieces would become submerged nad be carried along by the stream. The design of the experimental indirect-arc furnace made it impossible to reach under the furnace and do this.

Although SiZr gives the highest recovery of any of the Zr alloys, when added at the end, it will be noted that on heat 1182, when SiZr to give 1 per cent Zr was added at the start of the heat, none was found in the finished steel. This is checked by heats 1204 and 1205, in which crop ends of Zr steels were remelted, the data being shown below.

Results of remelting crop ends of zirconium steels.

Heat No.	Present in crop ends at start.		Analysis of finished steel.			
	Per cent Zr.	Per cent Ti.	Per cent Zr.		Per cent Ti.	
			Top.	Butt.	Top.	Butt.
1204	0.25	0.03	None.	None.	0.005	0.005
1205	.20	.03	None.	None.	.008	.008

All the Zr was removed, but a small amount of Ti remained in the steel, even though the amount of Zr present in the charge was much greater than that of Ti.

The relatively good recovery of Zr from a SiZr alloy found in the series noted above was checked up by the later series on which data are given below. The good recovery from a NiZr alloy made by reduction with aluminum (in the electric furnace) was also checked. It is hard to see why NiZr alloys thus made are readily absorbed and give a good recovery of Zr whereas FeZr alloys thus made give a low recovery, but this difference was shown consistently.

The NiSiZr alloy was used in the hope that the good recovery of the SiZr alloy could be combined with freedom from segregation, since in the first series the NiZr alloy gave steels that were not segregated, but in the second series neither the NiZr nor NiSiZr alloys gave steels in which Zr did not segregate if the Zr content was high.

Recovery and segregation of zirconium in second series of zirconium steels.

[Steel, 0.35 to 0.50 per cent C; Ni, 3 per cent; Si, 1.6 to 2.7 per cent; Mn, 0.55 to 0.75 per cent; S, below 0.04 per cent; P, below 0.03 per cent.]

HEAT 1317, REMELT OF ZR STEEL (CROP ENDS).

	C.	Si.	Mn.	Ni.	Al.	Ti.	Zr.
Calculated ....per cent..	0.47	2.76	0.74	2.93	0.03	0.034	0.44
Found ....do....	.40	2.73	.57	2.95	.01	.01	.03
Recovery ....do....	.85	.99	.77	100	30	30	7

ALLOY USED—SILICOZIRCONIUM.

[Zr, 29.84; Si, 46.68; Fe, 18.75; Ti, 3.07; C, 0.03; P, 0.12; S, 0.03.]

No. of heat.	Calculated, per cent. Ti.	Calculated, per cent. Zr.	Found, per cent. Ti.	Found, per cent. Zr. Top.	Found, per cent. Zr. Butt.	Found, per cent. Zr. Average.	Recovery, per cent. Ti.	Recovery, per cent. Zr.
1304	0.025	0.25	0.02	0.11	0.13	0.12	80	50
1305	.04	.40	.035	.19	.23	.20	86	50
1306	.06	.60	.03	.26	.22	.24	50	40
1307	.08	.80	.05	.55	.35	.45	62	56
1308	.10	1	.07	.70	.45	.57	70	57
1309	.05	.49	.02	.26	.23	.25	40	50
1310	.075	.75	.04	.55	.38	.46	53	61
1322	.025	.25	.02	.12	.11	.11	80	45
1323	.08	.80	.07	.50	.40	.45	87	56
1324	.10	1	.09	.65	.45	.55	90	55
Average	....	....	....	....	....	....	70	52

ALLOY USED—NICKEL-ZIRCONIUM.

[Zr, 25.29; Si, 5.20; Fe, 6.35; Ti, 0.65; C, 0.07; Al, 7.34; Ni, 54.90; Cr, 0.10; P, 0.066; S, 0.01.]

No. of heat.	Calculated, per cent. Al.	Calculated, per cent. Ti.	Calculated, per cent. Zr.	Found, per cent. Al.	Found, per cent. Ti.	Found, per cent. Zr. Top.	Found, per cent. Zr. Butt.	Found, per cent. Zr. Av.	Recovery, per cent. Al.	Recovery, per cent. Ti.	Recovery, per cent. Zr.	Ni added as— Ni.	Ni added as— NiZr.	Ni added as— Sum.	Ni found.	Ni lost.	Ni as NiZr minus Ni loss.	Per cent Ni added as NiZr recovered.
												P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1311	0.17	0.015	0.60	0.06	0.01	0.38	0.21	0.30	35	67	50	1.90	1.30	3.20	2.97	0.23	1.07	82
1312	.23	.03	.80	.19	.02	.45	.32	.38	83	67	48	1.52	1.73	3.25	2.97	.28	1.45	84
1313	.07	.005	.25	.02	.01	.11	.11	.11	29	100	44	2.55	.55	3.10	2.89	.21	.34	62
1314	.13	.015	.45	.08	.015	.24	.17	.20	61	100	45	2.17	.98	3.15	2.95	.20	.78	80
1315	.28	.02	.66	.12	.02	.45	.26	.35	43	100	53	1.78	1.42	3.20	2.84	.36	1.06	75
Average	.....	.....	.....	.....	.....	.....	.....	.....	50	86	48	.....	.....	.....	.....	.....	.....	79

ALLOY USED—NICKEL-SILICON-ZIRCONIUM.

[Zr, 27.17; Si, 35.21; Ni, 22.28; Ti, 1.40; Al, 2.54; Cr, 0.50; C, 0.14; Fe, 10.20.]

No. of heat.	Calculated, per cent. Al.	Calculated, per cent. Ti.	Calculated, per cent. Zr.	Found, per cent. Al.	Found, per cent. Ti.	Found, per cent. Zr. Top.	Found, per cent. Zr. Butt.	Found, per cent. Zr. Av.	Recovery, per cent. Al.	Recovery, per cent. Ti.	Recovery, per cent. Zr.	Ni added as— Ni.	Ni added as— NiSiZr.	Ni added as— Sum.	Ni found.	Ni lost.	Ni as NiSiZr minus Ni loss.	Per cent Ni added as NiSiZr recovered.
												P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1316	0.065	0.035	0.70	0.02	0.03	0.61	0.38	0.50	31	86	71	2.52	0.58	3.10	2.98	0.12	0.46	80
1318	.05	.025	.50	.02	.02	.40	.25	.32	40	80	64	2.64	.42	3.06	2.94	.10	.32	76
1319	.065	.035	.70	.01	.03	.55	.33	.44	16	86	63	2.52	.58	3.10	3.07	.03	.55	95
1320	.085	.045	.90	.02	.04	.65	.50	.57	24	89	63	2.44	.61	3.15	3.05	.10	.51	84
1321	.10	.06	1.10	.04	.05	.90	.60	.75	40	83	68	2.30	.90	3.20	2.96	.24	.66	74
Average	.....	.....	.....	.....	.....	.....	.....	.....	30	85	66	.....	.....	.....	.....	.....	.....	80

AVERAGE RECOVERY OF ALL ALLOYS.

	Per cent.
Ti	79
Zr	52
Ni	80
Al	40

The crushed alloys were added in the electric furnace at the end of the heat after the slag was carefuly skimmed, were immediately stirred in, and the steel then poured into the ladle.

Since Ni is quantitatively recovered, once it gets into the bath, and since there is but an 80 per cent recovery of Ni from the Zr alloy, it appears that about 20 per cent of the alloy added is mechanically lost, either by oxidation of the finer particles (the alloys were crushed to pea size and below and carried considerable fines) before it hits the steel so that the oxidized particles are not dissolved, or else is caught in traces of slag not skimmed off.

Ti averages an 80 per cent recovery also; that is, it appears that all the Ti in the alloy that hits the steel is recovered.

The SiZr and the NiZr alloys show a Zr recovery of 50 per cent; that is, about 62 per cent of the Zr in the alloy hitting the steel is recovered. The percentage loss does not vary directly with the amount added, but is quite constant, whether one-fourth or 1 per cent Zr is added.

The NiSiZr alloy shows a Zr recovery of about 65 per cent, over 80 per cent of the Zr in the alloy hitting the steel being recovered, the percentage loss being practically the same whether one-half or 1 per cent be added.

Al shows a recovery of 50 per cent from an alloy carrying 7.3 per cent Al, and of 30 per cent from one carrying 2.5 per cent Al.

When more than 0.5 per cent Zr is added (probably 0.4 per cent on the NiSiZr) and more than 0.25 per cent Zr recovered, there is a very marked segregation, even in these small 66 to 72 pound 6 by 3 inch ingots. There is no proof that the *average* Zr content, figured from top and butt analyses, is the real average, though it has been used, for want of better data, in the above calculation of recoveries. It is quite possible that the butt figure may come nearer to the actual recovery than the average, since the butt sample was taken from the bottom, which should freeze very quickly, and represent the Zr content of the melt. Segregation could not be studied on the ingot without ruining the ingot for rolling. The segregation is a true segregation, not analytical errors, for duplicate analyses from the same top or butt sample agreed within 0.05 per cent Zr or less.

Recovery figures on Ti and Al show the order of magnitude rather than the exact recovery, due to the large effect on the calculations of a difference of 0.01 per cent in these elements. The analyses usually checked to less than 0.01, but reporting figures to 0.001 or even 0.005 on these elements is hardly justified analytically, and not necessary for utilization of the figures.

Zr segregation appears to be the same with any of the alloys, and seems negligible if the final steel contains not over 0.25 per cent Zr. The remelt of Zr steel (heat 1317) shows, as have previous tests on the former series, that on remelting, even in an electric furnace without running either oxidizing or reducing slags, the Zr is almost entirely lost.

Although better recoveries of Zr from each type of zirconium alloy may be expected in commercial practice, it is probable that the order of recovery from each type of alloy will remain the same in these experiments.

Not only is the recovery of Zr from Zr alloy to steel much better from the SiZr than from the FeZr alloys made by Al reduction but the recovery of Zr from ore to alloy is higher.

In making up a number of FeZr alloys from baddeleyite ore by the thermit reaction, the Metal & Thermit Corp. got recoveries as follows:

Recovery of zirconium.

Composition of alloy per cent.			Per cent recovery Zr ore to alloy.
Zr.	Si.	Al.	
16.9	12.3	3.5	25
16.4	10	4.2	8
25.6	10	9.1	40
14.2	7.5	10	11

The Electro Metallurgical Co. in making alloys of the type 30 per cent Zr, 15 per cent Si, 10 per cent Al got a recovery from the ore of about 50 per cent. The recovery in making the NiZr alloy would be expected to be about the same. In refining this to reduce the Al, and in the previous treatment of the ore to lower the Si so as to make a final alloy of 30 per cent Zr, 5 per cent Si, and 2 per cent Al, the recovery would fall to 35 per cent.

In making the SiZr alloy on a commercial scale, however, the recovery from the ore is 80 per cent or better. The recovery of Zr from ore to ferro in making a FeZr by carbon reduction is not known, but will probably not be over 80 per cent. From the recovery of Zr from ore to alloy and that from alloy to steel we can calculate the recovery from ore to steel.

Recovery of zirconium from ore to steel.

Alloy.					Per cent recovery Zr—		
Zr.	Si.	Ni.	Al.	C.	Ore to alloy.	Alloy to steel.	Ore to steel
30	15	....	10	Tr.	50	15	7.5
25	5	55	7	Tr.	[a] 50	45	23
30	5	....	5	Tr.	35	10	3.6
30	45	....	....	Tr.	80	55	44
45	8	....	.5	3	[b] 80	4	3

[a] Or less. [b] Assumed.

The SiZr alloy is decidedly more promising than any of the others from the point of view of recovery, but this, of course, is only admissible for use in steels which may contain a good deal of Si in proportion to the amount of Zr desired.

The segregation of Zr is not accompanied by a similar segregation of Si in steels made by the use of SiZr or SiNiZr.

Recovery of zirconium and silicon from steels.

No. of heat.	Zr.			Si.		
	Top.	Butt.	Difference.	Top.	Butt.	Difference.
1133	0.70	0.30	+0.40	1.66	1.64	+0.02
1185	.50	.30	+ .20	1.41	1.36	+ .05
1187	.38	.27	+ .11	1.44	1.31	+ .13
1192	.80	.35	+ .45	1.49	1.48	+ .01
1196	.60	.48	+ .12	1.50	1.49	+ .01
1211	.80	.30	+ .50	1.18	1.07	+ .11
1212	.40	.20	+ .20	.73	.81	− .08
1250	.65	.35	+ .30	1.54	1.56	− .02
1307	.55	.35	+ .20	2.50	2.42	+ .08
1308	.70	.45	+ .25	2.76	2.74	+ .02
1310	.55	.38	+ .17	1.95	1.85	+ .10
1323	.50	.40	+ .10	2.46	2.31	+ .15
1324	.65	.45	+ .20	2.68	2.68	.00
1316	.61	.38	+ .23	1.79	1.82	− .03
1318	.40	.25	+ .15	2.54	2.53	+ .01
1319	.55	.33	+ .22	2.25	2.02	+ .23
1320	.65	.50	+ .15	2.46	2.51	− .05
1321	.90	.60	+ .30	2.10	1.98	+ .12
Average			+ .34			+ .05

There was about one and one-half times as much Si as there was Zr in these alloys used for adding Zr, so that if the segregation of Zr was due to undissolved particles of the alloy, the Si segregation should be greater than one-seventh as much as the segregation of Zr. It is very evident that the Zr alone, out of the SiZr, is segregated. Comparison of the segregated and uniform Zr steels as to C, Si, Mn, and Ni content shows that these elements vary as much or more in uniform Zr as in segregated Zr steels.

The only uniformity shown by the segregated Zr steels is that when segregation does occur the Zr is higher in the top of the ingot than in the butt.

It should be noted that, like titanium,[34] zirconium, even in annealed steel, interferes with the determination of sulphur by the evolution method, giving low results.

On some steels in Table 5 (see p. 56) Ti was added as ferrotitanium in addition to the small amounts present in the zirconium alloys used. The ferrotitanium used was made by the Thermit reaction and obtained from the Metal & Thermit Co. It contained about 23.6 per cent Ti, 1.4 per cent Si, and 5.4 per cent Al.

[34] Lord, N. W., and Demorest, D. J., Metallurgical analysis: New York, 1916, p. 98.

TABLE 5.—*Titanium-zirconium steels.*

No. of heat.	Total weight charge.	Weight SiZr added.	Weight FeTi added.	Kw. h. used.	1st or 2d heat.	FeTi and SiZr added—	Number Thermit heating cans used.	Size FeTi.	Per cent Ti— Calculated.[a]	Per cent Ti— Found. Top.	Per cent Ti— Found. Butt.	Per cent Ti— Found. Av.	Per cent Ti— Recovered.
	Lbs.	*Lbs.*	*Lbs.*										
1192....	48.5	1.4	0.33	33	2d...	At end..	0	Under 8-mesh	0.15	0.15	0.15	0.15	60
1193....	48.5	1.4	.33	35	1st..	...do....	1	.....do.......	.25	.18	.23	.2	80
1196....	48.5	1.4	.33	35	1st..	...do....	0	.....do.......	.25	.12	.14	.13	50
1197....	48.5	1.4	.33	33	2d...	...do....	0	.....do.......	.25	.17	.15	.16	64
1218....	48.5	1.3	.66	40	1st..	...do....	2	.....do.......	.4	.4	.28	.36	88
1219....	48.5	1.3	.66	37½	1st..	...do....	1	.....do.......	.4	.16	.14	.15	37
1224....	48.5	1.3	.33	37½	2d...	...do....	0	.....do.......	.24	.1	.1	.1	41
1225....	48.5	1.3	.33	37½	1st..	...do....	0	.....do.......	.24	.11	.11	.11	46
Average	......	......	......	......	......	......	......	......	......	......	......	......	58

[a] Includes Ti in SiZr.

TABLE 6.—*Titanium steels.*

The following data have been obtained on titanium steels, using FeTi of about 23.6 per cent Ti, 1.4 per cent Si, 5.4 per cent Al.]

No. of heat.	Total weight charge.	Weight FeTi.	Kw. h. used.	1st or 2d heat.	FeTi added.	Size FeTi.	No. Thermit cans used.	Per cent Ti— Calculated.	Per cent Ti— Found. Top.	Per cent Ti— Found. Butt.	Per cent Ti— Found. Av.	Per cent Ti— Recovered.
	Lbs.	*Lbs.*										
1098....	50	1.75 .45 2.2	40	1st....	At start...... At end.......	Pea..........	0	.9 .2 1.1	0.29	0.22	0.25	23
1099....	50	3.95 .45 4.4	40	1st....	At start...... At end.......	....do.......	0	2 .2 2.2	.4	.32	.36	14
1100 [a] ..	50	4.4	45	1st....	At end.......	.....do.......	0	2.2	.97	.98	.98	44
1102....	50	0.22	37½	1st....	.....do.......	.....do.......	0	.1	.06	.06	.06	60
1104....	50	0.11	37½	1st....	.....do.......	.....do.......	0	.05	.04	.03	.03	60
1110....	50	5.5	45	2d.....		.....do.......	0	2.6	.54	.54	.54	21
1113 [b] ..	50	0.11	37½	1st....	After 35 kw. h.	.....do.......	0	.05	.03	.04	.03	60
1116 [c] ..	50	5.5	45	1st....	.....do.......	.....do.......	0	2.6	.54	.44	.49	19
1118....	49.5	1.05	42½	1st....	At end.......	.....do.......	0	.5	.32	.38	.35	70
1130....	50	0.8	37½	1st....	.....do.......	.....do.......	0	.4	.32	.35	.33	82
1148 [d] ..	46.5	4.4	40	1st....	.....do.......	.....do.......	1	2.3	1.45	1.53	1.49	65
1149....	46.5	2.75	40	1st....	.....do.......	.....do.......	1	1.4	.89	.92	.90	64
1150....	46.5	1.45	42½	1st....	.....do.......	.....do.......	1	.75	.53	.15	.34	50
1151....	48.5	2.75	40	1st....	.....do.......	.....do.......	1	1.4	1.04	n. d.	......	74
1152 [e] ..	46.5	2.75	40	1st....	.....do.......	.....do.......	2	1.4	.66	1.05	.85	60
1153 [f] ..	46.5	4.9	42½	1st....	.....do.......	.....do.......	2	2.5	1.7	2.03	1.86	74
1174....	48.5	1.25	35	2d.....	.....do.......	Under 8-mesh	0	.6	.28	.26	.27	45
1179 [g] ..	46.5	2.75	40	1st....	.....do.......	.....do.......	2	1.4	.76	.71	.73	52
1216....	48.5	1.65	33	1st....	.....do.......	.....do.......	1	.8	.45	.44	.45	56
1217 [h] ..	48.5	1.65	35	1st....	.....do.......	.....do.......	2	.8	.49	.40	.45	56
1242 [i] ..	50	2.6	37½	1st....	.....do.......	.....do.......	1	1.2	.59	.62	.60	50
1246....	50	2.2	42½	1st....	.....do.......	.....do.......	2	1	.45	.44	.44	44
1269....	50	2.2	35	2d.....	.....do.......	.....do.......	1	1	.67	.62	.65	69
1284....	50	1.65	37½	2d.....	.....do.......	.....do.......	2	.8	.56	.54	.65	69
Average	......	......	......	......	......	......	......	......	......	......	......	65

[a] Metal was only normally hot. FeTi did not dissolve readily, but lumped together into a ball. It was stirred around as long as possible, but it was still undissolved when the steel was so cold it had to be poured into the ladle and then at once to the mold. Two and three-fourths pounds lump of FeTi plus adhering steel remained in furnace after pouring.

[b] FeTi was added after 35 kw. h., then furnace was closed and run 10 kw. h. more.

[c] FeTi preheated before charging, added after 35 kw. h., then 10 kw. h. more run, about 2 pounds FeTi skimmed off undissolved.

[d] Metal was very hot, surface was skimmed perfectly clean and FeTi added and stirred. Charge was rather pasty, so Thermit heating can was used and metal was poured by working fast.

[e] Metal was not very hot. Fluid poured into ladle at start, but was slushy at end, though not appreciably colder.

[f] FeTi was preheated to dull red; metal not very slushy at end.

[g] Steel was faintest trace slushy at very last of pouring into mold.

[h] Owing to lining coming off and covering bath, steel was not very hot.

[i] Same conditions as on heat 1242 existed as to lining and temperature.

As is shown in heats 1098, 1099, 1110, and 1116, in which the FeTi was in the furnace some time, the recovery of Ti is low unless it is added at the end of the heat. When this is done, the recovery seems to depend mainly on the temperature, very hot steel being required to take large amounts of FeTi into solution.

Segregation appears when the steel is too cold to dissolve the addition of FeTi rapidly, but is otherwise not troublesome. The recovery of Ti from the FeTi made by Thermit reduction is far higher than that of Zr from similarly made FeZr alloys. By analogy with Zr it seems possible that a SiTi alloy would be still more readily taken up by the steel. Petinot[35] has suggested an alloy containing Ti and Si in the rate of 5 to 1 as a deoxidizer for steel, because of the fusibility of SiO_2 and TiO_2 in the proportions given by the oxidation of this 5:1 TiSi alloy. This amount of Si would probably not be large enough to make any appreciable difference in the ease with which the alloy is dissolved by steel.

In regard to the solubility of ferrotitanium and its effect on steel, see Morehead,[36] Slocum,[37] Goldschmidt,[38] Fitzgerald,[39] Yensen,[40] and Hunter.[41]

CERIUM STEELS.

Since cerium is in the same group in the periodic system as titanium and zirconium some experiments on adding cerium to steel were planned.

Before these were performed information was obtained through the courtesy of L. W. Spring, metallurgist of the Crane Co., Chicago, Ill., on some tests he had made, using Mix-metal obtained from the Fansteel Products Co., said to contain under 2 per cent of elements other than the cerium group, with about 50 per cent Ce, the balance being made up of the other elements of the group.

Moldenke[42] has studied the effect of adding 0.05, 0.10, and 0.15 per cent cerium metals to cast iron. He found that the transverse strength and the deflection were increased by the use of cerium and that the metal froze more slowly than untreated metal, thus giving less combined carbon; hence a softer, more readily machined metal is obtained.

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35 Petinot, U., U. S. Patent 1260037, Mar. 19, 1918.

36 Morehead, J. T., Discussion: Trans. Am. Electrochem. Soc., vol. 12, 1907, p. 79.

37 Slocum, C. V., Titanium in iron and steel: Trans. Electrochem. Soc., vol. 20, 1911, p. 265.

38 Goldschmidt, H., The melting point and its relation to alloying capacity: Met. and Chem. Eng., vol. 9, 1911, p. 348.

39 Fitzgerald, F. A. J., Has titanium any influence on the properties of steel: Met. and Chem. Eng., vol. 13, 1915, p. 28.

40 Yensen, R. D., Forgeability of iron-nickel alloys: Mining and Metallurgy, No. 157, sec. 9, Jan., 1920.

41 Hunter, M. A., and Bacon, J. W., Some electrical properties of titanium alloys: Trans.

42 Moldenke, R., Cerium in cast iron: Preprint of paper presented at 1919 meeting of the American Foundrymen's Assn.

Am. Electrochem. Soc., vol. 37, 1920, p. 391.

No figures are given to show whether there was any change in the percentage of sulphur or phosphorus, but he states that even when 0.50 cerium metals were added no cerium was found in the castings.

The Crane Co. tried Ce in red brass and in gray iron, and decided that it was injurious in brass (acting much like silicon) and too expensive to be of great promise in gray iron; then the company tried it in converter steel. Their results are shown in Table 7.

TABLE 7.—*Results of addition of cerium metals to converted steel.*

Blow No. of heat.	Per cent Ce—		Analysis.					Physical properties.[a]				
	Added.	Found.	Comb. C.	Si.	Mn.	S.	P.	Tensile strength.	Yield point.	Per cent elong.	Per cent red of area.	Fracture.
1565	None.	....	0.37	0.42	0.84	0.086	0.054	107,000 90,250	60,600 51,900	21.5 22	18.4 31.2	Gray cryst., fibrous.
1565	0.5′	[b] 0.16	.41	.42	.82	.043	.056	[c] 68,500 98,050	47,500 51,250	[c] 4 20	17.1 24.5	Dirty brown and gray, fibrous.
			Loss of S.........			.043						
1598	None.	....	.40	.32	.75	.088	.056	90,400 89,000	50,500 45,500	20.5 20	23.4 25.8	Two-thirds granular, fibrous.
1598	1	n. d.	.39	.33	.79	.036	.051	[c] 83,250 91,100	49,500 46,550	[c] 7 21	—— 32	Dirty, broke in shoulder, fibrous.
			Loss of S.........			.052						
1643	None.	....	.36	.30	.70	.081	.057	81,750	44,500	18	24.1	Gray fir tree.
1643	1	.44	.36	.32	.71	.027	.059	77,800	35,300	26	42.1	Fibrous.
			Loss of S.........			.054						
1826	None.	....	.37	.32	.73	.084	.063	85,050	49,750	21	25.9	Gray fir tree.
1826	1	n. d.	.36	.33	.72	.041	.063	97,250	53,600	25	32.2	Gray and fibrous.
			Loss of S.........			.043						

[a] Test bars made in keel-block form. All test bars annealed at 1,700° F. 7 hours and furnace cooled.
[b] Bureau of Mines analysis.
[c] First test bars on cerium-treated steels of heats 1565 and 1598 contained rust-colored inclusions, probably cerium oxide. Second bars cut from bottom of test block were free from inclusions.

The cerium was tossed into the stream of the metal while it was being poured from bull ladle to hand ladle. No violent reaction occurred when the cerium was added. The steel did not become "dead" as soon with cerium as without. A dross formed on top of the steel and came to the top of the riser of the mold.

As only 100 pounds of steel was used in each test, it had to be poured quickly to prevent chilling, not giving time enough for any dross formed to rise, as is shown by the dirty tensile-test bars on heats 1565 and 1598.

Microscopic examination of annealed samples showed that the steel to which cerium was added was far more uniform than the samples without it. The ferrite network usually formed by manganese sulphide inclusions was absent in the cerium-treated samples. These steels were not examined for inclusions in the unetched condition and the tiny inclusions, normal to a cerium steel, probably escaped notice in the etched sample.

Bars taken from the lower part of castings made from the cerium-treated steels were clean or at least free from macroscopic flaws; they showed marked superiority in ductility.

The most noteworthy feature was the consistent removal of S. Table 8 shows the results of four heats.

TABLE 8.—*Results of four heats of cerium-treated steel.*

Heat No.	Ce added.	Per cent S before Ce added.	Per cent S after Ce added.	Per cent S removed.	Per cent S present removed.	Per cent Ce found.	Per cent recovery of Ce.
1565	0.5	0.086	0.043	0.043	50	0.16	32
1598	1	.088	.036	.052	59	n. d.	....
1643	1	.081	.027	.054	67	.44	44
1826	1	.084	.041	.043	53	n. d.	....

Reducing the S from an average of 0.085 per cent to one of 0.037 per cent by a ladle addition is an interesting feat, and on account of the above data from the Crane Co., some attention was paid to the effect of Ce on S.

Some " Volcano " brand Mix-metal, said to contain approximately 5 per cent iron and 95 per cent cerium-group metals, was obtained in which the amounts of cerium-group metals was said to be approximately as follows:

Cerium-group metals.	Per cent.
Cerium	45
Lanthanum	25
Neodymium and praseodymium	15
Samarium	10

The lot received actually contained about 10 per cent Fe and 90 per cent of the cerium-group metals. In heats 1252 and 1253, the Mix-metal was thrown into the furnace after the melt had been skimmed, and stirred in. It floated and partly burned with sufficient violence to cause a small "popping" noise, some steel spatter being thrown about. Thereafter the Mix-metal was fastened to a bent iron rod by iron wire, and submerged in the steel, the operator standing at the side of the furnace, not in front of the door. The metal was stirred after the Mix-metal was added. In heat 1268, a silicocerium alloy, obtained through the kindness of Dr. Alcan Hirsch, was used. This was said to contain 26.7 per cent Fe, 30 per cent Si, 0.61 per cent C, 0.05 per cent S, 0.04 per cent P, and 42.3 per cent cerium metals.

Since the Armco iron used in making up the steels was already low in S (about 0.02 per cent) and very low in P (about 0.005 per cent), sulphur was added in the form of iron sulphide on heats 1256, 1257, and 1268. No aluminum was added to any of these heats, and the ingots were sound, as far as could be told on examining and drilling samples.

The results are given in Table 9.

Heat number.	Total weight charged.	Weight sample poured.	Weight left in furnace.	Kw. h. used.	1st or 2d heat.	Weight Ce alloy added.	Per cent Ce group metals— Added.[a]	Per cent Ce group metals— Found. Top.	Per cent Ce group metals— Found. Butt.	Per cent Ce group metals— Found. Average.	Per cent recovery Ce metals.	Per cent S— Before Ce in sample.	Per cent S— After Ce in ingot. Top.	Per cent S— After Ce in ingot. Butt.	Per cent S— After Ce in ingot. Average.	Remarks.
	Pounds.	*Pounds.*	*Pounds.*			*Pounds.*										
1252	50	....	....	40	1st....	0.83	1.50	0.55	0.35	0.45	30	....	....	....	....	A brownish orange slag, evidently containing cerium oxide, was formed, a little clinging to the furnace walls after the steel was poured, and more of it being continually formed in the ladle while the metal was held for degasification. This was noted in all the heats to which 0.5 to 1.5 per cent Ce was added.
1253	50	....	....	87½	2d.....	.57	1.02	.22	.07	.15	14	....	....	....	....	Do.
1256	50	5	51	37½	1st....	.57	[a] 1	.06	.06	.06	6	0.155	0.068	0.066	0.067	Metal was allowed to stand in ladle until almost too cold to pour well, to allow dross to rise. Strong odor of SO_2 was noted as soon as Ce was added to the metal, persisting until the steel was poured. Probably 2½ to 3 minutes elapsed between adding Ce and pouring it into the mold.
1257	55	5.5	49.5	37½	1st....	.27	[a].52	.10	.09	.09	18	.085	.046	.043	.045	1½ minutes between adding Ce and pouring into mold. SO_2 odor was very faint.
1258	50	....	....	32½	2d.....	.86	1.54	1.35	.66	1	65	....	....	....	....	
1259	50	....	....	39	1st....	.40	.72	.31	.19	.25	35	....	....	....	....	
1260	50	....	....	32½	2d.....	.01	.02	.012	.008	.01	50	....	....	....	....	Ce was used as deoxidizer only, added in ladle. Metal was wilder than usual in ladle, and took longer to become dead, but the steel was sound.
1268	55	2	53	40	1st....	[b].88	.70	.20	.20	.20	28	.035	.025	.015	.020	Silicocerium was added in pea size and dissolved in steel readily. Not more than one minute passed between adding SiCe and pouring steel into mold. No SO_2 odor was noted.
1272	50	....	....	32½	2d.....	.56	1.01	.35	.35	.35	35	....	....	....	....	
1281	50	....	....	32½	2d.....	[c].025	.04	....	.03	....	75	....	....	....	....	Ce used as deoxidizer only in ladle, metal quiet at once after Ce was added. Steel was sound.
1332	71	....	....	52½	1st....	.115	.91	.54	.22	.38	42	.030	.024	.026	.025	
1333	71	....	....	52½	1st....	.116	1.05	.58	.33	.45	43	.029	.021	.009	.015	

[a] On basis of metal left in furnace.

[b] Silicocerium alloy.

[c] Part Mix metal, part CeFe alloy.

RECOVERY OF CERIUM.

In all heats, except that in which steel 1375 was manufactured, where 0.10 per cent Ce or more was found in the finished steel, the fresh drillings had a noticeable odor, like acetylene, perhaps indicating that some, at least, of the cerium metals are probably present as carbide.

Appreciable segregation of Ce metals will be noted in several of these heats, and where this did occur more Ce was in the top of the ingot than in the butt, although the specific gravity of the cerium metals is not very much lower than that of steel. Addition of the Ce metals, in the form of ferrocerium or silicocerium, might possibly decrease segregation. None occurred in heat 1268, where silicocerium was used. When 0.7 to 1.5 per cent Ce was added to steel low in S, the recovery of Ce averaged about 33 per cent.

There was an elimination of S, as shown in Table 10.

TABLE 10.—*Elimination of sulphur from steels.*

No. of heat.	Ce added.	S before Ce added.	S after Ce added.	S removed.	S present removed.	Recovery of Ce.	Time elapsed from addition of Ce to pouring into mold.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Minutes.*
1256	1	0.155	0.067	0.088	57	6	2.75
1257	.52	.085	.045	.040	47	18	1.5
1268	[a].70	.035	.020	.015	43	28	1±

[a] As silicocerium.

The more S there was removed the lower was the recovery of Ce. When a good deal of S was removed, there was a strong odor of SO_2, as if the S were taken out as cerium sulphide, which then rose as slag, some of the S being burned out in the air.

It was deemed possible that if the cerium were added to the molten metal and the metal held molten for a long time, the desulphurization might be more complete, therefore a couple of runs were made using as a base scrap steel containing about 0.10 to 0.11 per cent S and about 0.12 per cent P. More S was added as FeS. After the metal was melted, the furnace was opened, a sample poured, the Mix-metal added, the furnace at once closed tightly, and the heat continued. The data are given in Table 11.

TABLE 11.—*Tests showing effect of addition of cerium on desulphurization.*

Heat No.	Total weight charged.	Total kw. h. used.	1st or 2d heat.	Weight Mix-metal added.	Mix-metal added—	Time from adding Ce to pouring.	Weight sample poured.	Weight left in furnace.	Ce metals added.[a]	Ce metals found, per cent.			Re-covery of Ce.	S be-fore Ce added.	S after Ce added, per cent.		
										Top.	Butt.	Aver-age.			Top.	Butt.	Aver-age.
	Pounds.			*Pounds.*		*Min-utes.*	*Pounds.*	*Pounds.*	*Per cent.*				*Per cent.*	*Per cent.*			
1287	55	40	1st......	0.62	After 30 kw. h.....	17	3	52	1.08	None.	None.	0	0	0.135	0.101	0.108	0.105
1288	55	42½	1st......	.33	.....do............	26	3	52	.57	None.	None.	0	0	.144	.127	.131	.129

[a] On basis of metal left in furnace.

As soon as the Mix-metal was added to the steel in the furnace (in heats 1287 and 1288) a strong SO_2 odor was noted. While steel 1287 was being held in the ladle, a faint odor of SO_2 was noted, and while 1288 was held, the faintest odor was perceptible.

It was thought possible that in heats 1287 and 1288 the cerium might have been used up in eliminating phosphorus, since the scrap used was very high in P. Analysis showed, however that on both steels the sample taken before the cerium was added, the tops, and the butts of the ingot all contained the same amount of P—0.1 per cent.

In order to try cerium from more than one source, some "Cela iron" was obtained from the Fansteel Products Co. This was said to contain about 30 per cent iron, 70 per cent cerium metals (42 per cent cerium, 14 per cent lanthanum, and 14 per cent neo- and praseodymium). This was in shotted form, obtained by pouring the alloy into water. The Fansteel Co. stated that they believed this lot of alloy contained a good deal of oxide, due to shotting in water.

Two heats—1294 and 1295—were made as follows: Into the hot furnace was charged 51 pounds of scrap steel (such as was used in runs 1287 and 1288, but no extra iron sulphide was added), 4¾ pounds washed metal, and ¼ pound ferrosilicon.

After the metal was fully molten, a sample was poured for analysis, 3 pounds for heat 1294, 5½ pounds for heat 1295, and 0.83 pound Cela iron added and well stirred in. It went into the bath readily, without spattering. A few tiny flames or sparks were noted as it was stirred in. In heat 1294 the furnace door was at once put on, luted up tightly, and the arc started, every effort being made to keep a reducing atmosphere. In heat 1295 the door was not luted up, but the pouring spout and large cracks between door and furnace were kept open, and a slow stream of air was blown into the spout through an iron pipe, in order to keep the atmosphere at least partly oxidizing. In both tests nine minutes elapsed between adding the ferrocerium and pouring. Both runs were made exactly the same as to time and power consumption. A slight SO_2 odor was noted while heat 1294 was being poured and while the ladle was being skimmed. There was a thin slag on the metal. Both ingots were sound.

No final additions of any sort were made to heat 1294. The metal was perfectly quiet.

On steel 1295 there was noted only a trace of SO_2 while skimming from the ladle a little characteristic red cerium slag. On this heat the metal was wild, and 0.02 per cent Al was added to the top of the ladle after it had been poured. It was held as long as possible in the ladle and became practically quiet before pouring. It was poured before the ladle started to skull.

COMPOSITION OF SOME STEELS WITH CERIUM ALLOYS.

Assuming that the scrap steel all had the composition shown by a random sample, which may not be true, as it was in rather large pieces not necessarily all from the same lot, the calculated composition of the steel is as shown below:

Composition of steel 1294.

Constituents.	Calculated composition of sample.	1294 found in sample.	Calculated composition of ingot.	Found in ingot.[a]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.38	0.37	0.38	0.35
Si	.19	.21	.19	.18
Mn	.40	.41	.40	.41
S	.10	.104	.10	[b].033
P	.11	.102	.11	.105
Ce metals	....	....	[c]1.07	.04

[a] Samples of ingots 1294 to 1298 were made up of equal parts of drillings from top and butt.
[b] 0.067 removed.
[c] Added after taking sample; percentage of Ce metals in 1294 to 1298 is calculated on amount of steel left in the furnace after the sample is poured.

Composition of steel 1295.

Constituents.	Calculated composition of sample.	1295 found in sample.	Calculated composition of ingot.	Found in ingot.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.38	0.27	0.38	0.25
Si	.19	.23	.19	.20
Mn	.40	.31	.40	.30
S	.10	.104	.10	[a].077
P	.11	.101	.11	.10
Ce metals	....	....	[b]1.12	None.
Al	....	....	[c].02	n. d.

[a] 0.027 removed.
[b] Added after taking sample.
[c] Added in ladle.

Two more heats were then made, using in each 50 pounds of Armco iron of less than 0.01 per cent P, of 0.037 per cent S, of only a trace of Si, about 0.01 per cent C, and about 0.02 per cent Mn. Washed metal sufficient to bring the calculated carbon to 0.37 per cent ferrosilicon, and ferromanganese to bring the Si to 0.2 per cent and the Mn to 0.41 per cent, were added when the heats were started. Iron sulphide was also added at the start in amount sufficient to bring the calculated S to 0.093 in heat 1296 and 0.063 in heat 1297. These were run on the same time and power schedule as heats 1294 and 1295, a sample being poured, the ferrocerium (Cela iron) added and stirred in, the door at once replaced and luted in, and heating continued nine minutes.

Composition of steel 1296.

Constituents.	Calculated composition of sample.	1296 found in sample.	Calculated composition of ingot.	Found in ingot.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.37	0.22	0.37	0.26
Si	.20	.08	.20	08
Mn	.41	[a] .15	.41	[a] .26
S	.093	[a] .079	.093	.093
P	.01	n. d.	.01	n. d.
Ce metals	....	....	[b] .50	None.

[a] See note on steel 1298, p. 66.
[b] Added after sample was poured.

The metal was wild when the sample was poured. When the final steel was poured the metal was very hot and had a little red slag upon it and there was a very slight SO_2 odor when the furnace was opened, though none later. The metal was allowed to stand in the ladle and was quiet when poured. This was done before any skulling began. The metal was quiet in the mold until it began to freeze; then it effervesced violently and rose. The ingot was unsound clear to the butt. No Al or Ce was added to the ladle.

Composition of steel 1297.

Constituents.	Calculated composition of sample.	1294 found in sample.	Calculated composition of ingot.	Found in ingot.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.37	0.16	0.37	0.24
Si	.20	.06	.20	.04
Mn	.41	.23	.41	.23
S	.063	.067	.063	.064
P	.01	n. d.	.01	n. d.
Ce metals	....	....	[a] .24 [b] .03 .27	.015

[a] In furnace. [b] In ladle.

This heat was run like heat 1296, save that it was rather wild in the ladle, and 0.03 per cent Ce metals (but no Al) was added to the top of the ladle and stirred in. The metal then quieted, but effervesced and rose in the mold just as steel 1294 did, and the ingot was unsound clear to the butt.

No odor of SO_2 was noted save a suspicion of an odor on knocking off the metal within the hot-top after the ingot had frozen.

Another heat was then made, using Armco iron and washed metal as before, but adding no iron sulphide, adding the same amount of ferrosilicon, but only about two-thirds the amount of ferromanganese, pouring a sample, adding 0.28 per cent Ce metals (as Cela iron), closing the furnace, running it nine minutes more, then adding the other one-third of the ferromanganese and an extra 0.10 per cent Si as ferrosilicon, besides 0.06 per cent Ce, to the metal in the furnace. Nothing was added to the ladle.

Composition of steel 1298.

Constituents.	Calculated composition of sample.	1298 found in sample.	Calculated composition of ingot.	Found in ingot.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.37	1.01	0.37	0.25
Si	.20	.03	.30	.13
Mn	.27	[a].05	.41	.31
S	.038	.046	.038	.043
P	.01	n. d.	.01	n. d.
Ce metals	....	....	[b].28 [c].06 — .34	.02

[a] This manganese figure is, of course, impossible, as are those for S and Mn on the sample taken in 1296, but all these figures have been checked. The samples were small, were a mass of blowholes, and show much oxidation. It hardly seems possible that the manganese was not diffused through the melt so that the sample poured from the top was not representative, nor that the discrepancy is due to oxidation of the sample, but these are the only explanations that have been suggested.

[b] 9 minutes before end.

[c] At end.

A faint SO_2 odor was thought to be detected only just after the addition of the 0.28 per cent Ce metals to the furnace. The metal was hot and quiet in the ladle and was poured just after slight skulling began.

The metal evolved some gas in the mold and showed signs of wanting to rise. It was just between effervescence and quietness. The ingot was full of blowholes at the top, but almost free from them at the butt.

In some previous runs (starting with Armco iron) on high-silicon, high-manganese nickel steels (1260 and 1281) in which about 0.20 per cent Si and 0.30 per cent Mn were added at the end to "swamp the gases," and 0.02 and 0.04 per cent Ce metals, respectively, were added in the ladle, to take the place of the usual 0.01 or 0.02 per cent Al as final deoxidizer, the steels contained, respectively, 0.01 and 0.03 per cent Ce metals and were sound, although steel 1260 gave off a trace of gas in the mold. Those runs made it appear that Ce was almost as good a deoxidizer as Al. Runs 1296 to 1298 indicate that it is not.

Considering heats 1294 to 1298, it is seen that in heat 1294, on the remelt of a steel previously containing its Si and Mn alloyed with it, the addition of 1 per cent Ce metals, allowed to act for nine minutes, reduced the S greatly. In heat 1295, like heat 1294, save that air was blown in after the Ce was added, which would tend to oxidize the Ce and use it up, a slighter, though marked desulphurization took place with 1 per cent Ce.

In heats 1296, 1297, and 1298, the iron had not been previously alloyed with Si and Mn, and there was a large loss of these elements. These three steels were quite evidently not sufficiently "killed" before the Ce was added, and no appreciable desulphurization took place, even though the last two contained small amounts of residual Ce.

DESULPHURIZATION TESTS.

The steel must be carefully deoxidized and degasified, it appears, before the Ce is added. On this assumption, a material desulphurization without using some excess Ce seems unlikely, so that an appreciable amount would be left in the final steel. There would then be two questions remaining—first, how much Ce will it take to lower the S in a given steel from the given S content to the desired point, and how much Ce will remain in the steel? Second, how will this residual Ce affect the properties of the steel?

To test the desulphurization in a thoroughly deoxidized steel, another heat—1301—was made as follows: A steel calculating C, 0.37 per cent; Si, 0.20 per cent; Mn, 0.43 per cent; S, 0.066 per cent; P, 0.01 per cent; and Al, 0.03 per cent, was made up from Armco iron, washed metal, ferrosilicon, ferromanganese, and iron sulphide, melted on the usual schedule, and the furnace then opened, skimmed, and 0.13 per cent more silicon, 0.12 per cent more manganese, and 0.03 per cent aluminum added and stirred in, the sample then poured, 0.36 per cent Ce metals then added as Cela iron and stirred in, the furnace closed and run nine minutes more. The steel was then poured into the ladle onto an additional 0.02 per cent Al.

The idea was to "kill" the steel in the furnace by additions of ferromanganese, ferrosilicon, and aluminum before the cerium was added, leaving the cerium free to confine its attention to desulphurization and not to deoxidation. This heat was run on the same time and power schedule as the previous ones.

No SO_2 odor was noted at any time. Both the sample and the ingot were sound.

Composition of steel 1301.

Constituents.	Calculated composition.	Sample.	Calculated.	Ingot.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.37	0.20		0.31
Si	.33	n. d.		n. d.
Mn	.55	.40		.40
S	.066	.067		.064
Ce			0.36	.01
P below	.01			

In the preparation of the Ithaca-Halcomb series of Navy steels two cerium steels gave the following:

Comparison of two cerium steels.

Heat number.	Calculated.						Found.					
	C	Si.	Mn.	Ni.	S.	Ce.	C.	Si.	Mn.	Ni.	S.	Ce.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1332	0.52	1.68	1.00	3.00	0.029	[a] 1.50	0.43	1.77	0.78	2.78	0.024T .026B	0.54T .22B
1333	.52	2.49	.99	3.00	.029	[b] 1.64	.43	2.54	.91	2.86	.021T .009B	.58T .33B

[a] Half from Mix-metal, half from Cela iron.
[b] All Mix-metal.

These were cast into 6 by 3 inch molds, no hot-top being used. Steel 1332 weighed 70½ pounds; steel 1333, 66 pounds. A faint SO_2 odor was noted after the Ce was added to steel 1333, but none was noted on steel 1332. The analysis shows a desulphurization on steel 1333, the sulphur being higher in the top than in the bottom of the ingot, whereas the desulphurization on steel 1332 is barely appreciable.

Allison and Rock [44] cite some tests on converter steel for castings to which 0.10 and 0.15 per cent cerium-lanthanum were added. The physical tests showed no favorable effect due to cerium. According to a private communication from Allison and Rock, there was no desulphurization.

In 1919, the Crucible Steel Co. made a few heats of cerium steels which showed myriads of tiny inclusions, supposed to be cerium-oxide spots. Samples were sent to Watertown Arsenal to have the count of the spots checked. The inclusions ran from 200,000 to 900,000 per square inch and were extremely tiny, globular, and disseminated all through the steel.

Through the Fansteel Co. data have been received on tests of Mix-metal in open-hearth steel made by a large steel foundry that does not wish its name used. The Mix-metal was said to contain 30 per cent iron-balance cerium.

These steels were of about 0.30 per cent C, 0.60 per cent Mn, 0.25 per cent Si, 0.04 per cent S, and 0.04 per cent P, with none, 1, 2, 3, 6, 8, and 12 ounces of cerium per ton; that is, 0.003 to 0.14 per cent cerium. The physical properties showed no effect due to cerium. It was stated that the cerium steels showed fewer inclusions, and larger ones than in the steel free from cerium, the cerium being thought to cause coalescing of the inclusions. The S content on the cerium-free steel was 0.043 per cent, whereas that on the cerium-treated steels, presumably from similar raw materials and similarly treated save

[44] Allison, F. G., and Rock, M. M., Studies of the microstructure of cast steel: Chem. and Met. Eng., vol. 23, 1920, p. 383.

for the final Ce addition, ran from 0.037 to 0.046 per cent. that is, no desulphurization is indicated.

No data on segregation of Ce have been secured from any outside source. Taking the average Ce as the mean of analyses from top and butt we have a recovery of 25 to 40 per cent on the average when the cerium is added last. When much over 0.3 per cent Ce is present there is, even in a small 50 to 100 pound ingot, a distinct segregation, cerium being higher in the top and lower in the bottom of the ingot. A similar segregation is the rule in zirconium steels.

No desulphurization has been noted when less than 0.5 per cent Ce was added in the Bureau of Mines experiments, and none of the outside tests in which Ce has been used in tiny amounts as a scavenger have showed desulphurization. With 0.5 per cent and above, the Crane test and several of the bureau tests show a marked desulphurization, but other tests which were attempted to be run uniformly with those that did show it show none at all.

When desulphurization occurs it appears to be a true desulphurization, not an error in analysis. The presence of Zr in steel, like that of Ti, causes low results in determining S by evolution, but the evolution and the gravimetric methods agree, as is shown by Table 11.

TABLE 12.—*Determination of sulphur by evolution and by gravimetric method.*

Heat No.	S sample.	S by evolution.	S by gravimetric method.
		Per cent.	*Per cent.*
1256	S sample	0.156	0.155
1256 T		.069	.068
1256 B		.067	.066
1257	S sample	.086	.080
1257 T		.051	.046
1257 B		.045	.043
1268	S sample	.037	.034
1268 T		.028	.019
1268 B		.014	.011
1375 T		.021	.022
1375 B		.013	.009

COOPERATIVE TESTS WITH WELSBACH CO.

In the cooperative tests with the Welsbach Co. steels were made in heats of about 90 pounds, the cerium (New Process Metals Co.'s Mix-metal) being added just before the melt was poured from the furnace, and the steel allowed to stand in the ladle until it was thoroughly quiet.

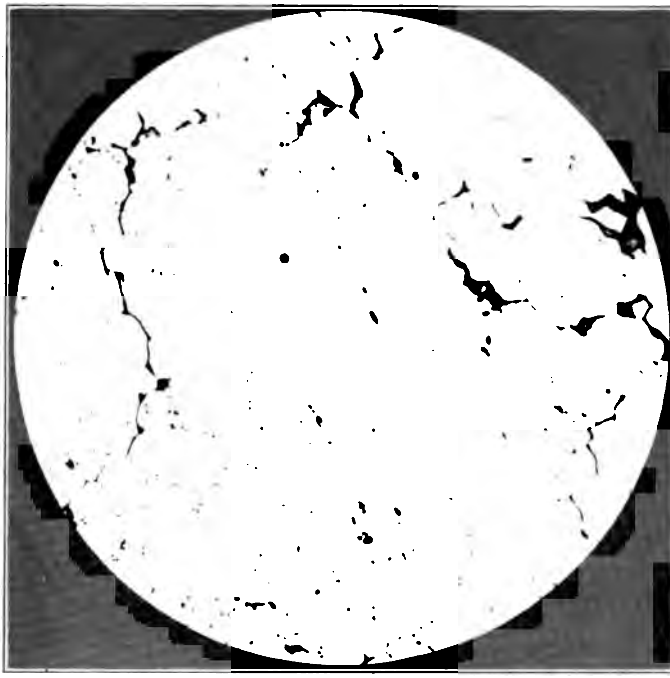
In polishing the cropped ends of the ingots of cerium steel made in the cooperative work with the Welsbach Co. for macro-etching, to see if there was any ingotism, it was discovered that one or more hair cracks had appeared in some ingots. The bottoms of the ingots were then cropped, polished, and examined as well.

The composition of this series of Ce steels was as follows:

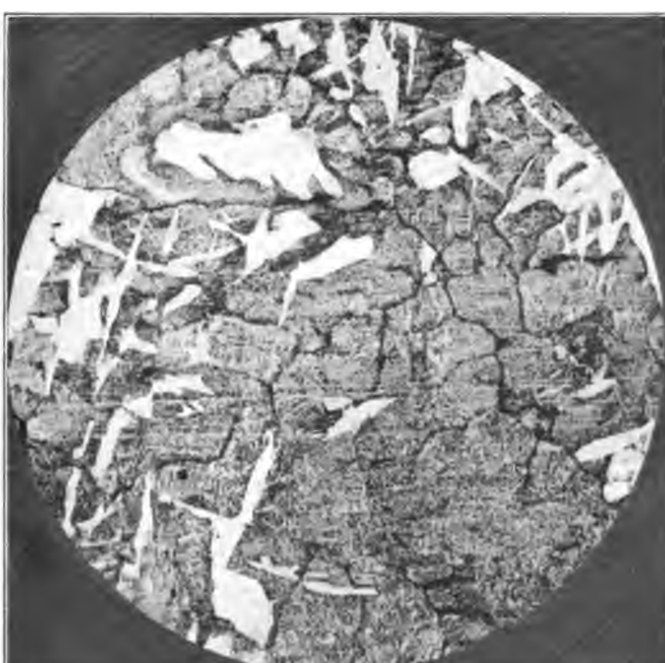
TABLE 13.—*Cerium steels made in cooperation with Welsbach Co.*

Heat No.[a]	Series No.	C.	Si.	Mn.	S.	P.	Ni.	Cr.	Ce.[b]	Ce used.	Results as to cracks.
1338 A	4	0.38	0.32	0.71	n. d.	n. d.	nil.	nil.	n. d.	1.7	Mass of fine cracks in center of butt, ingots discarded.
1339 A	5	.38	.35	.68	0.016 T; .007 B	0.008	nil.	nil.	0.61 T; .41 B	1.7	Very tiny cracks on top, hardly discernable; inclusions large; several very small cracks on butt. Ingot rolled.
1347 A	13	.41	.27	.64	.019 T; .007 B	.012	nil.	0.98	.34 T; .32 B	1.4	Showed cracks on top, but not on butt. Ingots rolled.
1347 B	14	.41	.27	.64	.021 T; .007 B	.01	nil.	.99	.50 T; .41 B		
1352 A and B[c]	19	n. d.	n. d.	n. d.	n. d.	n. d.	1.5±	.75±	n. d.	1.3	Both ingots showed cracks both on top and butt. Ingots discarded.
1357 B	25	.43	.35	.58	.017 T; .017 B	.008	2.47	.95	.22 T; .25 B	1	No cracks found on polished faces. After deep etching one hair crack appeared on ingot top. Ingot rolled.
1363 [d]	31	.42	n. d.	n. d.	n. d.	n. d.	nil.	1±	n. d.	1	6 by 3 inch ingot. Several approximately parallel cracks were found across the short width of the ingot top. Inclusions large. Ingot discarded.
1365 A	20	.41	.33	.63	.031 T; .006 B	.007	1.17	.77	.25 T; .25 B	1 (B)	Tiny hair cracks on top and butt opening up on deep etching. Ingot rolled.
1370 [e]	36	.36	.34	.66	.012 T; .012 B	.012	2.46	.92	.18 T; .19 B	1	6 by 3 inch ingot. No cracks. Inclusions mostly small.
1374 A [f]	52	.54	.48	.84	.013 T; .011 B	.006	1.02	.84	.42 T; .36 B	.6	No cracks.
1375 A [g]	53	.31	.55	.07	.020 T; .009 B	.003	nil.	nil.	.15 T; .13 B	1	Do.
1376 A [h]	54	.30	.65	.06	.032 T; .032 B	.005	nil.	nil.	.04 T; .05 B	1.1	Do.

[a] A means the first 3 by 3 inch ingot poured, B the second.
[b] Acknowledgment is made to J. P. Bonardi, formerly of the Bureau of Mines, for some of the cerium analyses.
[c] A and B ingots both cracked, no analytical determinations. Ni and Cr figures are amounts added, probably contains about 0.4 per cent C, 0.3 per cent Si, and 0.65 per cent Mn.
[d] Cracked ingot, C only determined. Cr figure is amount added, probably contains about 0.3 per cent Si, 0.65 per cent Mn, 6 by 3 inch ingot.
[e] 6 by 3 inch ingot.
[f] This steel was poured cold, being dumped from furnace to ladle and from ladle to mold as rapidly as possible. It gave a high cerium recovery and did not crack.
[g] Calculated sulphur content of charge, 0.028 per cent.
[h] Calculated sulphur content of charge, 0.069 per cent.



A. HEAT 1338, INGOT A, BUTT, CERIUM STEEL, UNETCHED, SHOWING CRACKS. MAGNIFICATION 100 DIAMETERS.



B. SAME AS *A*, HNO_3 ETCH, SHOWING CRACKS AT GRAIN BOUNDARIES. MAGNIFICATION 100 DIAMETERS.

A. HEAT 1347. INGOT A, BUTT, CHROMIUM-CERIUM STEEL HNO_3 ETCH, SHOWING GLOBULAR INCLUSIONS MOSTLY AT GRAIN BOUNDARIES, BUT NO DEFINITE CRACKS. MAGNIFICATION 100 DIAMETERS.

B. HEAT 1347, INGOT B, TOP, CHROMIUM-CERIUM STEEL, UNETCHED, SHOWING CRACKS. MAGNIFICATION 100 DIAMETERS.

Heats 1338, 1339, 1347, and 1352, in which 1.7 to 1.3 per cent Mix-metal was added, were a trifle slushy. None of the cracks extended to the edges of the ingots, but appeared only at or near the center. None of the cracks were visible on a machined surface, and without magnification most of them were hard to detect on a ground and polished surface. The ingots with the tiniest cracks were rolled to ascertain whether the cracks would weld up in rolling.

On the ingots which did not crack there were globular inclusions ranging from very small ones, very close together, to much larger ones, farther apart. The tiny inclusions had coalesced in the cracked ingots to a greater or less extent, and nearly all globular inclusions were large. Most of the inclusions in the cracked ingots were, however, collected into the cracks, and appeared to be the cause of the cracks. These cracks appeared at the grain boundaries, and the material in the cracks is gray, looking like manganese sulphide. It would seem that there may be a cerium-manganese sulphide which has a low melting point, is the last thing to freeze, and is therefore mainly rejected to the grain boundaries, forming a line of weakness that causes a crack as the ingot solidifies and cools.

No cracks were found in any of the companion ingots which did not contain cerium, although quite a number were examined. These companion ingots contained around 0.65 per cent Mn and 0.017 to 0.038 per cent S, averaging about 0.025 per cent S; that is, they were much higher in S than most of the cracked ingots, particularly the butts of the ingots.

Desulphurization may be due to the formation of a readily fusible cerium sulphide (or cerium-manganese sulphide) which rises to the surface of the melt, burning in the air to SO_2 and cerium oxide. It may be due to some other cerium-group element in the Mix-metal. That there is a tendency for a sulphide to rise is clearly indicated by the fact that sulphur is often much lower in the butt than in the top.

The rising of this assumed complex sulphide may also account for the fact that the cracked ingots showed more and wider cracks on the top than on the butt.

Plates II, *A* and *B*; III, *A* and *B*; IV, *A* and *B*; and V, *A* and *B*, show typical cracks and inclusions.

Most of the cerium steels showed secondary pipe below the primary pipe, and had to be cropped deeper than other similar steels without cerium. This fact, combined with the trouble from cracking, the much dirtier appearance of the cerium steels than that of similar steels without cerium, the low recovery of cerium and its cost, all militate against the possibility of the commercial use of cerium, unless it confers exceptional physical properties. Nevertheless, the desulphurizing action of cerium or the cerium group of metals is interesting from the theoretical point of view.

TESTS TO DETERMINE CONTROL OF SULPHUR BY CERIUM.

On the theory that cerium enters a complex cerium-manganese sulphide, it seemed possible that cerium might control sulphur just as manganese does, and do so in the absence of manganese. It was, therefore, thought worth while to make up a couple of steels, using cerium, and holding the manganese as low as possible.

Steels 1375 (series 53) and 1376 (series 54) were so made up, using Armco iron, washed metal, ferrosilicon, and Mix-metal.

Calculated and found constituents of steels 1375 and 1376.

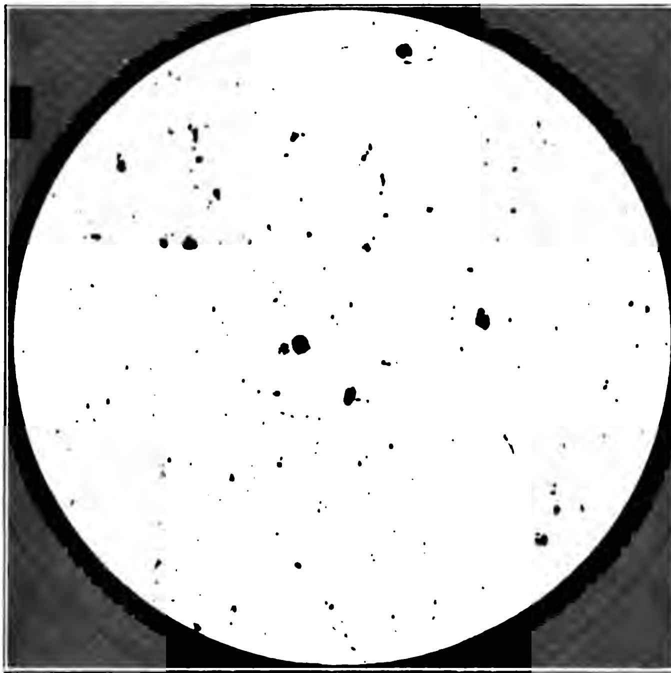
Constituents.	Steel 1375.		Steel 1376.	
	Calculated for no loss.	Found.	Calculated for no loss.	Found.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	0.44	0.31	0.44	0.30
Si	.40	.55	.40	.65
Mn	.03	.05 T .07 M .08 B	.03	.06 T .07 M .06 B
S	.028	.020 T .009 M .009 B	0.69	.032 T, M, B
P	.007	.003	.007	.005
Cu	.03	n. d.	.03	n. d.
Ce	1	.15 T .13 B	1.10	.05 T, M, B

The furnace was thoroughly cleaned and fresh hearth lining put in before these steels were made. No aluminum was used. On account of the low Mn, the Si was raised a trifle to aid in deoxidation, and more Si was evidently reduced from the fire-clay bond in the fresh alundum-cement lining.

Steel 1375 had no S in addition to that contained in the raw materials, but iron sulphide was added to steel 1376 (with the rest of the charge). Half the ferrosilicon was added at the start. After the charge was melted and at pouring temperature, the melt was thoroughly skimmed, the other half of the ferrosilicon added, and the Mix-metal added and stirred in.

On steel 1375 one minute elapsed between adding the Mix-metal and pouring the mixture into the ladle and four minutes more before pouring into the mold. The metal was poured at 1,610°. No SO_2 odor was noted. The metal was thoroughly "dead."

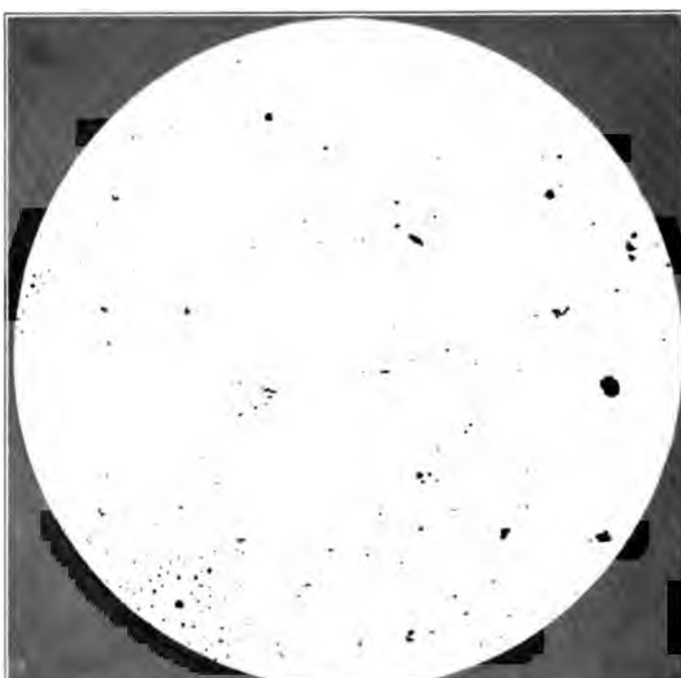
On steel 1376 one minute elapsed between adding the Mix-metal and pouring the mixture into the ladle and three minutes more before pouring into the mold. The metal was poured at 1,610°. A slight SO_2 odor



A. HEAT 1347, INGOT B, BUTT. CHROMIUM-CERIUM STEEL, UNETCHED, SHOWING INCLUSIONS AND ABSENCE OF CRACKS. MAGNIFICATION 100 DIAMETERS.

B. HEAT 1352, INGOT A, TOP, NICKEL-CHROMIUM-CERIUM STEEL, UNETCHED, SHOWING CRACKS. MAGNIFICATION 100 DIAMETERS.

A. HEAT 1363, TOP OF INGOT, CHROMIUM-CERIUM STEL, UNETCHED, SHOWING CRACKS. MAGNIFICATION 100 DIAMETERS.



B. HEAT 1370, TOP OF INGOT, NICKEL-CHROMIUM-CERIUM STEEL, UNETCHED, SHOWING INCLUSIONS AND ABSENCE OF CRACKS. NOTE PATCH OF TINY INCLUSIONS GROUPED ABOUT A LARGER INCLUSION LYING IN A SMALL AREA FREE FROM INCLUSIONS AS IF THE TINY INCLUSIONS WERE COALESCING WHEN THE STEEL FROZE. MAGNIFICATION 100 DIAMETERS.

was noted after the Mix-metal was added. The metal was thoroughly "dead."

Considering the analyses, there is found a normal or slightly greater than normal drop in carbon, a pick-up of silicon, probably from the lining, and a pick-up of manganese which is difficult to account for. The maker's analysis of the Armco iron was 0.015 per cent Mn. The Bureau of Mines analysis of a random sample gave 0.037 per cent Mn. The washed metal contained only a trace of Mn, on a random sample, as it was supposed to do. No Mn was found in the Mix-metal, and the ferrosilicon would have had to contain 5 per cent Mn to supply the picked-up manganese, which is out of the question. There was no steel left in the furnace from previous heats, as the inside lining was purposely chipped out and replaced by fresh.

The Mn analyses for the steel are correct, having been checked repeatedly for every sample (top, middle, and butt) by two methods. It seems probable that the Mn in the Armco must have run high.

This pick-up of Mn is regrettable, because it was hoped to secure a steel with Mn below the amount needed to combine with S as MnS.

The S found in steel 1375 requires 0.035 per cent Mn, top, and 0.012 per cent Mn, middle and butt, and 0.05 to 0.08 per cent Mn was present.

The S found in steel 1376 requires 0.055 per cent Mn, and 0.06 to 0.07 per cent was present, so that even in steel 1376 there was, at the end, a very small amount of Mn above that required to form MnS. Although more S was present in the charge than would form MnS with the Mn present, this Mn content is extremely low for a soft steel. In high-speed steel, manganese is held as low as possible, but even in such steel there is usually at least six times as much Mn as S. Levy, quoted by Sauveur,[45] says that on account of mass action, more Mn than corresponds to MnS is required to bind all the S as MnS and prevent the presence of FeS. Most metallurgists would expect steel 1376 to be decidedly red-short.

On steel 1375 the S came down from a calculated 0.028 to an average of 0.012, and on steel 1376 from 0.069 to 0.032.

The Ce recovery was very low, being only 5 per cent on steel 1376, in which more S was removed. These heats were held in the ladle quite a long time for so small heats (60 pounds), which probably tends toward a high loss of Ce.

The lower halves of each ingot were forged down from the 3 by 3 inch ingot to seven-eighths inch round under a steam hammer in a small local shop where they received no special care. They showed no sign of red-shortness and forged as well as any good 0.30 per cent C steel. The blacksmith said they acted like good stuff.

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[45] Sauveur, Albert, Metallurgy and heat treatment of iron and steel: Cambridge, Mass., 1918, p. 146.

A very remarkable feature of the boron steels was that while the steel was freezing in the mold it had, for a very long period, a peculiar consistency. As the fluid started to cool it would first be like molasses, then like dough or modeling wax. Then the top of the ingot within the hot-top was poked to keep a hole open into the pipe for the escape of gas, the steel could be poked into any shape desired and the shape would be retained, acting as pie crust does when the fluted border is put on with the thumb.

This plasticity is retained far below the solidifying point of ordinary steel, apparently down to approximately the melting point of cast iron or even below. The steels poured fluidly, the plasticity shown in the mold apparently being due to a very different cause from the slushiness shown while pouring some of the steels high in uranium, which acted as if material was held in suspension.

Two other steels were made up, calculated to contain respectively 0.73 and 0.20 per cent B, and containing respectively 0.15 and 0.32 per cent C, which the Bureau of Standards attempted to roll. When the ingots were heated to the usual temperature for hot rolling, and were seized at one end by the tongs for lifting them from the preheating furnace, these two ingots dropped to pieces of their own weight. It was necessary to lower the preheating temperature materially in order to roll the other ingots of B steel. These two ingots were not analyzed for boron.

Even less than 0.1 per cent B seems to be sufficient, over a range of 0.15 to 0.7 per cent C, to produce the plasticity while freezing, and to render the ingots hot-short in rolling unless the rolling temperature is reduced from the normal.

It is probable that boron forms a very low melting eutectic with carbon, so that the range between the liquidus and solidus of a steel containing boron is enormously increased. In addition to work on the melting point of ferroboron, the Bureau of Standards has planned to determine the melting points, or melting ranges, of the boron steels made. The results of this work, when available, should throw light on the cause of the plasticity.

Boron appears to confer marked hardness on steel. If the other physical properties of the boron steels are good enough to be applicable to commercial use, their remarkable plasticity at temperatures below the melting points of ordinary steels might make it possible to utilize this characteristic.

SUMMARY.

A cheap, experimental indirect-arc furnace has been designed and constructed for making up small experimental heats of alloy steels in which no refining slags are made. In this furnace some 375 heats of simple and complex alloy steels have been made in sufficiently close agreement with widely divergent chemical specifications.

The addition to steel of such alloying elements as tungsten, uranium, vanadium, chromium, molybdenum, nickel, silicon, manganese, zirconium, titanium, aluminium, cerium, boron, and copper has been quantitatively studied with especial reference to alloy recovery.

The recovery of tungsten, molybdenum, chromium, nickel, and copper, and of vanadium in amounts up to about 1 per cent, has been found to be practically quantitative when the ferro-alloy or metal is added to the furnace charge at the beginning of a heat.

With uranium, which is more easily oxidized than the elements mentioned above, the recovery has been shown to be somewhat erratic, but in general the best recovery was obtained by using a low-carbon ferro of 40 to 60 per cent uranium content, with the steel sufficiently superheated and the ferro added in the ladle or to the furnace after the heat is finished. Adding the ferro to the bath in the furnace before the heat was finished resulted in a very low recovery of uranium. The addition of much over 0.5 per cent was accompanied by marked segregation of uranium in the ingot.

With zirconium, the lowest recoveries were obtained when ferroalloys made by reduction of zirconium ore with carbon were used; often the recovery was practically zero. This does not check with experience reported by metallurgists of the Ford Motor Co. It should be noted, however, that there was a radical difference in the ferro-alloys used in the two groups of experiments, that used by the Ford Co. containing about 13 per cent zirconium, whereas none of the high-carbon ferros used in the experiments described above contained less than 44 per cent zirconium.

With ferrozirconium alloys, made by reduction of zirconium ore by the Thermit reaction alone, without electrical heating the recovery of zirconium was low, never being over 23 per cent and averaging about 10 per cent.

Nickel-zirconium alloys gave a better recovery of zirconium, an average recovery of 40 to 50 per cent being obtained when the alloy was added to the furnace at the end of the heat.

The best zirconium recoveries were obtained with alloys containing (*a*) about 30 per cent Zr and 45 per cent Si, and (*b*) 27 per cent Zr. 35 per cent Si, and 22 per cent Ni. These were very readily soluble in the steel bath when added at the end of the heat. Alloys of this type gave an average recovery of zirconium of 50 to 65 per cent. Steels containing over 0.3 per cent Zr generally showed marked segregation, more Zr being found in the top of the ingot than in the bottom.

Experiments with titanium showed that fair recoveries may be expected with a ferrotitanium made by the Thermit reaction, pro-

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O

Bulletin 200

DEPARTMENT OF THE INTERIOR

ALBERT B. FALL, SECRETARY

BUREAU OF MINES

H. FOSTER BAIN, DIRECTOR

EVAPORATION LOSS OF PETROLEUM IN THE MID-CONTINENT FIELD

BY

J. H. WIGGINS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

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First edition, February, 1922.

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EVAPORATION OF PETROLEUM IN THE MID-CONTINENT FIELD.

By J. H. Wiggins.

INTRODUCTION.

In 1919 the United States was threatened with a shortage of gasoline. In spite of this well-known fact, a detailed field investigation has shown that in one stage only of handling crude oil the volume of gasoline that evaporates is equal to one-thirtieth of the country's yearly gasoline production. This loss occurs during the few days that the oil is stored on the leases before being taken by the pipe line, and in 1919, in the Mid-Continent field alone, it amounted to 122,100,000 gallons. Large as it is, it is only a part of the loss on the lease.

Investigation has further shown that the gasoline in crude oil evaporates from one-half to six-tenths as rapidly as the same gasoline after being distilled and stored, all evaporative conditions being the same.

Many wastes in the oil fields are called "necessary." By this is meant that the cost of preventing the waste is greater than the gain through saving. Evaporation losses have fallen heretofore in this category, but now they must be considered unnecessary. In other words, it is no longer economical for any handler of crude oil to permit losses through evaporation.

In accordance with its purpose of seeking to conserve mineral resources, the Bureau of Mines investigated the loss of gasoline by evaporation in the storage and handling of petroleum. Inasmuch as most producers had not decided that their losses justified corrective measures and no evidence was available on the comparative losses in various stages of handling the oil, the investigation was limited to determining by experiment and observation the nature and magnitude of evaporation losses, where the greatest losses are, and the factor controlling evaporation.

The results of the investigation, as presented in this report, indicate that losses from evaporation are so large that they should receive serious consideration at once by the industry, which should make every endeavor to reduce them to a minimum. The Bureau of Mines is now making a supplementary study of methods of reducing these losses.

This bulletin has three parts: First, a general discussion of the problem and the methods of attack; second, volumetric losses during various stages of handling and in various kinds of storage; third, scientific data on the evaporation of petroleum.

ACKNOWLEDGMENTS.

The preparation of this report was made possible by the active aid of certain oil companies in the Mid-Continent field, including the Prairie Oil & Gas Co., the Empire Gas & Fuel Co., the Magnolia Petroleum Co., the Sinclair Oil & Gas Co., and the Marland Refining Co. Others offered assistance, but owing to lack of time, it was impossible to take advantage of their courtesy.

Especial thanks for interest shown in this work are due Mr. Herbert Straight, general manager; Mr. H. O. Ballard, former superintendent of production; and Mr. R. M. Stuntz, superintendent of production, of the Empire Gas & Fuel Co.; Mr. E. R. Brown, vice president and general manager of the Magnolia Petroleum Co.; Mr. N. K. Moody, vice president of the Prairie Oil & Gas Co.; and Mr. C. R. Waltz, in charge of the Prairie Oil & Gas Co. tank farms at Ranger, Tex. Much help was given by department heads of these oil companies and their assistants.

The engineers who aided in the field work are D. S. Foster, J. H. Simmons, and J. P. Murray, of the Empire Gas & Fuel Co., and A. L. Gersdorff, of the Magnolia Petroleum Co.

C. P. Bowie, in charge of the San Francisco office of the Bureau of Mines, has given encouragement and constructive criticism. J. O. Lewis, former chief petroleum technologist of the bureau, has shown continued interest in this work.

While determining methods of making distillations the author consulted E. W. Dean, of the Pittsburgh station, and R. O. Neal, of the Bartlesville station, of the bureau. S. M. Law of the Bartlesville station made nine-tenths of the distillations; L. A. Penn and E. C. Lane, of the San Francisco office, made the rest. All curves and sketches were drawn by J. G. Shumate, of the San Francisco office.

A. R. Elliott, H. H. Hill, E. W. Dean and A. W. Ambrose, of the Bureau of Mines, offered helpful criticisms.

Mr. W. E. Perdew, of the Union Petroleum Co., made valuable suggestions and additions.

PART I.—GENERAL DISCUSSION OF EVAPORATION PROBLEM AND METHODS OF ATTACK.

CONSENSUS OF OPINION OF OIL INDUSTRY.

This investigation was authorized because of the general knowledge that in handling or storing crude oil an appreciable loss from evaporation occurred. More than 40 men, representing the petroleum industry in all its departments, and including engineers, superintendents, managers, and vice presidents of producing, pipe-line, and refining companies and companies which manufacture gasoline from natural gas, were interviewed to determine what they had done toward the elimination of evaporation losses and what their attitude had been regarding such losses. The consensus of their opinions was as follows:

The proportion of the lighter products that evaporate from crude oil from the time it leaves the well until it reaches the refinery was not known even approximately. All admitted loss and some considered it serious, but more looked upon it simply as a necessary evil, the escape of a valuable product.

The expression was often heard that the oil "settles" or "gas gets out of it." Varying opinions were offered as to the reason for the shrinkage, but the general, vague conclusion of all was that "something happens to it." That evaporation was generally conceded to be an appreciable loss, however, is proved by the fact that a pipe-line company never gages a tank of oil that it is buying unless the oil can be handled immediately.

Some of the larger companies had endeavored to determine their evaporation losses at various stages, but these records had generally been discarded. This did not, however, apply to the handling of refined products, for much had been done to overcome the evaporation of gasoline. Although the companies separately evaded the issue of estimating their own evaporation losses, they were anxious to cooperate with the Bureau of Mines in evolving a standard method of determining and avoiding such losses.

VARIOUS CONDITIONS UNDER WHICH EVAPORATION TAKES PLACE.

It is incorrect to list all evaporation of oil in the field under the general heading "evaporation," as used in the text. Losses that are or are not chargeable to this heading are as follows:

LEAKS.

Connections or tanks may leak so slightly that all of the leakage will evaporate except a black residue commonly seen as a stain on oil-field tanks. It is obvious that such losses are not considered as evaporation but as leaks. They are, therefore, not within the province of this paper.

SPRAY.

When oil flows into a tank from above, the wind may whip some of it away. Such loss is not considered "evaporation," though it is needless and frequently very large. If, however, the oil flows into the tank and then, owing to the splash and spray, vaporizes and is carried off, the loss is charged to "evaporation."

EBULLITION.

Oil forced into the bottom of a tank contains gas and perhaps air, which rise rapidly and form bubbles that burst at the surface. In consequence, finely divided particles of oil are projected into the mixture of air and vapor above the oil. These particles may evaporate very rapidly and be carried off as vapor, or they may be so light that with a slight wind and a nearly full tank they are removed in the liquid state. All such losses are placed under evaporation.

EVAPORATION.

From the above three descriptions, it is quite clear what part of the losses are charged to this item. In this bulletin, "evaporation" refers to the part of the oil lost (under ordinary conditions of handling and storage) after that part has been changed from a liquid to a vapor. This change may occur from a still oil surface, while oil is splashing into a tank, or while the surface is stirred by oil entering a tank at the bottom.

DISCUSSION OF GRAVITY AND SPECIFIC GRAVITY.

In the present report, "gravity" is usually discussed in terms of the familiar Baumé scale, the Bureau of Standards scale with a modulus of 140 being employed. Specific gravity is used when needed, as, for example, in mathematical formulas. The Fahrenheit temperature is that chosen for presenting results.

PROBLEMS OF SAVING.

It is certain that there are no engineering obstacles to the elimination of these losses. The problems involved have been solved in great measure by the natural-gas gasoline industry. Even the so-called "wild" gas could be saved if saving would pay. In some parts of Pennsylvania old gas wells that yield gas of exceptionally high heating value are pumped; the gas which corresponds to the so-called "wild" gas is compressed into cylinders and sold for use in welding. This is possibly an extreme example of saving small losses.

Questions of profit confront the average engineer, however. Does it pay to save vapors? Does the loss of usable vapor justify the expenditure of a fairly large sum, say $5,000, to make the installation that would prevent it? Under some special conditions these questions are answered in the affirmative, but even where they are, the loss is not generally recognized or the means of elimination put into practice. Work has been done to protect tanks from heat by water-sealed tops, lagging, and sprinkling the roofs, but statistics showing the actual value of such protection have not been generally available. In fact, the meager data that have been published do no more than indicate that the evaporation problem should have been considered years ago.

LIMITATIONS OF THE PRESENT INVESTIGATION.

To cover all conditions, an extensive investigation would be necessary, because of the number of the conditions that affect the rate of evaporation of oil. This paper considers merely the handling and storage of the average oil produced in the Mid-Continent field. Naturally, such information will give a standard for estimating the evaporation losses of special oils.

COMPARISON OF OILS.

Crude oils in the field are generally compared by their Baumé gravity, which is, in a rough way, an indication of their gasoline content. For instance, a Garber crude of 45° B. yields about 50 per cent gasoline, whereas an El Dorado 34° B. oil yields about 22 per cent. Although gravity is not the most trustworthy method of determining the comparative values of crudes, it is the most practical field test and is an approximation of the real value and nature of an oil, especially if the field from which the oil comes is known. A distillation test gives the information necessary to judge the relative rates of evaporation of different oils. Such information also shows the quality of the portion lost. An oil of 35° B. evaporates more rapidly than an oil of 40° B. only if the former contains fractions more volatile than those in the latter.

CHANGE IN OIL AND CONDITIONS OF EVAPORATION AS A FIELD GROWS OLDER.

When the first wells are drilled in a new field, much permanent gas is generally found with the oil, sometimes having such a pressure that it forces out the liquid, causing the well to flow intermittently or even steadily. Oil produced under such conditions evaporates very rapidly during the first day or two that it is stored, because it contains much dissolved gas. This gas volatilizes quickly on exposure to the air and naturally carries with it some of the lighter gasoline fractions.

As a field grows older, the gas pressure decreases until the oil has to be pumped. As the oil then has much less permanent gas in solution it evaporates more slowly and, if the conditions of handling are unchanged, does not show the large evaporation losses of the early life of the field.

However, in a new field, when the production is greatest, the oil is handled more quickly; that is, in order to make room for the large production a tank is filled more rapidly and stands full on the lease a shorter period. As production declines, the stream is smaller and the time of filling a tank three or four times as long, or more. An excess of tankage is available for storage, hence the oil is not moved off so soon. Under the same evaporative conditions, therefore, the proportion lost will be largest during the early life of a field. At a later date, however, conditions favoring evaporation may be so aggravated that the percentage of the original volume lost will yet be high.

HISTORY OF OIL FROM WELL TO REFINERY.

Oil passes through pipe lines, pumps, tanks, and railroad tank cars on its way from the well to the refinery. Figure 1 illustrates this oil path and history with the province of each type of company indicated by arrows. A more detailed description of the various steps follows.

LEASE GATHERING SYSTEM.

The lease gathering system is generally 2 or 3 inch pipe connecting the wells either to the lease stock-tank or to the receiving tank. A separate line may run each well to the tank or a number of wells may be joined to a single lead line. Although the oil is mixed with gas, it is under pressure and there is no opportunity for evaporation while in the pipe.

RECEIVING OR FLOW TANKS.

Oil coming directly from the well often contains much gas or free water mixed with it. To separate these, the mixture is run into a "flow tank," "settling tank," or "receiving tank" as it is variously called. In the Mid-Continent field, it is customary to separate the oil either from water or from gas, or both, hence two types of flow tank are used. That used to separate the gas has a cover nearly gas-tight, fitted with a short stack to emit the gas. Such a tank is shown in Plate I, *A* (page 32). The tank for separating the free water is of wood or steel, either with no cover or with a very poor one; it is not housed nor protected. Such tanks also separate sand or sediments from the crude oil.

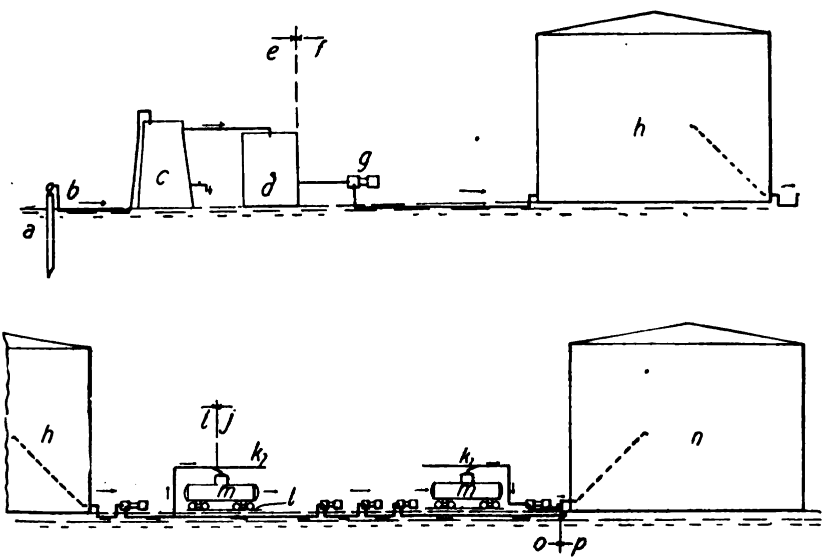


FIGURE 1.—Course of oil from well to refinery: *a*, well; *b*, lead-lines; *c*, flow tank; *d*, lease storage-tank; *e*, producing company; *f*, pipe-line company (to *i* or *o*); *g*, pump station; *h*, pipe line to tanks; *i*, pipe-line company; *j*, refining company; *k*, loading rack; *l*, railroad; *m*, tank car; *n*, storage at refinery; *o*, pipe-line company; *p*, refining company.

DEHYDRATION PLANTS.

When water to the extent of 2 per cent or more is emulsified in oil, some special means has to be used for breaking the emulsion so that the water will free itself by gravity. These means include electricity, centrifuge, chemicals, and heat. All of them necessarily involve some evaporation loss of the oil. With the first three methods this is comparatively small, but with the last it is usually very large. In the Mid-Continent field the practice has been to run the oil through hot water ranging in temperature from 100° F. to 200° F. A more detailed description of such plants will be found on page 31. See Plate I, *B*, page 32.

LEASE STORAGE-TANKS.

After having gone through either a flow tank, or both a flow tank and a dehydration plant, the oil flows into storage tanks on the lease—called in this report lease stock or lease-storage tanks—where it is held on an average of about five days before it can be taken by the pipe line. A detailed description of the different types and sizes of these tanks will be found on page 45. Except for losses in dehydration by heating it is in field storage that the losses are greatest.

TRANSPORTATION TO REFINERY.

Pipe lines ranging from 2 to 6 inches or more in diameter connect the lease tank with the pipe-line storage tanks. While the oil is in the pipe line there is no chance for evaporation, but when forced into the tank and stirred violently it suffers loss by ebullition. The oil goes from the pipe line to a type of tank that is better than those on the lease, being usually of steel with a roof supposedly gas tight. After it has stood here for variable lengths of time, the oil is transported to the refinery either by large pipe lines or by tank cars.

In passing through a main pipe line, the oil goes through a number of pump stations. Sometimes the pump at a certain station picks up the oil as rapidly as the pump at the rear station delivers it, but this does not always happen, and there must be tanks at each station to store the surplus. These tanks are generally of 55,000-barrel size and number two or more. Evidently oil in passing through a long pipe line may be flushed into tanks many times.

TANK FARMS AND REFINERY TANKS.

Instead of going directly to the refinery, the oil sometimes stands in storage on tank farms in large steel tanks of 35,000 to 55,000 barrels capacity, with approximately gas-tight roofs. These farms may contain as many as 100 or more such tanks, and some oil may stand there for years. Many refinery crude-oil tanks are like the tanks on the farms and store enough to run the plant a month or more. While the oil is standing in these tanks the rate of evaporation is slower, but the oil is held there for a longer period than on the lease, thus constituting another important point of evaporation loss.

CLASSIFICATION AND LOCATION OF LOSSES.

CLASSIFICATION.

Evaporation losses may be divided, as to rate, among the following five classes of conditions:

1. Filling a tank by overshot connections. This represents the highest loss per unit of time and is an example of loss through spray.

2. Filling a tank by bottom connections, the oil entering at the bottom of the tank and not being exposed to the air except at the surface. This class has a somewhat slower rate of evaporation and represents loss aggravated by ebullition.

3. Storage of oil in small tanks, not protected from the sun's rays nor from the free circulation of air.

4. Storage of oil in small tanks, protected both from the sun and free air circulation.

5. Storage of oil in large 37,500 or 55,000 barrel standard steel tanks.

The last three represent losses from still surfaces or surfaces agitated by wind only.

These five classes of conditions are placed in the order of their rate of evaporation per unit of time, the first having the highest and the last the lowest rate. For example, the oil might lose 1 to 2 per cent of its volume in a few hours while a tank is being filled from an overshot connection. In the last class the rate of evaporation is found to be between 1½ and 3 per cent a year, depending upon the age and kind of oil.

It is necessary to note that the order of this classification holds only for oil of practically the same volatility. For example, an oil which had already evaporated 10 per cent would probably lose less during a transfer from one tank to another, even when a tank is filled from above by overshot connections or from below with possible loss by ebullition, than the original fresh oil would have lost while standing 24 hours in a small tank exposed to sun and air. It is seen, then, that the volatility of the oil affects the rate of evaporation.

Other factors that affect the rate of evaporation are wind velocity, atmospheric temperature, and cloudy or clear weather. Within ordinary limits, however, the method of handling has more effect on evaporation than any other single condition.

DISTRIBUTION OF EACH CLASS OF CONDITIONS.

The loss on the lease is chiefly within the first three classes named. A great deal of oil is splashed and sprayed in filling the flow tank through the usual overshot connection. In addition, the surface of the oil in the flow tank is exposed to the free circulation of air. If the crude is dehydrated by heating, it is again splashed one or two times and its surface again exposed to the air.

In filling the lease tank, loss is caused either by overshot connections or by ebullition. It can usually be accredited to overshot connections, however, because this condition exists at practically all lease tanks. During storage on the lease, after free water, emulsified water, or excessive gas has been separated from the oil, evaporation may take place by storage in unprotected small tanks. Sometimes, however, evaporation is noted from protected small tanks, especially those of wood.

Oil gathered from a number of leases by the pipe-line company and stored in very large tanks is again subjected to an evaporation loss from ebullition, for practically all of the filling connections are at the bottom of the tanks. When a lease tank is emptied, air is often sucked into the gathering system, increasing the effect of ebullition at this point. While oil stands in a pipe-line stock tank, in tank farms, or in refinery-storage farms, it is liable to surface evaporation. Every time that the oil is pumped from one station to another and allowed to flow into a working tank, it is again subjected to evaporation from ebullition. When it is transported by cars, oil is transferred by overshot connections; when the car is filled, the conditions are those of small protected tanks during transportation, and the oil is subjected to ebullition when the car is emptied.

In this investigation, representative conditions of the five classes of conditions cited have been covered. Although the rate of evaporation per unit of time for each follows in the order given, the wide differences in the average time for carrying out each of the above operations changes their rank as regards total loss in each. (See Table 23, p. 85.) For instance, even should 1 per cent be lost in filling a lease tank from an overshot connection in 24 hours, and only four-tenths of 1 per cent of volume be lost during the first 24 hours of storage in the lease tank, yet as the oil is kept in the lease tank for an average of five days the total loss is about 1½ per cent, or half again as much as the loss during the filling of the tank by overshot connections.

METHOD OF DETERMINING LOSSES.

FIELD WORK.

Two methods of determining evaporation loss were used, field measurements and distillation in the laboratory of oil before and after it was subjected to evaporation. Work in the field comprised the accurate measurement of a volume of oil (reduced to 60° F.) before being subject to a certain test of conditions, and a similar measurement at the end of the test. For example, to determine the loss in filling a lease tank, the oil was measured so as to obtain its exact volume at 60° F. before it flowed into a lease stock tank. After such flow had taken place, the gain in the amount of oil in the latter tank was again measured and reduced to 60° F. The difference between the gain in the stock tank and the measured amount flowed in represented the evaporation loss. In studying loss during storage in large tanks, the total amount of oil in a tank was measured semimonthly and the volume at 60° F. was calculated. The losses were computed periodically and an average loss determined. Similar procedure was applied to every experiment.

The data kept for each test were: Depth of the oil, temperature of the oil, and measurement of the tank for its net volume. In addition, a 2-quart average sample of the oil studied was taken for distillation in the laboratory.

Table 1 is a form for keeping field data and for making calculations to obtain evaporation losses. This form is headed "Lease storage,"

TABLE 1.—*Form of keeping field notes and making calculations to obtain evaporation loss at a lease storage-tank.*

Experiment: D-18.
Company: Number 1377.

Date filled: September 19, 1919.
Kind of tank: Steel-bolted, lease storage.

Roof: Steel.
Protection: None.
Size: 500 barrels.

Date.	Hour.	Position.	Fluid depth.	Average depth of fluid.	Oil temperature. Bottom.	Oil temperature. Middle.	Oil temperature. Top.	Oil temperature. Average.	Temperature factor.	Temperature correction.	Volume of fluid. Actual.	Volume of fluid. At 60° F.	Cumulative evaporation loss.	Cumulative evaporation loss.	Sample. Gravity.[a]	Sample. Temperature.	Sample. Can No.
1919.			*Ft. in.*	*Ft. in.*	*° F.*	*° F.*	*° F.*	*° F.*		*Bbl.*	*Bbl.*	*Bbl.*	*Bbl.*	*Per ct.*	*° B.*	*° F.*	
Sept. 9	1.55 p. m.	A	16 11/16	16 5/8	80	81	81	80.6	1.00906	4.4	487.6	483.2	0	0	39.5	93	237
		B	16 1/2														
		C	16 11/16														
10	10.10 a. m.	A	16	15 11 7/8	81	82	82	81.6	1.00049	4.6	485.0	480.4	2.8	.58	....	....	....
		B	15 11 7/8														
		C	15 11 7/8														
11	11 a. m.	A	15 11 1/4	15 11 1/16	81½	82	82	81.8	1.00958	4.6	483.7	479.1	4.1	.85	....	....	....
		B	15 10 3/4														
		C	15 11 1/4														
12	11.30 a. m.	A	15 10 1/16	15 9 15/16	79¼	79¼	80	79.5	1.00858	4.1	480.9	476.8	6.4	1.33	....	....	....
		B	15 9 3/4														
		C	15 10														
13	2.20 p. m.	A	15 9 1/4	15 9	76½	77½	78	77.1	1.00752	3.6	478.5	474.9	8.3	1.72	....	....	....
		B	15 8 3/4														
		C	15 9 1/8														
14	9.45 a. m.	A	15 8 11/16	15 8 9/16	73	75	75	74.4	1.00634	3.0	477.4	474.4	8.8	1.82	....	....	....
		B	15 8 3/8														
		C	15 8 5/8														
15	2.45 p. m.	A	15 8 13/16	15 8 11/16[b]	80	82½	82	81.5	1.00945	4.5	477.7	473.2	10.0	2.07	38.0	82	10
		B	15 8 1/4														
		C	15 8 3/4														
16	1.35 p. m.	A	15 8 5/16	15 8 5/16	80	81	81½	81.0	1.00923	4.4	477.1	472.7	10.5	2.18	....	....	....
		B	15 8 3/8														
		C	15 8 3/8														
17	3.40 p. m.	A	15 8 1/16	15 8 3/16	78	78¼	78¾	78.4	1.00810	3.8	476.8	472.0	11.2	2.32	....	....	....
		B	15 8 3/8														
		C	15 8 3/8														

[a] By hydrometer in the field.

[b] It rained between Sept. 14 and 15.

Notes.—Filled at 1 p. m. Flat roof; one 20-inch hole at center, open; two 8-inch openings, one on either side, closed, but not tight enough to exclude any rain water that might collect. All valves and gates pertaining to this tank were checked and no leaks observed. Tank appeared in good condition, except roof. Discharge gates were locked. Estimated that 50 per cent of rainfall on roof leaks into tank.

but may be applied to any experiment by change of heading. An examination of the measurements for a test at a lease storage tank shows exactly what happened to that tank of oil during this period. Temperatures were always taken at three points in a tank. Similar detailed records were kept for every test. In determining the depth of a tank of oil it was necessary to measure in exactly the same place each time. To this end a point on the tank roof was marked and measurements taken from it at each gaging. To eliminate chances of error and to increase the accuracy of the measurement, three depth measurements were made. Under "Position," in Table 1, the three points for these depths are marked A, B, and C. Tables for the net volume of a tank have been given by Bowie.[1]

LABORATORY WORK.

The second method of determining the percentage of loss was by distillation. At the beginning of any field test, a 2-quart average sample of the oil under examination was taken; periodically during the test and at the end of it similar samples were taken. The cans containing the oil were sealed to prevent evaporation, then sent to the laboratory for distillation. A description of the distillation apparatus is given on p. 26.

FORMULA FOR DETERMINING EVAPORATION LOSS.

Evaporation losses increase the specific gravity of a crude oil. If the specific gravity at the beginning and that at the end of the test, and the specific gravity of the part that has evaporated are known, then by formula the percentage of the volume lost may be determined. Or, if the percentage that has evaporated and the specific gravities of the crude before and after evaporation are known, the specific gravity of the portion evaporated may be determined. This may be worked out as follows (note that gravity in degrees Baumé must be reduced to specific gravity):

Let d_1=specific gravity of the crude before evaporation takes place.
d_2=specific gravity of the crude after evaporation.
d_3=specific gravity of the portion lost through evaporation.
x =proportion of the original volume that was lost.
V=volume of the crude before evaporation takes place.

Then,
$1-x$=proportion of the volume remaining after evaporation.
$(1-x)V$=actual volume of the crude remaining after evaporation.
Vx=actual volume evaporated.
$d_1V=W_1$=weight of the crude before evaporation.
$d_2(1-x)V=W_2$=weight of the crude after evaporation.

[1] Bowie, C. P., Oil-storage tanks and reservoirs, with a brief discussion of losses of oil in storage and methods of prevention: Bull. 155, Bureau of Mines, 1917, p. 59.

$d_3Vx = W_3$ = weight of the portion evaporated.

Now, since the weight of the crude before evaporation must necessarily equal the weight of the crude after evaporation plus the weight of the portion that is evaporated

$W_1 = W_2 +_3$ or, W_3

$d_1V = d_2\ (1-x)\ V + d\ Vx$

The V's cancel and the equation when solved for x becomes

$$x = \frac{d_2 - d_1}{d_2 - d_3} \text{ and solving for } d_3.$$

$$d_3 = \frac{d_1 - d_2\,(1-x)}{x}$$

This formula will be used with results of distillations to determine the percentage of volume lost. (For determination of the specific gravity of portion lost from the distillations, see p. 19.)

DISTILLATIONS.

Very small cuts were desired in the first part of the distillation. These were at intervals of 2 per cent to the first 19 per cent off, then 5 per cent intervals. In order to get enough distillate to take the gravity with a 2 per cent cut, 1,000 c. c. was used as a charge for the copper still. Figure 7 (see p. 36) shows the layout of the distillation apparatus.

Heat was applied to the still until the oil boiled. The vapors passed upward through a 10-inch Hempel fractionating column filled with small chain nearly to the vapor take-out. The thermometer bulb was placed in the fractionating column opposite this take-out and the temperature read at each cut. The vapors continuing passed downward through the condenser, and the resulting liquid was caught in a graduate surrounded by ice-water. The gravity of the cuts was determined by a pycnometer for the 1 per cent cuts and by a hydrometer for the others. Distillation was made at the rate of 2 to 3 drops per second.

Table 2 shows the complete record for a single sample. When the sample was taken in the field the data shown opposite "Sample taken," were written on a tag and attached to the can. This eliminated all possibility of samples being mixed.

TABLE 2.—*Form for keeping distillation records on evaporation work.*

EVAPORATION EXPERIMENT.

[Laboratory record.]

Sample taken	From, Houston {Empire 1655. Prairie 82910.}
	Date, August 24, 1919.
	Hour, 2.30 p. m.
	Gravity: At 80° F., 33.2° B. At 60° F., 31.8° B.
	By D. S. Foster.
	Can No., 260.

Distilled { Date, October 18, 1919.
Gravity: At 64° F., 31.6° B. At 60° F., 31.4° B.
By S. M. Law.

Over point=236° F.

Per cent over	Temperature, ° F.	Gravity.
1	295	57.8
2	310	56.1
3	317	55.2
4	324	54.6
5	330	53.85
7	342	53.1
9	352	52.2
11	362	51.2
13	373	50.1
15	384	48.9
17	395	47.9
19	407	46.9
24	437	45.0
29	470	42.7
34	498	40.9
39	526	39.2
44	549	37.7
49	575	36.1

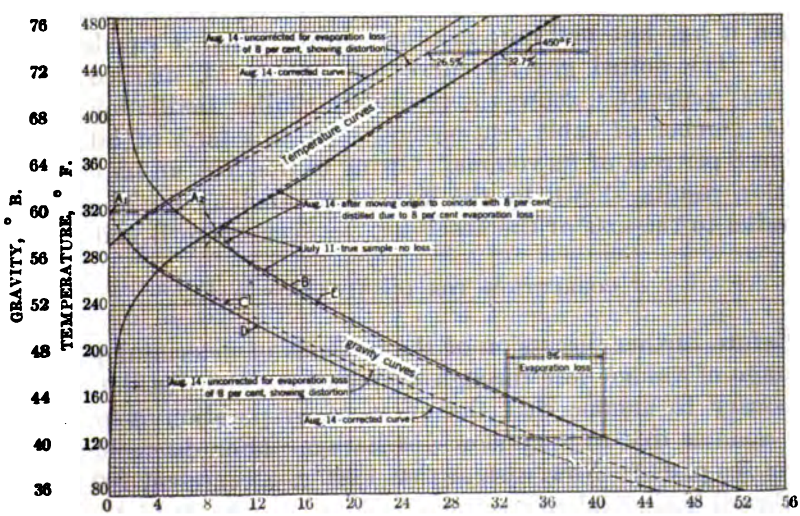


FIGURE 2.—Curves plotted from distillation data of samples taken from same tank of oil on two different dates, the first before evaporation and the latter after an evaporation loss of 8 per cent.

PLOTTING OF DISTILLATION DATA.

Distillation data were plotted as in figure 2 with the per cent distilled as abscissas and the degrees Baumé of the cut as ordinates. On the same sheet and with the same abscissas another curve was plotted with the temperature of the cut as the ordinates. This applies to the sample taken at the beginning of a test. Distillation data of a subsequent sample were plotted similarly and on the same sheet, with a correction applied to the per cent distilled, as explained below.

In plotting gravities it is necessary to place the point at the average of each increment, thus: The 1 per cent cut should be plotted at the ½ per cent point, the cut between 1 and 2 per cent at the 1½ per cent point. Now, if the next cut were between 2 and 4 per cent, then this reading should be plotted at the 3 per cent point, and so on. When very small cuts are taken little change will be shown in the shape of the curves.

Figure 2 embodies distillation data of two samples from the same tank, one taken on July 11 and the other on August 14. The "gravity per cent" curves have been lettered B, C, D, and E.

B represents the sample of July 11, true and correct.

C represents the sample of August 14, uncorrected.

D represents the sample of August 14, after correction.

E represents curve D after it is moved to the right 8 per cent or the amount of the evaporation loss.

First, consider curve B of July 11. This represents a tank of oil when it has lost nothing; in other words, when it equals 100 per cent. The dotted gravity curve for August 14, marked "uncorrected" (curve C), shows the result of a similar distillation with the same number of cubic centimeters, after this tank of oil has lost about 8 per cent of its volume. Owing to this loss, an improper distortion results, shown by the lack of parallelism (as along a line parallel to the axis of the abscissas) between curve B and curve C.

CORRECTION FOR DISTILLATION DATA.

Before further discussion of the methods of determining the percentage of volume lost through evaporation from distillations, it is necessary to assume that the effect of evaporation is practically the same as that of very slow distillation. (For discussion of this point see p. 92.) Now, assume that 1,000 c. c. represent 100 per cent of the oil in the tank at the beginning, and that by the later date the oil has lost 8 per cent of its original volume. If the 1,000 c. c. had been exposed to evaporation 920 c. c., or 92 per cent of the original oil, would be left. If the 1,000 c. c. had been distilled until 8 per cent were over, again only 920 c. c. would be left. If distillation were continued the succeeding cubic centimeters distilled would be charged against 1,000 c. c., the original quantity. If comparative results were to be directly obtained from a distillation of a sample of the later date (after 8 per cent had been evaporated from the tank), then this same number of cubic centimeters—920—should have been used and the number of cubic centimeters distilled charged against 1,000 for the per cent cut, just as in continuing the distillation.

It is, however, impossible to know what percentage of the volume is lost until the distillations have been compared; therefore the same number of cubic centimeters—1,000—were always run. True comparative results can be obtained by multiplying the percentage distilled by $(1-x)$, x representing the portion evaporated. For 8 per cent loss, the percentages distilled would have to be multiplied by 0.92 or 92 per cent. The result of plotting the gravity curve of August 14 with these new percentages distilled (curve D) is that this gravity-per cent curve parallels (along the ordinates) that of July 11 (curve B). In order to emphasize this parallelism, curve D was moved to the right 8 per cent, where it gives the dotted curve, E, marked "Aug. 14," after moving origin to coincide with 8 per cent distilled due to 8 per cent evaporation loss. Curve E, then, theoretically should coincide with curve B of July 11. Although coincidence actually is not exact the results are as close as can be expected from such work.

The correction, percentage distilled, as applied above to the gravity of a fraction, apply to the boiling points of the fractions in the same way.

THREE METHODS OF DETERMINING EVAPORATION LOSS FROM DISTILLATIONS.

1. SPECIFIC GRAVITY FORMULA.

The following method of obtaining the loss by formula obviates the necessity of making the correction on the percentages distilled. As the correction on curve C of August 14 at 1 per cent distilled is very small, the continuation of either curve C or D to zero will differ very slightly. From A_1, the point where these curves cut the zero per cent line, draw a line parallel to the axis of abscissas until it cuts curve B (July 11); that is, at A_2. Then the gravity of the portion lost is represented very closely by the part of the curve lying above A_2, and the average of that part of the curve will give a close approximation of the gravity of the portion lost through evaporation, which equals d_2 in the formula. (See p. 15.) An average of such a part of a curve may be obtained by taking points along it at equal intervals of abscissas and averaging them. (Baumé degrees are to be changed to specific gravity for the formula.) The formula will now give the percentage of volume lost very closely, since d_1 and d_2 should have been determined for the crudes before distillation. It is important that d_1 and d_2 should be determined accurately, for a small error in them makes a larger error in x, but a considerable error in d_3 causes a much smaller error in x.

Table 3 is a form for determining the percentage lost by the formula.

TABLE 3.—*Form for determining evaporation loss by formula.*

[Formula $x = \frac{d_1 - d_2}{d_3 - d_2}$ = fraction lost.]

Date.		d_1		d_2		d_3		d_1-d_2	d_3-d_2	x
From—	To—	° *B.*	Sp. gr.	° B.	Sp. gr.	° B.	Sp. gr.			
										P. ct.
Sept. 19, 1919	Oct. 19, 1919	35.2	0.8475	33.7	0.8552	77.2	0.6757	0.0077	0.1795	4.29

2. TEMPERATURE—PERCENTAGE DISTILLED DATA.

A certain proportion, call it a, of the fresh oil distills at a given temperature, whereas oil that has been exposed to evaporation yields only b per cent of distillate at the same temperature. If x represent the proportion lost, then the correction previously described on page 19 must be applied to b in order to get a true comparison of percentages. The true comparative percentage distilled from the sample after evaporation is $b\ (1-x)$. The portion lost, then, is $x = a - b\ (1-x)$

whence $x = \frac{a-b}{1-b}$.

This will be termed the "temperature" formula.

In figure 2 consider the 450° F. point:

$a = 32.7$ per cent $\qquad b = 26.5$ per cent

$$x = \frac{32.7 \text{ per cent} - 26.5 \text{ per cent}}{100 \text{ per cent} - 26.5 \text{ per cent}} = \frac{6.2 \text{ per cent}}{73.5 \text{ per cent}} = 8.4 \text{ per cent.}$$

3. GRAVITY OR TEMPERATURE CURVES.

The percentage lost may be determined approximately by inspection from curves B and C of figure 2, by measuring the distance from A_1 to A_2 in percentages. Using this percentage loss, the distillation curves of August 14 may be corrected as explained previously. The gravity curves only are to be considered first. Curves B and D give a third or graphic method of determining the percentage loss. If the corrected curve is parallel, along the ordinates, to the original one, the determined loss is correct. If not, a second estimate can be made and the curve corrected a second time and replotted. (After the first correction is made in a number of instances the loss by inspection will be very close.) Now there may be considered a line parallel to the axis of abscissas which is cut by the correct gravity curves of both dates. The number of per cent between the two points where this line is cut, first curve B of July and, second, by curve D of August 14 should give the per cent lost as found by the formula. One such result is represented by the 8 per cent evaporation loss noted in figure 2. A number of such operations should be averaged for accurate results.

This method tends to smooth out experimental errors and should therefore give the most dependable results. If results from the graphic method do not check those from the specific-gravity formula, there is probably some error in determining the specific gravities of the crudes, since that is the point of the greatest probability of error, if the sampling has been done properly. Similar treatment of the temperature curves will also give the per cent evaporated. The graphic method involves basic principles of the second method (temperature—per cent distilled), but as this third method is a graphic summation of a number of operations, each like the second, and this is applied to both temperature and gravity data, it has been classed separately.

COMPARISON OF METHODS.

In discussing the relative values of these three methods, the following points should be noted:

1. In applying the formula, the percentage of volume lost can be found if only the first two points on the "gravity" curves and the specific gravities of the crudes on the two dates are known.

2. The method described under "temperature" may be used if only a single cut were made for each group of samples at the same temperature without the gravity reading. This temperature should be taken far above the point at which the first drop comes over, however.

3. The graphic method acts as a check on itself and actually gives the average result of a large number of calculations. It also visualizes in a very striking way the evaporation loss.

If all the data necessary for the third method were available, then the second method could be used, but the additional data on the gravities of the crudes would still be necessary for the first method. With barely enough data available for either method 1 or 2, then only method 1 or 2 could be used. A combination of all three methods should give accurate and dependable results.

If the percentage of volume lost and the specific gravity of the crude before and after evaporation are known, then by use of the formula the specific gravity of the portion evaporated can be determined.

The three methods from distillation plus the field method give a total of four.

Table 4 shows typical comparative results of the four methods of determining per cent loss due to evaporation. That the field measurements show a slightly lower loss than the laboratory results is probably caused by insufficient allowance having been made for rainfall leakage, such leakage settles to the bottom of the tank and raises the fluid level. It is practically impossible to tell exactly how much a roof leaks per inch of rainfall, but the allowance made was conservative. As noted in this table, all of the experiments recorded in this bulletin were checked.

In laboratory work all the distillations of a single experiment should be made with the same apparatus and in the same manner.

TABLE 4.—*Typical results of four methods of determining loss per cent due to evaporation.*

Experiment No.	Dates.		Loss per cent.			
	From—	To—	Specific gravity formula.	Graphically.	Temperature data.	Field.
	1919	*1919*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
6	July 10	Aug. 23	8.35	10.00	6.30	9.46
7	July 12	Aug. 25	10.40	11.50	12.90	10.52
8	July 11	Aug. 14	5.43	6.50	6.00	6.14
9	..do.....	Aug. 24	9.45	9.00	9.20	8.31
10	..do.....	Aug. 14	7.19	7.00	6.50	6.67
11	July 10	Aug. 23	7.95	7.70	8.00	7.36
15	Sept. 9	Oct. 19	4.29	5.00	4.33	3.70
16	Sept. 17	Oct. 27	11.37	11.70	11.70	11.33
17	Sept. 10	Oct. 15	1.64	1.45	1.63	1.50
19	Sept. 22	Oct. 27	3.93	4.60	4.18	3.60
20	Sept. 14	Oct. 24	10.17	10.65	10.66	9.37
21	Sept. 10	Oct. 15	8.45	7.55	6.83	8.90
22	Sept. 14	Oct. 24	6.30	6.50	7.65	5.72
23	Sept. 15	Oct. 5	6.39	6.70	7.26	5.90
Average	....	....	7.23	7.56	7.37	7.03

SOURCES OF ERROR.

PERSONAL ERRORS.

Instrumental errors should be eliminated by checking or calibrating, but two other classes of errors are possible in this kind of work. The first includes personal errors, such as misreading a depth or a temperature in the field, or improperly determining gravities, temperatures, or percentages in the laboratory. In order to eliminate personal errors a number of readings of depths and temperatures were always taken. The same man started and completed a single experiment, and one man made all of the distillations. Enough samples were taken to duplicate the work.

ERRORS OF METHOD DUE TO TEMPERATURE INCREASE.

The second source of error is in the method used for making calculations as affected by increased temperature, including the expansion of steel tanks and measuring tapes, and thermal expansion of the oil.

EXPANSION OF STEEL TANKS AND MEASURING TAPES.

Although the measurements and calculations needed to obtain the volumetric contents of the tank are made by men who specialize in this work, these can not always be accurate, because of the expansion of steel tanks and steel measuring tapes with rise in temperature. This charge is negligible, in fact, too small to read for small lease tanks or other small storage tanks, but is appreciable for 37,500 and 55,000 barrel tanks.

With increased temperature, both expansion of the circumference and of the measuring tape are changes in the same direction; that is, for an increase of 1° F. there is a correction due to the circumferential expansion, which is additive, and one for the expansion of the tape, also additive. With a 1-degree rise in temperature a 55,000-barrel tank has a volumetric increase of 0.655 barrel, due to the increase of circumference only, while the measuring tape would expand enough to cause an error of plus 0.368 barrel. These two errors added give 1.023 barrels. The similar correction for a 37,500-barrel tank is plus 0.67 barrel per degree Fahrenheit. For a 1-degree rise in temperature this error is much smaller than would be warranted by the closeness with which the volume in the tank at 60° F. can be determined. For 20°, 30°, or even 50° difference in temperature, however, it amounts to a corresponding number of barrels, which is measurable. This correction was made in all the measurements of large tanks.

THERMAL EXPANSION FACTOR OF OIL.

The factor used for calculating the expansion of the oil with temperature increase is another possible source of error. Within very narrow limits, it might be said that every oil has a different coefficient of thermal expansion, but the Bureau of Standards has made a thorough investigation of this subject and has published factors for oils of different gravities. Technologic Paper 77 [2] of that bureau is particularly valuable for reference; the factors used in this report were taken from it. On page 19 of that paper is a table showing the variation of this factor for petroleums. For further information on the subject, see Circular 57 of the Bureau of Standards.[3]

In determining the volume of large tanks, 5,000 barrels and more, it is important to have a close average temperature of the contents. The volumetric error introduced by 1° F. error in temperature for a filled 55,000-barrel tank is 24 barrels. To reduce this error as much

[2] Bearce, H. W., and Peffer, E. L., Density and thermal expansion of American petroleum oils: Bureau of Standards, Technologic Paper 77, 1916, 26 pp.

[3] United States standard tables for petroleum oils: Bureau of Standards, Circular 57, 1916, 64 pp.

as possible, temperatures were taken at three points in a tank. Some special work was done on 55,000-barrel tanks to determine the possible accuracy in obtaining the average temperature (see p. 77), a special thieving thermometer being designed and constructed for that purpose. This and other apparatus will be described in the following pages.

APPARATUS USED IN DETERMINING QUANTITY OF OIL.

MEASURING TAPE.

Almost always the depth of the fluid was determined by the standard steel gaging-tape, which is 33 feet long with a heavy plumb bob at one end. This tape is lowered into the oil rapidly until it approaches the bottom of the tank; then the rate of lowering is decreased until the tape barely moves. After the plumb bob has lightly touched the bottom, the tape is quickly wound up until oil first shows on the tape. At least three readings are taken at every point. If the bottom has so much B. S. on it that a good touch is impossible, the difference in the depth of oil during the test is determined by measuring from some point marked on the roof down to the surface of the oil.

HOOK GAGE.

Another instrument used occasionally for determining the change in the depth of oil in a tank was the hook gage, consisting merely of a sharp-pointed hook on a short wooden gage-pole. This rod can be raised or lowered and is controlled by a collar with a set screw, the collar being fixed at some point on the roof. Although this device does not give the actual depth of the oil, it shows changes in depth very accurately.

TANK THERMOMETER.

For tanks of 1,600 barrels capacity or less, temperatures are taken with an ordinary small tank thermometer, which is merely a metal temperature scale attached to a wood back. The bulb of the thermometer is in a small copper cup with a large opening at the top, tacked to the lower end of the back. The large opening of the thermometer cup allows some interchange of oil while the cup is being raised from the bottom of a tank. In this case the same thermometer was used throughout a single experiment. All thermometers were calibrated to a standard instrument.

THIEVING THERMOMETER.

For use with 55,000-barrel tanks, a special thieving thermometer was devised. Figure 3 shows this in detail.

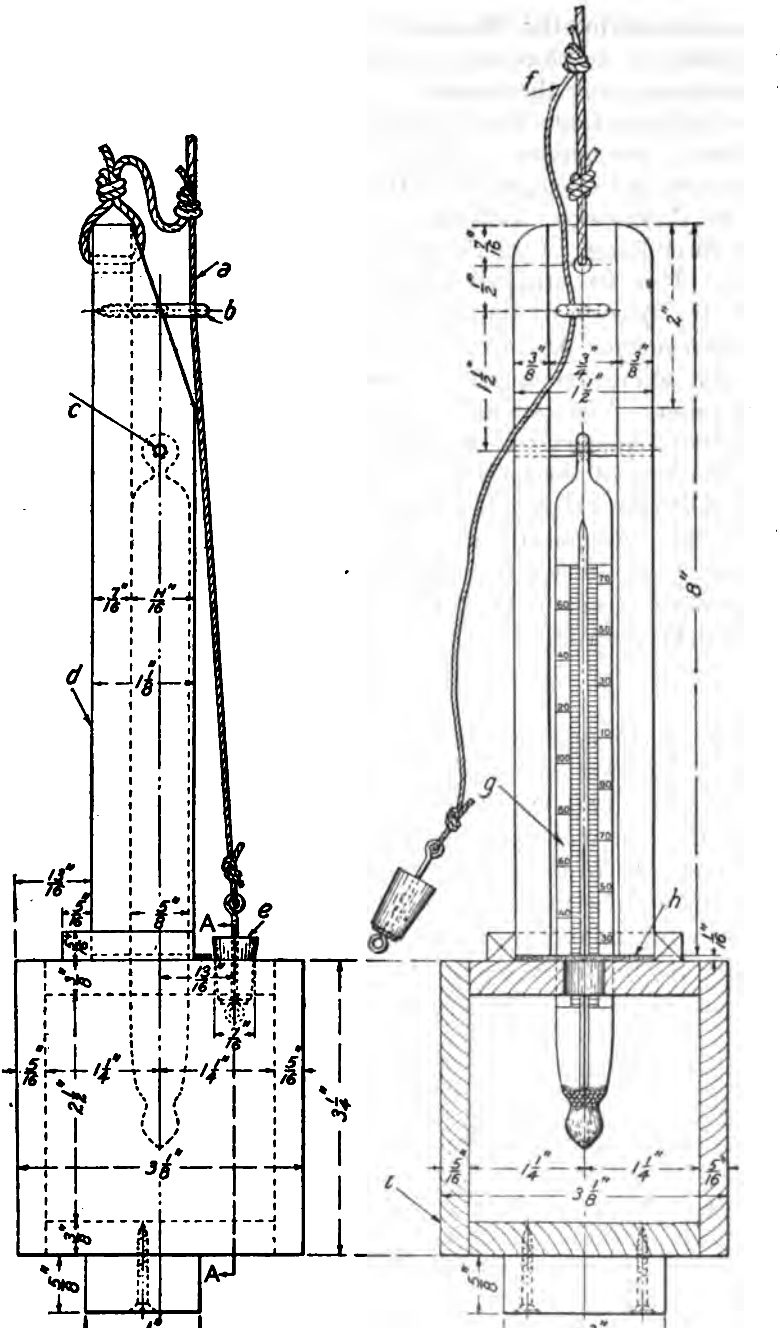


FIGURE 3.—Detailed drawing of thieving thermometer used to obtain accurate temperature readings at any depth of a tank of oil; *a*, cord with cork in place; *b*, screw eye; *c*, ⅛-inch wood pin; *d*, wood protector; *e*, cork; *f*, cord after jerking cork; *g*, thermometer with protected scale; *h*, $\frac{1}{16}$-inch leather washer, squeeze fit; *i*, box made of wood or other nonconductor of heat.

In constructing this thermometer, two objects were to be attained. The first was to eliminate the interchange of oil that occurs while an ordinary tank thermometer is being brought to the surface, because in large tanks the temperature difference from 5 feet off bottom to the top may be as high as 6 to 10° F. The second object was to prevent an exchange of heat through the sides of the cup surrounding the thermometer bulb while it was being raised. In order to prevent interchange of oil the hole for entrance of oil was made very small. This was stopped with a cork during the lowering into the tank, the friction of the cork being sufficient to hold the weight of the instrument. At the desired depth the cork was removed by jerking the string and a sample flowed into the nearly closed cup at that point. After standing 15 to 20 seconds the thermometer was withdrawn quickly and read at once.

Insulation of the bulb was accomplished by constructing the cup of a material which is not a good conductor of heat, such as wood. With this thermometer it is possible to determine the temperature at any point in a tank within the possible limits of reading the thermometer used. Work with this thermometer will be discussed in Part II, page 76.

SAMPLER.

Many methods of obtaining samples from tanks of oil have been devised, but that used was as follows:

Place a 2-quart sampling can in a leather frame and weight this until the can will sink in the oil. To obtain an average sample, lower the can to the bottom, then raise it evenly at such a rate that the can will be not quite full by the time it reaches the surface. After a few trials this can be done with great accuracy. When the sample is brought to the top the cover should be screwed on tightly at once. This cover has a composition gasket which insures a tight joint.

SAMPLE CANS.

Ordinary rectangular soldered tin cans were used. Until shipped to the laboratory and while stored there awaiting distillation they were kept in a cool place.

DISTILLATION APPARATUS.

The distillation apparatus consisted of a copper flask with a distillation capacity of 1,000 c. c. of oil connected to a Hempel fractionating column. The vapor on leaving the column passed through a vertical condenser consisting of a staggered glass tube surrounded with ice water. The resultant liquid was collected in the graduate below, which was also immersed in ice water to decrease evaporation. This is a modification of the standard method of making distillations recommended by the Bureau of Mines, and was designed for the particular needs of the present investigation. Any slight variation in distillation apparatus would be just as effective, provided the same apparatus were used throughout all the experiments.

PRESENTATION OF RESULTS.

PERCENTAGE OF ORIGINAL VOLUME LOST.

Evaporation losses are shown in four principal ways. The first is by the percentage of the original volume which is lost through evaporation. At first it may seem incorrect to determine such a loss by percentage, because if the volume of oil stored were the same the manner in which it is stored would cause the percentage lost to vary greatly. For instance, if the area exposed for a unit volume were doubled, the percentage of the original volume lost will be much increased. As, however, the conditions under which such losses occur are fully described and defined, such a percentage can be considered as applying to these conditions only.

ACTUAL VOLUME LOST.

The second presentation is by the actual volume lost under any prescribed conditions. This volume is always shown in this report as barrels or gallons and gives a more vivid mental picture of the direct result of evaporation.

ACTUAL VALUE LOST.

The third method will be to show the actual value, in dollars, of the loss for the same conditions of storage as considered above. In calculating the value lost, the loss is considered primarily as gasoline at 22 cents per gallon. This is necessary because the loss is gasoline that would, if saved, have a market value equal to that of the best grade of gasoline available, since the effect of evaporation is that of a slow distillation in which fractionation is very good. Secondarily, the loss has been considered as crude at $3 per barrel. Although the loss is not crude oil, nevertheless, as far as the producer or pipe-line operator in the Mid-Continent field is concerned the effect is a reduction in the volume of his crude.

If, however, the oil were bought on the sliding-scale gravity basis, as in California, the producer would feel the loss both as one of quality and of quantity. Suppose, for instance, that 1,000 barrels of 35° B.

oil lost 5 per cent through evaporation. Then 950 barrels of oil of about 33° B. would be left. If the 35° B. oil brought \$3.10 per barrel and the 33° B. oil \$3 per barrel, then the loss would be \$3.10×1,000−\$3×950, or \$3,100−\$2,850, or \$250. Without the sliding scale, that is, if both the 33 and 35° B. oil were worth \$3 per barrel, the loss would be only 50×\$3, or \$150. Thus, with such a sliding scale, the producer, by suffering a 5 per cent evaporation loss, loses 50 barrels at \$3 per barrel plus 10 cents on the 1,000 barrels. Therefore, if a producer prevents evaporation loss he should be rewarded by a better price for his crude than he formerly received.

PERCENTAGE OF VALUE LOST.

The fourth method of presenting results for the same conditions of storage and handling of the refined products mentioned is to show the percentage of loss in value of the original crude by evaporation.

As a barrel of oil leaves the well it has one price, which represents the gross income to the producer, and as it leaves the refinery it has another and much higher price, which represents the gross income to the refiner. Using these two values of crude as a basis and considering the part lost as having the value of gasoline gives two bases for the percentage of value lost; using the value of crude in the field as a basis and considering the part lost as crude gives still a third basis for computing the percentage lost. These three may be described as follows:

GASOLINE VALUE v. FIELD PRICE OF CRUDE.

The volume lost considered as gasoline at 22 cents per gallon, as against crude valued at \$3 per barrel, represents the condition where the producer of the oil should save the vapor, turn it into gasoline, and sell it as such. Naturally, the cost of such saving must be subtracted from the value of the gasoline manufactured and sold. The gross percentage of value lost, considered alone, may be estimated as follows:

Method of estimating gross percentage of value lost.

Gasoline at 22 cents per gallon .... per barrel..	\$9.24
Crude on lease at .... do....	3.00
1 per cent volumetric loss gives an actual value loss of	0.0924
The percentage of the total value lost is then	$\frac{0.0924}{3.00}=3.08$

Thus an evaporation of 1 per cent of the original volume causes a loss of 3.08 per cent of the original value.

GASOLINE VALUE V. PRICE OF REFINED PRODUCTS.

The loss considered as gasoline at 22 cents per gallon as against the value of refined products at $4.28 per barrel represents the condition if the refiner assumed such losses by evaporation. Assume that a barrel of oil gives the following products:

Fraction.	Product.	Value.
Per cent.		
25	Gasoline, at 22 cents per gallon, or $9.24 per barrel	$2.31
25	Burning oil, at 10 cents per gallon, or $4.20 per barrel	1.05
46	Fuel oil, at $2 per barrel	.92
4	Loss in refining	.00
100	Total	4.28

The gross income to the refiner is, therefore, $4.28. The evaporation loss is from the gasoline fraction.

Then 1 per cent volumetric loss means 4 per cent of the gasoline gone—value, $0.0924.

And 1 per cent volumetric loss gives the percentage value lost as $\frac{0.0924}{4.28}=2.16$ per cent.

Here an evaporation of 1 per cent of the original volume means a loss of 2.16 per cent of the original value.

CRUDE V. CRUDE AT ANY PRICE.

The loss considered as crude as against the value of crude at any price shows what percentage of the value lost the producer or pipe-line operator assumes when he considers the commodity lost as having a value no higher than that of his crude. This loss is easy to estimate, for when it is considered as crude oil, the percentage volume lost equals the percentage of value lost.

A consideration of the percentage of value lost by evaporation emphasizes the fact that with crude oil this kind of loss has a doubly detrimental effect—a decrease in volume and a decrease in quality. When the loss as gasoline is compared with the loss as crude at $3 per barrel, the qualitative loss is greater than the quantitative loss. Consideration of loss as gasoline versus refined products at $4.28 per barrel shows that the loss in quality is just about as great as that in quantity. From the third consideration—loss as crude versus crude at any price—it is presumed (erroneously, of course) that there is no qualitative loss. A saving of evaporation loss, then, will have the double effect of increasing the quantity and quality of the gasoline produced in the United States.

PART II.—VOLUMETRIC LOSS FROM EVAPORATION DURING VARIOUS STAGES OF HANDLING.

INTRODUCTION.

NATURE OF TESTS.

As it is impossible to determine what the loss might be in every possible case, experiments were planned to cover the most important features and to represent, as nearly as possible, average conditions. The meager accounts of evaporation tests published to date represent either laboratory experiments or special conditions. In this report the author sought to avoid special conditions and to obtain results that apply generally. Field experiments were made with tanks, pipe lines, tank cars, and dehydration plants, just as they are used in practice. In other words, the tests were planned to show neither a very large evaporation loss nor a very small one.

The tests are grouped to show evaporation losses under the following conditions:

1. Dehydration by steaming.
2. Filling lease storage tanks.
3. Storing oil on the lease.
4. Storing oil in 55,000-barrel steel tanks.
5. Transferring oil from lease to refinery.
6. Filling large tanks through bottom connections.

A description of the layout and method of each test will be given, together with the presentation and discussion of results. The tests are apportioned as follows:

Apportionment of tests.

Type of test:	No. of tests.
Dehydration plants	4
Lease storage tanks	40
Filling tank by overshot connections	2
Large storage tanks	80
Tank cars	12
Filling tank by bottom connections	1

EVAPORATION LOSSES IN DEHYDRATION BY STEAMING.

CONDITIONS FOR MAKING TESTS.

A summary of the conditions under which the tests were made follows: Location—El Dorado Pool, Kans.; daily production of the lease—300 barrels; degrees Baumé of the oil—37.55; gasoline content of the oil—410° F. end point—30 per cent; length of test—36 hours; season—summer; weather conditions—average.

DESCRIPTION OF PLANT.

Dehydration of crude oil is necessary to remove emulsified water. The method largely used is to pass the oil through water heated by steam. This steam may be carried through a pipe to the bottom of the tank, where it is allowed to flow into the water and condense, or it may be taken to the bottom through a series of coils, then up and expelled into the air.

A few small concrete dehydrators using steam have been built. These were not tested for evaporation loss because they represent so small a proportion of those in use. The usual type is that sketched in figure 4. The oil and water are passed through *d*, a conductor pipe, which reaches from the top of the tank to a point somewhat

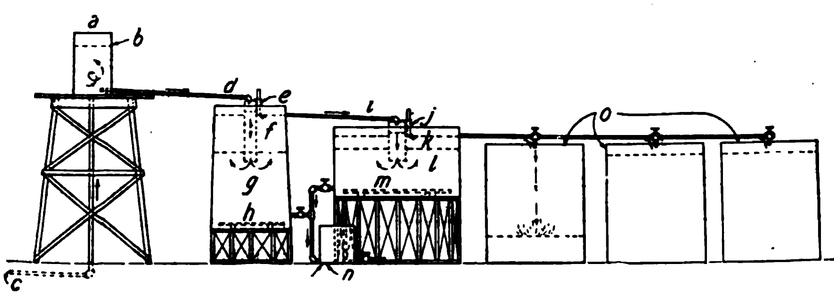


FIGURE 4.—Plant equipped for dehydration by passing emulsion through hot water: *a*, mixture of oil and water; *b*, measuring tank; *c*, buried lead pipe; *d*, first dehydration; *e*, hook gage; *f*, oil; *g*, water; *h*, steam coils; *i*, second dehydration; *j*, hook gage; *k*, oil; *l*, water; *m*, steam coils; *n*, water-measuring tank; *o*, stock tanks.

below the bottom of the oil layer *f* in the first dehydrating tank. As the mixture bubbles up through the water it is heated, causing the globules of water in the oil to coagulate and settle. The oil gradually passes through this stage and by *i* into the second dehydrating tank, where it is treated similarly; from there it flows into the stock tank *o*. The measuring tank *b* on the scaffolding and the measuring tank *n* were set up for the test to determine evaporation losses.

METHOD OF DETERMINING EVAPORATION LOSS.

As has been stated, such a plant was selected for tests because it represents average conditions. The general method of determining the loss was to measure accurately what went in and came out of the plant. For measuring the inflow two 25-barrel tanks (*b*, fig. 4) were placed in an elevated position on the scaffold. These tanks

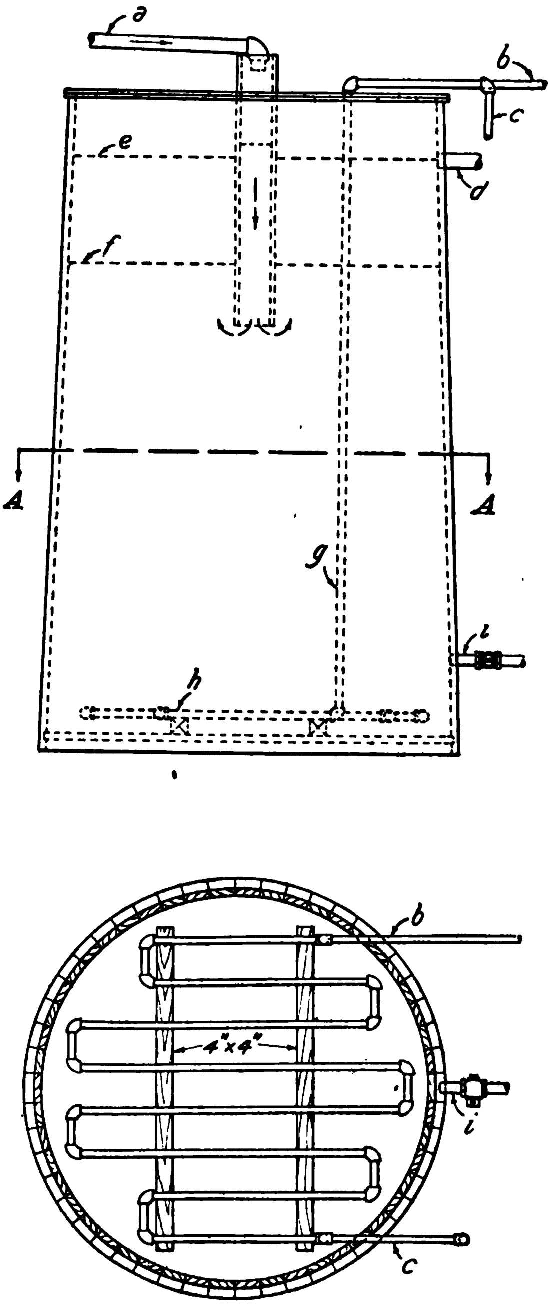


FIGURE 5.—Dehydrator tank, showing closed steam coils: *a*, 3-inch oil inlet; *b*, steam inlet; *c*, steam outlet; *d*, 3-inch oil outlet; *e*, oil level; *f*, water level; *g*, 1-inch pipe; *h*, steam coil; *i*, 2-inch water outlet.

were manifolded, as indicated in Plate II, *A*, in such a way that one could be filled while the other was being emptied and a change from one tank to the other made without stopping the inflow of oil. Plate II, *B*, shows method of filling tank cars.

In order that no error might be introduced by steam flowing into the water in the tanks closed coils were installed, as shown in figure 5. After installation these coils were tested for leaks, for any leak would decrease the apparent loss from evaporation. The tanks were absolutely tight and remained so throughout the test. In order to take care of water settled from the oil the dehydrating tanks were tapped near the bottom and the outlets manifolded and run into another measuring tank represented in figure 4 by *n*. Two hook gages were installed, one in each tank, to determine at any instant the total amount of oil in the two steaming tanks. These gages were so arranged that the change in level of the oil surface in either tank could be determined to

A. FLOW TANK TO SEPARATE GAS FROM OIL. MIXTURE ENTERS AT TOP OF TANK; GAS OUT STACK, OIL OUT NEAR BOTTOM, AND WATER OUT BELOW OIL OUTLET.

B, FIRST STAGE OF DEHYDRATION: *a*, OIL OUTLET; *b*, STEAM INLET; *c*, SECOND STAGE TANK; *d*, WATER OUTLET.

A. TANKS USED FOR MEASURING THE VOLUME ENTERING DEHYDRATION PLANT DURING TEST.

B, LOADING TANK CARS.

the nearest thirty-second of an inch. Even though the oil level were approximately constant, there may be a change of an inch or two due to the change in rate of inflow into the plant. By this installation and by the measurement of oil in the stock tank with a steel tape it was possible at any instant to determine how much liquid had gone through the plant.

Plate III, *A*, shows the plant before the installation of any special apparatus, Plate III, *B*, the construction of the scaffolding and the enlarged stock tanks, and Plate III, *C*, the same plant from another angle after the measuring tanks and piping had been installed. Plate IV, *A*, shows the top of the first dehydrator tank in figure 4, and how the oil falls from the overshot connection through the wooden conductor, which reaches 6 or 7 feet into the tank. The top of the hook gage can be seen projecting from the small hole in the foreground. Plate IV, *B*, shows how the oil enters the second dehydrating tank. The small pipe carries the entering steam to the coil below. The top of the hook gage is seen between the steam pipe and the oil pipe. Plate I, *B* (see p. 32), shows the first dehydrating tank with the outlet steam pipe projecting over the roof. The water-outlet connections which lead to the water-measuring tank appear at the bottom.

TEMPERATURES RECORDED.

Temperatures were taken of the oil in the measuring tanks, and in each of the dehydrator tanks, of the vapor above the oil in each of the dehydrator tanks, of the oil in the stock tank, and of the atmosphere. These temperatures were taken approximately one hour apart. In addition, the depth of the oil in each of the dehydrator tanks was recorded. This depth was kept as nearly constant as possible to equalize the conditions of the test.

MAKING THE TESTS.

At first, measurements and temperatures were taken at all points necessary to give the total volume of liquid in the whole plant; then the volume of oil and water in the first measuring tank was determined and later the oil and water was allowed to flow into the plant at approximately the normal rate of production of the lease. By the time this tank had run out, the other was about full.

The first tank was shut off when the oil ceased to flow, and its depth and the temperature of the contents were taken. Immediately thereafter, another set of measurements was taken throughout all the tanks in use in the plant, to determine again the total volume of liquid therein. With no evaporation loss the increment of liquid in the plant should have been equal to the volume of liquid that had been passed into it from the first full measuring tank. Any difference showed the evaporation loss.

Next, the second full measuring tank was measured and its contents allowed to flow into the plant at a normal rate. This process was continued for 36 hours and represented one test. Although the flow of oil from each full measuring tank was in itself a short test, the impossibility of obtaining exact volumetric measurements made it advisable to sum a 36-hour run to get the average loss during the whole period.

In addition to the field measurements to determine volumetric losses, samples were taken at the same time of the oil in the measuring

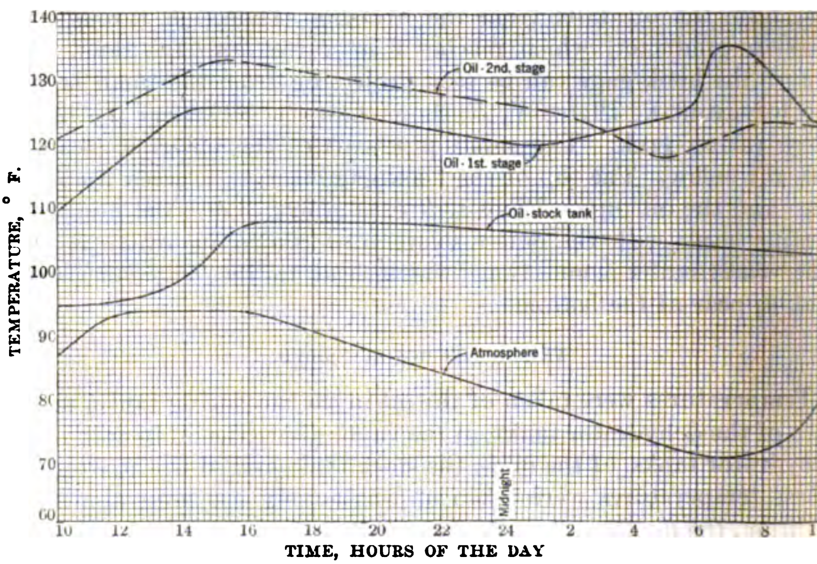


FIGURE 6.—Temperature conditions of third dehydrator test. Dehydrators average 125° F.

tank and at each successive stage. These were sealed and the percentage of volumetric loss determined, as before explained, by distillation and calculation. The results check the field determinations very closely.

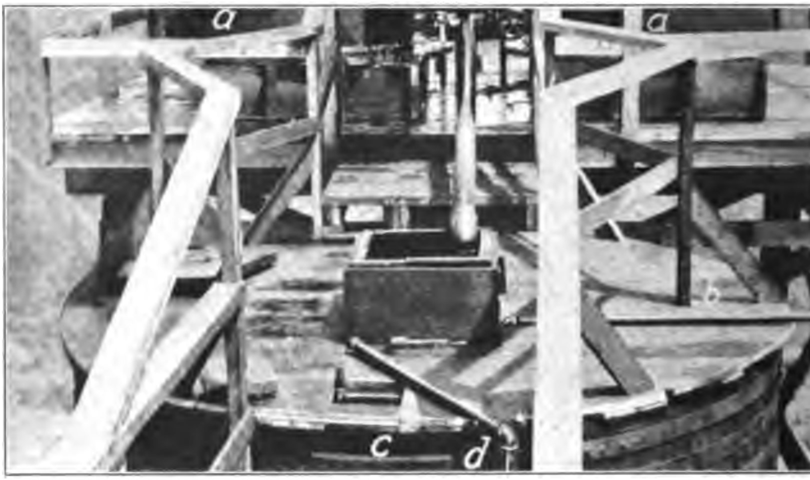
SCOPE OF TESTS.

In order that as wide a range of conditions as possible might be covered four tests were run with a different temperature of the dehydrators in each at a plant handling an average daily volume of 300 barrels. The lowest temperature averaged 84° F. In this test no steam was forced through the coils in the dehydrating tanks. The second test was run at an average temperature of 105° F., the third

A, DEHYDRATOR AS USED BEFORE TEST.

B, MEASURING-TANK SCAFFOLD ERECTED FOR DEHYDRATION TEST.

C, PLANT EQUIPPED FOR TEST.



A. FIRST STAGE OF DEHYDRATION, OIL ENTERING AT TOP: *a*, MEASURING TANKS; *b*, OUTLET OF STEAM PIPE; *c*, HOOK GAGE; *d*, INLET STEAM PIPE.

B, OIL ENTERING SECOND STAGE OF DEHYDRATION: *a*, OIL INLET; *b*, STEAM INLET.

at 125° F., and the fourth at 150° F. During all these tests there was absolutely no leakage in any of the tanks or in any of the connections.

The temperature conditions under which the tests were run showed considerable variation in the temperature of the dehydrators during a test especially at the higher temperatures. It is believed that the effect is practically the same as if they had been held at the average temperature.

Table 5 is an example of the measurements taken in deducing the evaporation loss. Under measurement of fluid entering is shown the total volume entering the plant. Under first dehydrator tank, second dehydrator tank, and lease storage tank are shown the total volume in the plant at specified stages. An increment between any two points of time determined from the summation of these three stages gives the total amount that passed through the plant. The difference between such increment and the measured entering volume represents the evaporation loss.

TABLE 5.—*Field data taken on dehydrator test, June 20, 1919.*

Measurement of fluid entering.						Last three stages.	First dehydrator tank.		Second dehydrator tank.		Lease storage tank.			
Tank No.	Hour.	Depths.				Hour.	Hook gage.	Oil temperature.	Hook gage.	Oil temperature.	Fluid depth.	Temperatures.		
		Full.		Empty.	Temperature.							Bottom.	Middle.	Top.
		Ft.	*In.*	*Ft.* *In.*	*°F.*		*In.*	*°F.*	*In.*	*°F.*	*Ft.* *In.*	*°F.*	*°F.*	*°F.*
E-1	16.35	6	$6\frac{1}{8}$		73									
E-1	17.25			0 $3\frac{1}{2}$	71	17.30	$3\frac{1}{8}$	110	$3\frac{1}{16}$	117	6 $5\frac{5}{8}$	92	98	105
E-2	17.35	5	$8\frac{3}{8}$		69									
E-2	18.30			0 $3\frac{11}{16}$	70	18.35	$3\frac{1}{4}$	108	$3\frac{1}{16}$	114	6 $11\frac{3}{16}$	92	102	102

RESULTS.

Table 6 shows, in condensed form, the results of the four tests on this dehydration plant. These results have been analyzed and plotted in curves (figs. 7—10), each of which presents graphically a specified phase of the tests.

TABLE 6.—*Summarized results of dehydrator evaporation tests.*

Average temperature of dehydrators.	Test No.	Daily production.	Volume lost.		Gravity of portion evaporated.	Daily actual value lost.[a]		Per cent value lost.[b]			Gravity lost by crude starting at 37.55 °B.
						As crude.	As gasoline.	As gasoline— At 22c. per gal. v. crude at $3 per bbl.	As gasoline— At 22c. per gal. v. refined products at $4.28 per bbl.	As crude v. crude.	
°*F.*		*Bbls.*	*Per ct.*	*Bbls.*	°*B.*			*Per ct.*	*Per ct.*	*Per ct.*	°*B.*
84	1	300	1.76	5.3	80.3	$15.90	$49.00	5.4	3.8	1.76	0.65
105	2	300	3.30	9.9	78.0	29.70	91.50	10.2	7.1	3.30	1.10
125	3	300	5.45	16.4	76.9	49.00	151.20	16.8	11.8	5.45	1.55
150	4	300	6.70	20.1	73.1	60.30	185.80	20.6	14.5	6.70	1.95

[a] See p. 27.
[b] See p. 28.

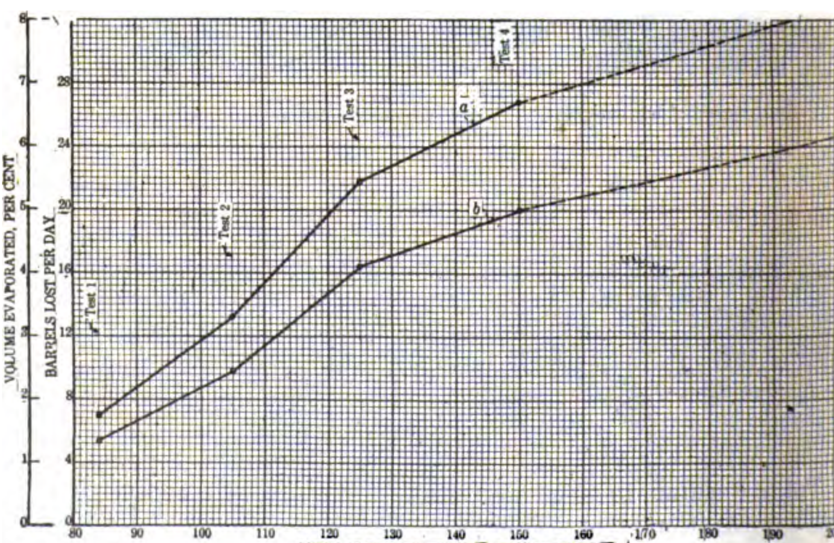


FIGURE 7.—Effect of temperature of dehydrators on volume lost: *a*, variation of percentage of volume lost with variation in temperature of dehydrators; *b*, variation of actual volume lost with variation in temperature of dehydrators.

Figure 7 shows the variation in the percentage of volume lost with the variation in the temperature of the dehydrators. This percentage increases at an almost constant rate until 125° F. is reached, where the curve tends to flatten because of the more rapidly evaporating fractions being eliminated in the early stages at such high temperatures; the heavier gasolines remaining evaporate at a much slower rate. It is well to notice that if this curve were projected to 200° F. for the temperature of the dehydrators the percentage of

volume lost would reach as high as 8.5 per cent. As a matter of fact, 200° F. is not an uncommon temperature for these dehydrators.

Figure 7 also shows the effect of different temperatures—this time in barrels instead of in percentage of volume lost.

Figure 8 shows the rapid increase in value lost, considered as gasoline at 22 cents per gallon and as crude at $3 per barrel, as the temperature in the dehydrators increases. Figures 8 also shows the effect on the percentage of value lost as the temperature in the dehydrator rises. The lowest curve in this figure, loss as crude v. crude, represents the percentage of volume lost as well as the percentage of value lost. Examination of the other two curves shows how much the percentage of value lost exceeds the percentage of volume lost.

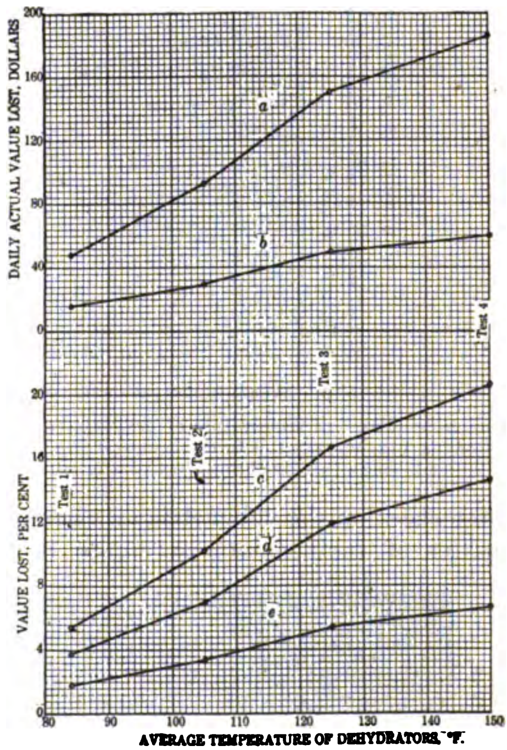


FIGURE 8.—Variation of actual value lost with increasing temperature of dehydrators, when loss is considered (*a*) as gasoline at 22 cents per gallon and (*b*) as crude at $3 per barrel; variation of percentage of value lost with increasing temperature of dehydrators, when loss is considered (*c*) as gasoline at 22 cents per gallon v. crude at $3 per barrel, (*d*) as gasoline at 22 cents per gallon v. refined products at $4.28 per barrel, and (*e*) as crude v. crude.

In figure 9, curve *a* shows the gravity of the portion evaporated for the different temperatures of dehydrators represented in four tests. At the lowest temperature, 84° F., the gravity of the portion that has evaporated is 80.3° B., but in the last test, that at 150° F., the average gravity of the fraction that has evaporated is 73.1° B. Naturally, the rate of evaporation of the lower fractions is much slower, even though at a higher temperature.

Another effect of heating oil is shown in curve *b* of the same figure. The incoming oil had an average gravity of 37.55° B. When the dehydrators were held at 84° F., the oil lost 0.65° B. while passing through the plant, and left it with a gravity of 36.9° B. at the end of the test. As the temperature was increased to 150° F., this loss rose as high as 1.95° B., the oil leaving with a gravity of 35.6° B.

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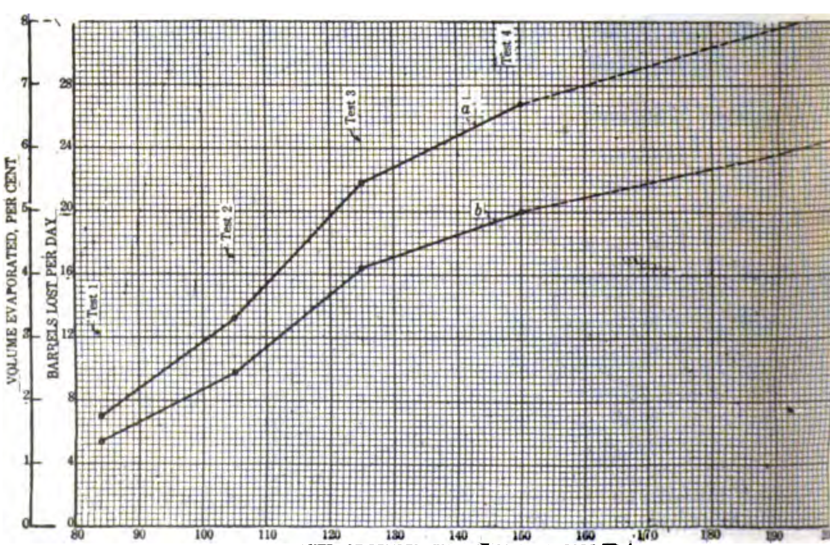
Average temperature of dehydrators.	Test No.	Daily production.	Volume lost.		Gravity of portion evaporated.	Daily actual value lost.[a]		Per cent value lost.[b]			Gravity lost by crude standing 37[illegible] ° B.
						As crude.	As gasoline.	As gasoline— At 22c. per gal. v. crude at $3 per bbl.	As gasoline— At 22c. per gal. v. refined products at $4.28 per bbl.	As crude v. crude.	
° F.		Bbls.	Per ct.	Bbls.	° B.			Per ct.	Per ct.	Per ct.	° B.
84	1	300	1.76	5.3	80.3	$15.90	$49.00	5.4	3.8	1.76	0.6[illegible]
105	2	300	3.30	9.9	78.0	29.70	91.50	10.2	7.1	3.30	1.1[illegible]
125	3	300	5.45	16.4	76.9	49.00	151.20	16.8	11.8	5.45	1.5[illegible]
150	4	300	6.70	20.1	73.1	60.30	185.80	20.6	14.5	6.70	1.9[illegible]

a See p. 27.
b See p. 28.



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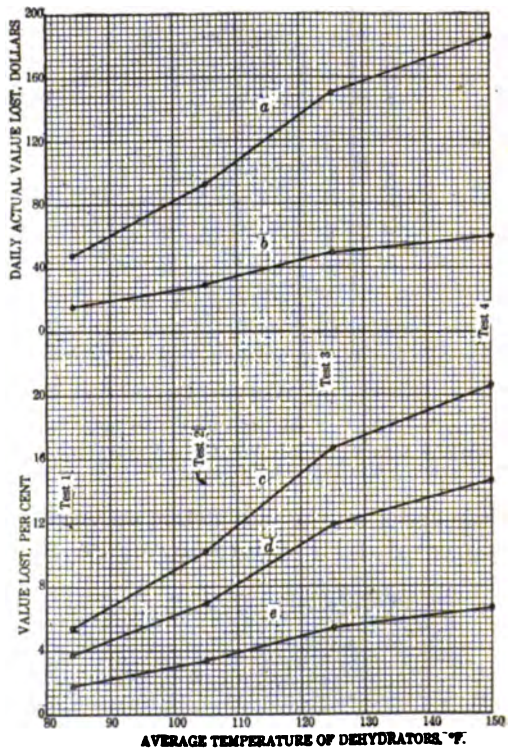

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Average temperature of dehydrators.	Test No.	Daily production.	Volume lost.		Gravity of portion evaporated.	Daily actual value lost.[a]		Per cent value lost.[b]			Gravity lost by crude starting at 37.[illegible] ° B.
						As crude.	As gasoline.	As gasoline—At 2¢. per gal. v. crude at $3 per bbl.	As gasoline—At 22c. per gal. v. refined products at $4.28 per bbl.	As crude v. crude.	
° *F.*		*Bbls.*	*Per ct.*	*Bbls.*	° *B.*			*Per ct.*	*Per ct.*	*Per ct.*	° *B.*
84	1	300	1.76	5.3	80.3	$15.90	$49.00	5.4	3.8	1.76	0.65
105	2	300	3.30	9.9	78.0	29.70	91.50	10.2	7.1	3.30	1.1[illegible]
125	3	300	5.45	16.4	76.9	49.00	151.20	16.8	11.8	5.45	1.55
150	4	300	6.70	20.1	73.1	60.30	185.80	20.6	14.5	6.70	1.95

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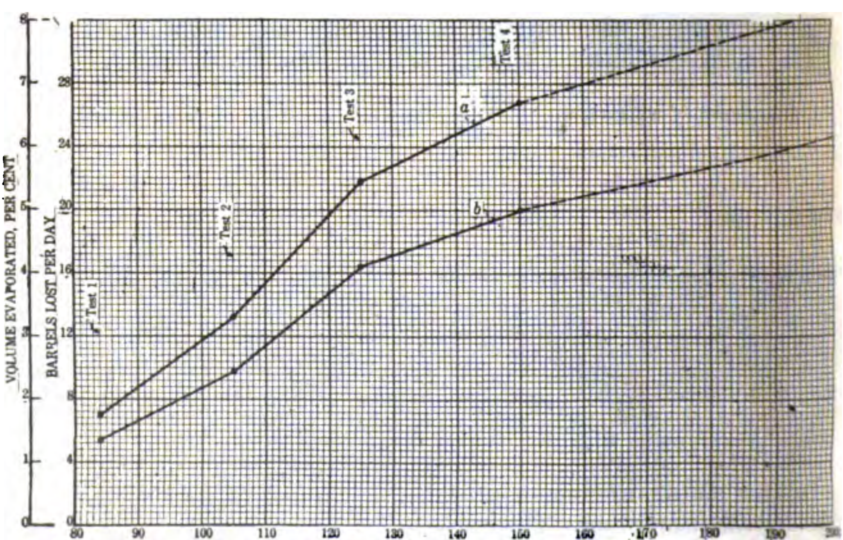
b See p. 28.



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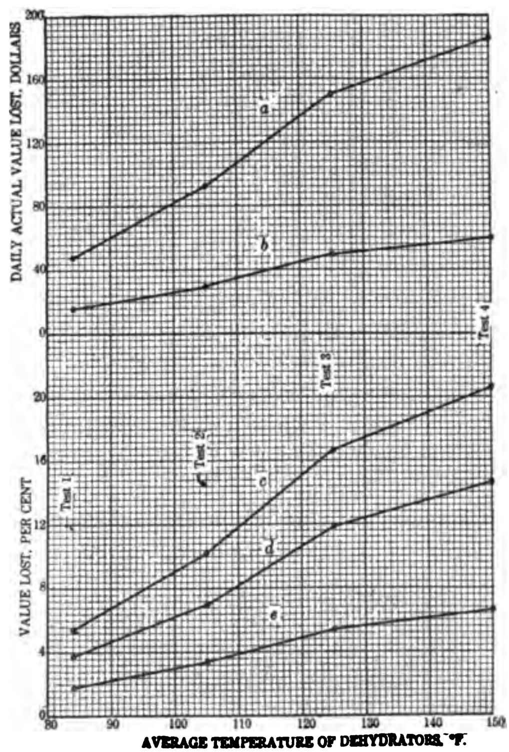

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The data presented in figure 7, when taken in conjunction with the specific gravity formula for percentage of volume lost, give a very

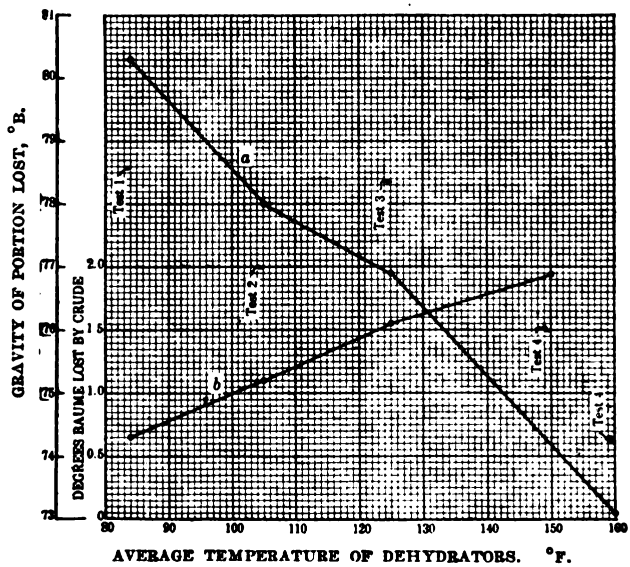


FIGURE 9.—Effect of temperature of dehydrators on loss of gravity of oil: *a*, gravity of portion evaporated at different temperatures of dehydrators; *b*, degrees Baumé lost by crude while passing through dehydrator at varying temperatures.

close check on the volumetric measurements made in the field. As a matter of further interest, figure 10 has been drawn. In these

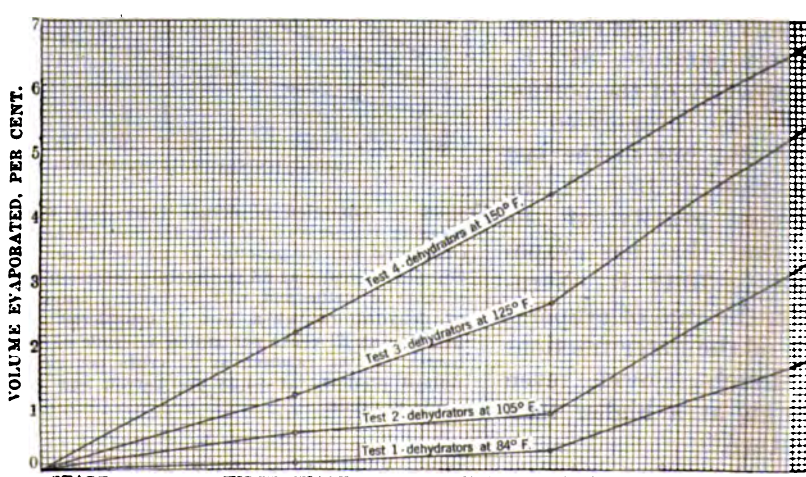


FIGURE 10.—Cumulative percentage of volume lost as the oil passes through successive stages of the dehydration plant.

curves, the percentage of volume lost has been taken as ordinates and the stages of the whole dehydration plant as abscissas, with an equal interval for each stage. Each curve represents the results of a single test. The depth of oil in the first and second dehydrator tanks was such that the oil remained in the first approximately two hours and in the second about six hours, making a total of about eight hours in passing through both. The average time spent in the third stage, or stock tank, during a 24-hour test would be 12 hours. Although ordinarily the temperature in the stock tank is much lower than in the dehydrators, still, as the oil spends more time in this stage and has farther to fall on entering the tank than in the other two stages, it would naturally be supposed that the greatest part of the loss would occur here.

For the lower temperature—84 and 105° F.—the loss in the third stage is very much greater than in either of the other two stages. At 125° F. the proportion of this loss has decreased, and at 150° F. it is shown to be much less than that in the second dehydrator tank. A combination of conditions causes this difference. The first condition of note is that the temperature of the third stage is much lower than that of the second stage for the 150° F. test. The next consideration is one that has been mentioned before—the lighter fractions evaporate in the first and second stages, leaving only the comparatively heavy gasolines to evaporate in the third stage.

GENERAL DISCUSSION OF DEHYDRATOR TESTS.

DISCUSSION OF ERRORS.

When these results are examined, it seems at first that an error may have been made in obtaining them. The fact that they are so large makes one pause to be absolutely sure that the work done is correct. As has been mentioned, each of these four tests is a combination of a number of small tests represented by each measuring-tankful that was run into the plant. Personal errors are thus eliminated, as each test checks the others. Not only was the professionally made tank gage-table used but check measurements were made to cover this point. The volumes of the measuring tanks for fluid entering were also checked thoroughly. The thermal expansion of the steel tank in the third stage, due to high temperatures and a possible wrong temperature-reduction factor for the oil itself had been considered and calculations made for possible errors from this source. The greatest possible combined error from these two sources was less than three-tenths of 1 per cent of volumetric loss.

In addition to these precautions, the percentage of volume lost was carefully determined from the distillations of the samples. These percentages checked the field results as closely as could be expected.

Another question that may throw doubt on the results is—why have the losses not been noticed if they are so large? The reason is that in dehydration plants the total liquid that a well or a lease makes is never measured. The net oil of a lease is measured only after it has passed through flow tank and dehydrator.

COMPARISON OF PLANT USED TO GENERAL CONDITIONS OF SUCH PLANTS.

The plant utilized for the tests does not represent conditions especially favorable to loss by evaporation, but as nearly as could be arranged approximates the average conditions prevailing in field plants dehydrating by steaming. In fact, care was taken that this plant should represent such plants at their best. To this end, the roof of the tank, representing the first stage of the dehydrator, was made practically vapor tight. The oil was of 37.55° B. gravity, the average of the better grade of oil in the El Dorado, Kans., field, where these experiments were made. The variations in the temperature of the tests cover average conditions. However, only one season was considered—the summer. In order to get results that would apply for the whole year, two or three additional groups of tests should be run, one in the fall or spring and one in the winter, for the temperatures of the dehydrators are approximately 25° F. higher in winter than in summer. As the temperature of the oil controls the rate of evaporation, it is probable that the loss at such plants during the cooler seasons is fully as large as during summer.

FACTORS CAUSING VARIATION IN PERCENTAGE OF LOSS.

Several factors can cause a variation of the percentage of volume lost. One of these is a change in the quality or quantity of the oil passing through the plant. If the daily production should increase greatly the percentage of volume lost would decrease somewhat, although the actual volume lost would be greater. If a plant were normally dehydrating 300 barrels a day and for some reason this should be increased to 600 barrels a day, then the oil would remain in the plant only half as long. The percentage of loss would be decreased, but would not be one-half of the former rate, for the loss would include a larger volume of very light gasoline which evaporates faster.

If for any reason the kind of oil passing through a plant were changed so that the gravity of the lighter fractions was lowered decidedly, the percentage of loss would be decreased because of the slower rate of evaporation of the heavier fractions.

Figure 11 shows different conditions of operating three plants; 1 and 2 are plants having tanks of the same size and therefore the same area of oil surface exposed, the daily production being considered as a constant. In plant 1, the depths a_1 and b_1 are such that the volume of oil in A_1 and B_1 is twice that in A_2 and B_2, hence the oil has to remain in plant 1 twice as long and the evaporation loss will be almost twice as large.

Now compare plant 1 with plant 3, in the same figure. The area in A_3 and B_3 is double that in A_1 and B_1, respectively, but the depths a_3 and b_3 are such that the volume of oil in plant 3 is exactly the same as that in plant 1. With the same daily production passing through both these plants, the number of hours that the oil is subjected to evaporation in each is the same. As, however, the area exposed is doubled in plant 3, the percentage of volume evaporated is almost double that of plant 1.

Evidently there are many such combinations of daily production, volume of oil held in tanks, relative oil areas exposed, and tempera-

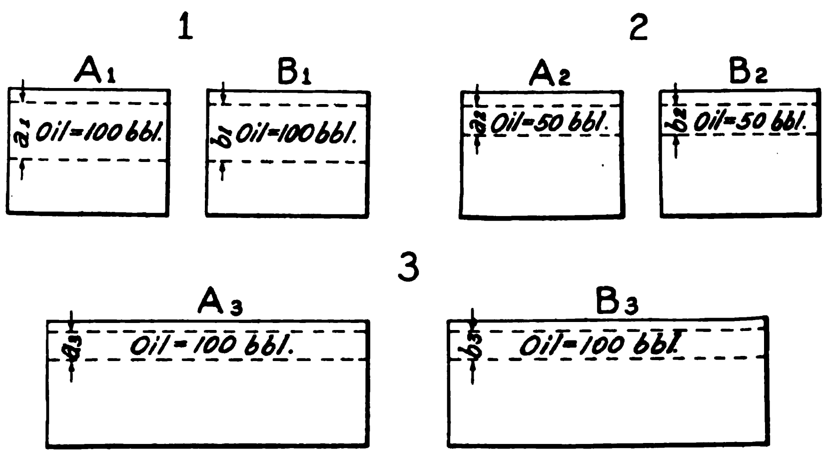


FIGURE 11.—Three dehydration plants handling the same daily production under different conditions; A_1 and B_1=two of A_2 and B_2, respectively. Area of 3=twice the area of either 1 or 2.

ture of dehydrators. For this reason investigation on a scientific basis would necessitate a great number of tests. This one phase alone illustrates the magnitude of the evaporation problem.

Table 7, based on the results of the tests, indicates the volume and the value lost for plants of various sizes obtained from these tests.

TABLE 7.—*Evaporation loss in dehydration plants of different daily capacities and for different temperatures.*

[Gasoline—22 cents per gallon, 42 gallons to the barrel; crude—$3 per barrel.]

Temperature of plant.	Volume lost.	Daily capacity.											
		50 barrels.			100 barrels.			300 barrels.			1,000 barrels.		
		Volume lost.	Value lost.		Volume lost.	Value lost.		Volume lost.	Value lost.		Volume lost.	Value lost.	
			As crude.	As gasoline.		As crude.	As gasoline.		As crude.	As gasoline.		As crude.	As gasoline.
°F.	Per ct.	Gals.			Gals.			Gals.			Gals.		
84	1.76	36.9	$2.64	$8.12	73.9	$5.30	$16.26	223	$15.90	$49.00	739	$52.80	$162.00
105	3.31	69.5	4.97	15.30	139.0	9.95	30.55	417	29.80	91.60	1,390	99.40	305.00
125	5.46	114.7	8.20	25.25	229.4	16.40	50.40	688	49.20	151.40	2,294	164.00	503.00
150	6.72	141.2	10.10	31.00	282.3	20.20	62.10	847	60.60	186.00	2,823	220.00	619.00
200	8.30	174.2	12.45	38.30	348.5	24.90	76.50	1,046	74.60	230.00	3,485	249.00	764.00

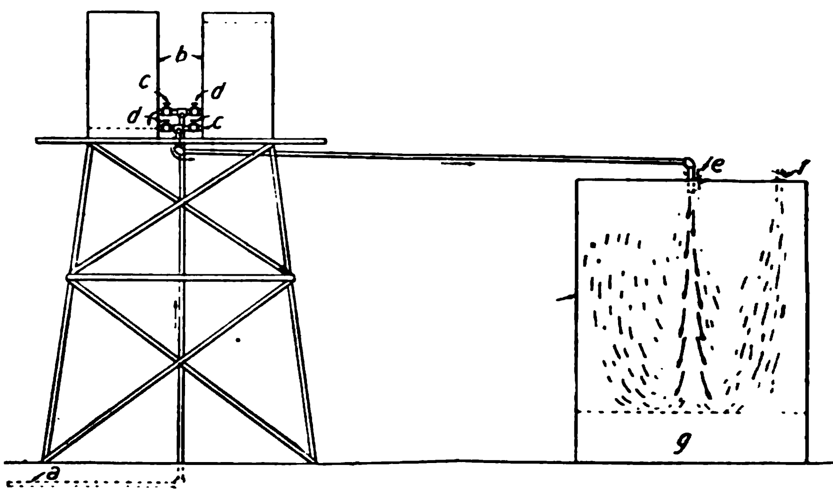


FIGURE 12.—Layout for determining evaporation loss in filling lease tank: *a*, from well; *b*, 25-barrel measuring tanks; *c*, open; *d*, closed; *e*, center hole; *f*, gage hole; *g*, steel tank, unprotected, 500 barrels.

EVAPORATION LOSSES IN FILLING LEASE STORAGE-TANKS.

DESCRIPTION OF LAYOUT.

In order to get some idea of the loss in filling a tank with overhead connections, a test was planned as pictured in figure 12. The oil from the wells was run into the measuring tank *b*, one being filled while the other was emptied. The oil flowed through the pipe to the lease tank *g* at a rate comformable to the production of the wells, in order to duplicate actual conditions. Two tests were made, one with the connecting pipe 30 feet long, the other with the pipe only 11 feet long. The distance from the overshot connections to the surface of the oil was 8 feet in one and 13 feet in the other test. Presentation of the details of these tests is made in Table 8. When oil falls a distance of 12 feet it strikes the surface at a speed of about 28 feet per second, or 19 miles per hour. The resulting splash causes the formation of a spray of oil, and as the oil particles have a large exposed surface compared to their volume, they evaporate very rapidly, filling the tank with rich gasoline vapor. Much of this vapor escapes through openings in the roof of the tank.

TABLE 8.—*Conditions and results of tests on filling lease tanks.*

Description of condition.	Test 1.	Test 2.
Gravity of oil..........°B..	37	39
Time out of well..........hours..	10	5
Tanks already passed through..........	3	1
Length of pipe, measuring tank to stock tank..........feet..	11	30
Average fall..........do....	8	13
Daily production..........barrels..	300	100
Average volume lost..........per cent..	1.55	2.24

RESULTS OF TESTS.

The results of these experiments show that such filling-tank losses range from 1.5 to 2.25 per cent for one day's production. Naturally, the losses include the evaporation of the oil in the tank and the evaporation of the spray. The results show that the percentage of loss is much less for a 300-barrel than for a 100-barrel output. Producers who allow a very small stream of oil to flow into a comparatively large tank have evidence here that such practice is wasteful. Some leases that produce not over 50 barrels a day have 250-barrel tanks, and as filling one of these at that rate takes about four days, the percentage of oil lost in filling alone can be imagined. The quicker the tank is filled the lower the percentage of loss from this source.

Figure 13 shows the conditions under which test 2 was run. The results of test 1 bring out the fact that with larger production the percentage of loss did not vary greatly when the temperature of the entering oil decreased from about 89 to 82° F. Test 2, illustrated in Figure 13, shows that as the temperature of the entering oil decreased from 86 to 57° F. the rate of loss decreased decidedly. The daily production of the plant used in this test was low, being only 100 barrels.

When the percentage of volume loss was lower, as in test 1, the gravity of the oil was heavier, the number of hours the oil had been out of the well was greater, the number of tanks through which the oil had passed was greater, the length of the pipe line from the measuring tank to the lease tank was less, the average fall was less, and the daily production was three times as great. Every one of these different conditions tends to make the percentage loss in test 1 less than in test 2.

CONCLUSIONS FROM FILLING-TANK TESTS.

Oil should be taken into the bottom of the tank to avoid the splashing and spraying of overshot filling. When a lease has a very low production the tanks used should be small.

Although the percentage of volume lost in these two tests differ widely, still when the relative conditions are taken into consideration they are in reality a check on each other.

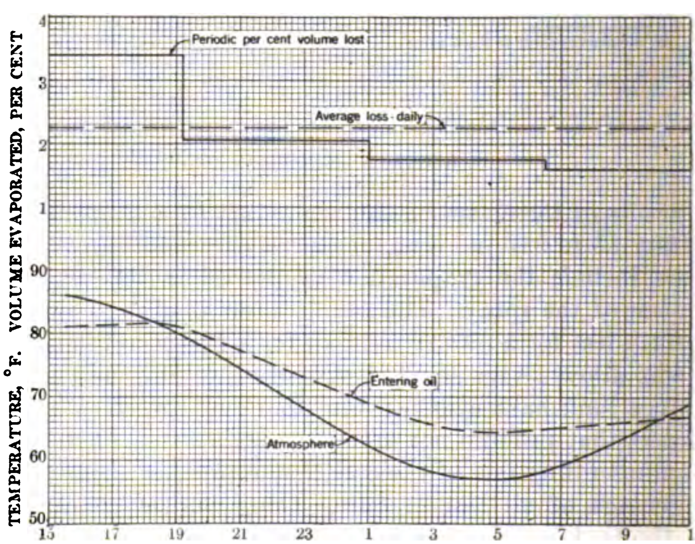


FIGURE 13.—Test 2, temperature conditions and results of test on filling lease tank.

EVAPORATION LOSSES IN STORING OIL ON THE LEASE.

DETERMINATION OF AN AVERAGE TANK.

Data on all the tankage of two of the larger producing companies in the Mid-Continent field were used for deducing the results shown herein. Table 9 shows the number and the total capacity of each size of tanks on leases and the percentage that each size is of the total tankage. The sizes range from 60 to 1,800 barrels.

TABLE 9.—*Sizes of tanks from which the three principal groups are determined.*

Size of tank.	Number of each size.	Total capacity of each size.	Per cent of total capacity.	Group.	Per cent of total by groups.
Bbls.		*Bbls.*			
60	10	600	0.15	1	31.79
100	118	11,800	2.93		
250	462	115,500	28.71		
500	258	129,000	32.07	2	33.46
800	7	5,600	1.39		
1,000	24	24,000	5.96	3	34.75
1,600	76	114,000	28.34		
1,800	1	1,800	0.45		
	956	402,300	100.00	....	100.00

On examination it is found that the 60-barrel, 100-barrel, 800-barrel, 1,000-barrel, and 1,800-barrel sizes number less than one-sixth of the total, and that their total capacity is less than one-seventh of the total. When reduced to percentage of total capacity, the predominating sizes are shown to be 250-barrel, 500-barrel, and 1,600-barrel tanks. As a result of such observations all sizes of tanks have been grouped in three principal classes. The 250-barrel group includes the 60-barrel and the 100-barrel sizes; the 500-barrel group, the 800-barrel size; and the 1,600 barrel group, the 1,000 and 1,800 barrel sizes. Each of these groups represents about one-third of the total tankage in the Mid-Continent field. From the percentage of volume lost, presented for these three groups, is determined the percentage of volume lost for the average size tank by prorating the loss for each size according to the percentage for each group according to total tankage. To obtain the volume lost and hence the actual value lost, the average sized tank has been considered to hold 750 barrels, which is an approximate average of the three principal sizes.

DESCRIPTION OF TYPES OF TANKS.

Lease tanks are made of wood or of steel. Nearly all the wooden tanks are housed as in figure 14 and in Plate V, *A*, which shows the 1,600-barrel size. The primary reason for putting up this board house is to keep the sun from drying out the staves so much when the tank is empty that it will leak profusely when it is filled. The housing reduces the temperature of the air and vapor above the oil in the tank and decreases the circulation of air due to wind. Wooden tanks have given much trouble from leaks, however, and are being discarded for the bolted steel type as rapidly as possible.

Steel tanks on the lease are usually of the bolted type and only exceptionally are they protected from sun, wind, or rain. Plate

V, *B* and *C*, shows a battery of steel lease-tanks with typical roofs. The roofs, of thin sheet metal, have a 20-inch hole at the center and gage holes at the side. The center holes have lids which are supposed to be kept in place, but generally they are laid about halfway across, this being necessitated by pipes running across the center of the tank. In addition, it may be that three or four smaller holes are cut in the top of the tank for gaging, and these holes are never covered. Plate VI, *A* and *B*, shows large steel lease-tanks with overshot connections and roofs in bad condition.

SPECIAL TYPES OF TANKS.

In addition to these usual types of storage, here and there are others, such as steel tanks, housed with a structure like that for

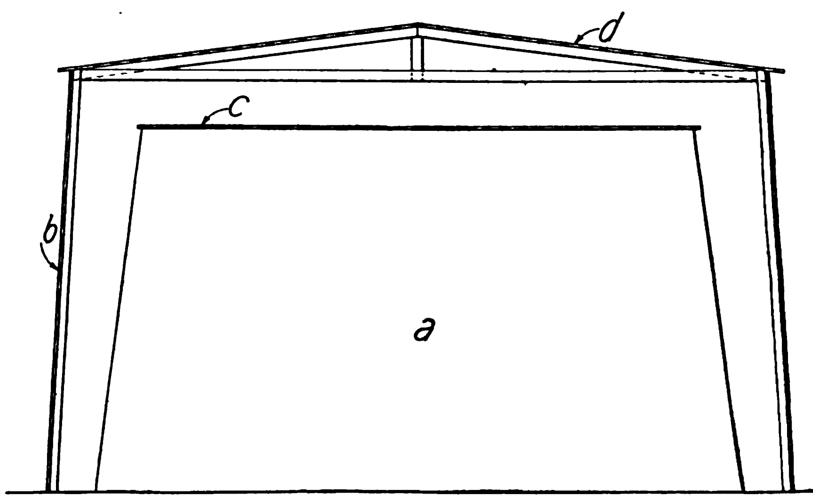
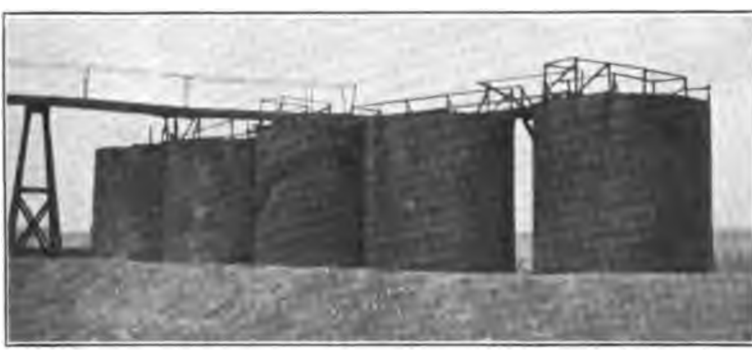


FIGURE 14.—Wood housing for 1,600-barrel lease stock-tank to decrease the circulation of air: *a*, 1,600-barrel wood-stave stock tank; *b*, 1-inch board; *c*, 1-inch boards laid across top of tanks; *d*, 1-inch board roof.

wooden tanks, as shown in figure 21; and steel tanks with a tight jacket, so constructed as practically to prevent the wind causing air circulation. These types represent the most advanced equipment for reducing evaporation. The second type cited is a sample of tank protection designed to keep the oil warmer in winter; it decreases evaporation decidedly. The effect of such housing and the jacketing of steel tanks will be discussed later on page 60. Plate VII, *A*, *B*, and *C*, gives several views of these tanks.

Figure 15 is a detailed sketch of the construction of one of these jackets on a 500-barrel steel tank. The sides are of 2-inch lumber, tongue-and-grooved, held in place by four circular ¾-inch rods. The roof is of 1-inch planks covered with tar paper, battened down in such

A, HOUSING FOR WOODEN LEASE TANKS.



B, BATTERY OF 500-BARREL UNPROTECTED STEEL TANKS.

C, TYPICAL CONDITION OF THE ROOFS OF SUCH TANKS AS ARE SHOWN IN PLATE V, *B*.

A. OVERSHOT CONNECTION FOR LARGE LEASE TANK.

B. LARGE STEEL TANKS WITH BAD ROOF SHOWING NEGLECT OF EVAPORATION LOSSES.

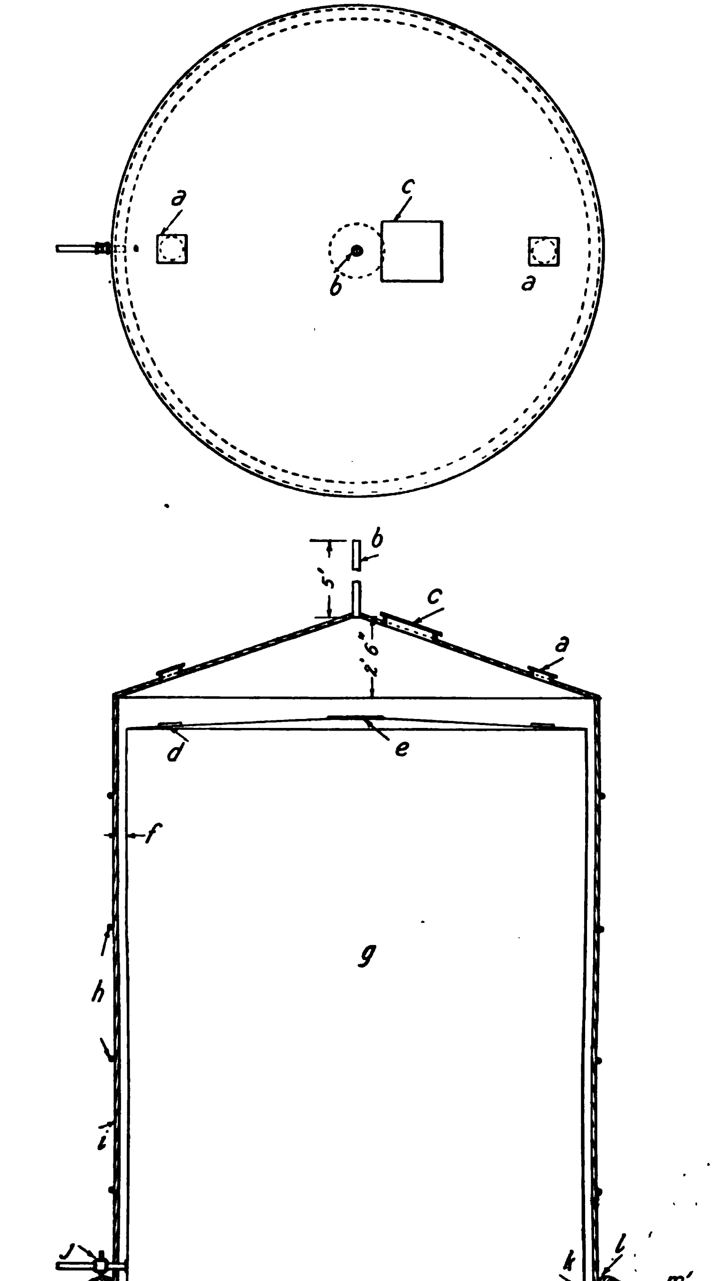


FIGURE 15.—Sketch showing practically air-tight jacket around steel lease tank: a, removable cover over 8-inch opening; b, 2-inch vent pipe; c, removable cover over 20-inch opening; d, 8-inch opening; e, 20-inch opening; f, 3-inch clearance; g, tank; h, ¾-inch rods; i, jacket; j, 2-inch stop valve; k, 2 by 10 inch pine board base for jacket; l, earth seal; m, ground line.

a way as to prevent the escape of air. The bottom has for a foundation 2 by 10 inch pine boards sunk slightly into the ground and making an earthen seal to eliminate air circulation.

AVERAGE PERIOD OF STORAGE ON THE LEASE.

Data from the same companies gives the information shown in Table 10. This table shows that in winter the period of storage is about 70 per cent longer than in summer, a fact well known by oil operators. The average period of storage throughout the year is 5.5 days. This does not include the length of time that the oil previously remained in a flow tank or in a dehydration plant, which may range from a few hours to a whole day. Five days have been taken as the average duration of storage on the lease in all calculations to determine the evaporation loss in the Mid-Continent field.

TABLE 10.—*Number of days that oil is held on the lease throughout the year.*

	Days.		Days.
January	7.4	August	4.4
February	7.4	September	5.0
March	7.1	October	4.8
April	5.3	November	5.0
May	4.8	December	6.0
June	4.4		
July	4.4	Average	5.5

SEASONAL TEMPERATURES IN THE MID-CONTINENT FIELD.

In the Mid-Continent field the yearly cycle of temperature resolves itself naturally into three principal divisions, which do not coincide exactly with the calendar seasons of spring, summer, autumn, and winter, but overlap in places. The results presented here are taken as the average cycle for a period of approximately 30 years and are based on records of the Weather Bureau. As the Mid-Continent field extends from north central Kansas to northern Texas, the temperature of the average normal season for the entire field was determined from temperature records at three places widely separated—Wichita, Kans.; Oklahoma City, Okla.; and Abilene, Tex. In figure 16 the normal temperatures of these places are plotted according to months. As would be expected, the average temperature is cooler farther north, and the differences between the three places are less in summer than in winter. December, January, and February are the coldest months; March, April, May, October, and November are months of medium temperature; June, July, August, and September are the warmest months. The whole year was divided into three

A. TOP OF JACKETED TANK BEFORE CONSTRUCTION OF ROOF.

B. ROOF OF JACKETED TANK SHOWING DOOR OPEN.

C. BATTERY OF JACKETED STEEL LEASE-TANKS.

periods representing these three groups of months, from which the average temperature for each period was determined, as shown in the figure.

CHANGE IN RATE OF EVAPORATION WITH CHANGE OF TEMPERATURE.

After the average seasonal temperature of the oil while on the lease has been determined, it is necessary to determine how the rate of evaporation for an average tank changes with the change in temperature. Figures 17 and 18 show the method. The percentage of volume lost is plotted against the average temperature to which the oil is subjected during a test. In the tests made for this report

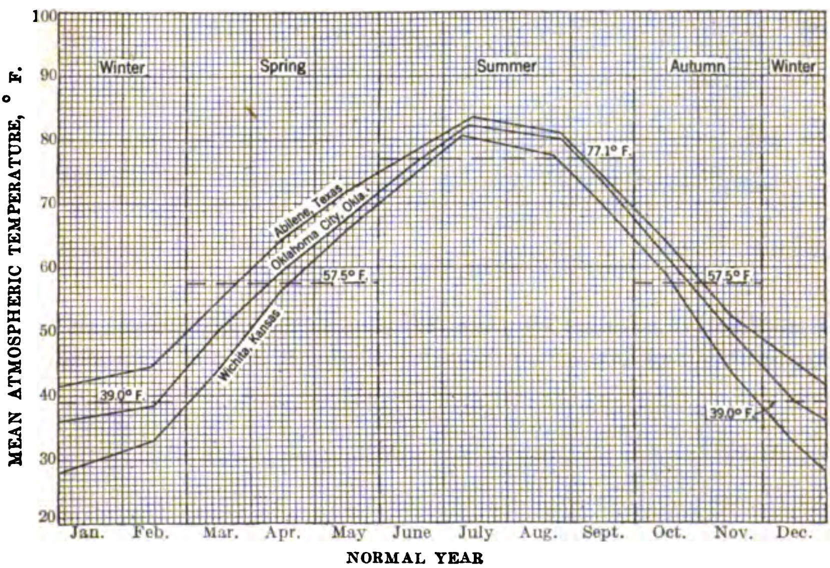


FIGURE 16.—Method of obtaining average normal temperatures for the four seasons of the year in the Mid-Continent field.

enough points were not always obtainable to project the curve to average winter temperature. In order to determine the shape of the curve representing this percentage of volume lost, special data were taken which showed a variation in temperature from 81° to 20° F. In these special data all of the evaporative conditions were constant except temperature. When the general shape of this curve had been determined similar data were plotted for the three main groups of lease-storage tanks—250-barrel unprotected steel, 500-barrel unprotected steel, and 1,600-barrel housed wood. Each curve plotted represents the variation in percentage of volume lost for a different period of storage. Table 15 (see p. 68) shows one interpretation calculated from these curves. Many other interpretations can be made

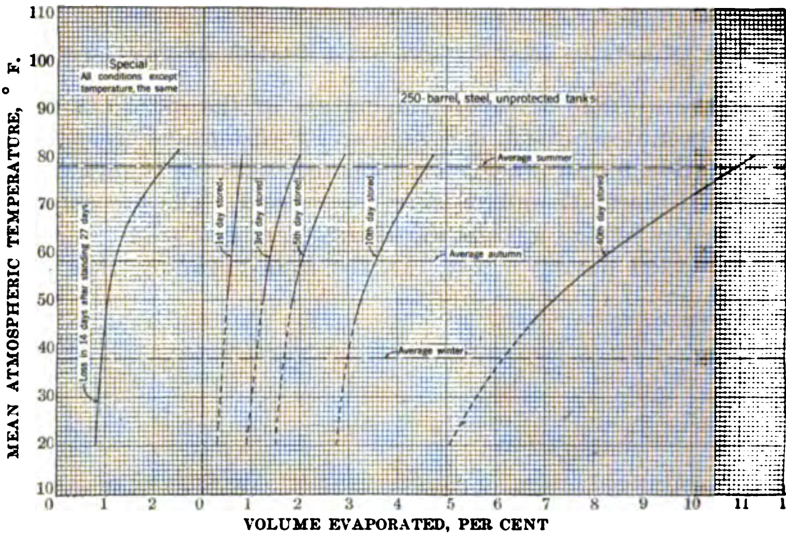


FIGURE 17.—Variation of percentage of volume lost from 250-barrel unprotected steel tanks with variation of mean oil temperature.

by application of local temperature conditions. The curves in these two figures summarize the intensive study of all the tests made on

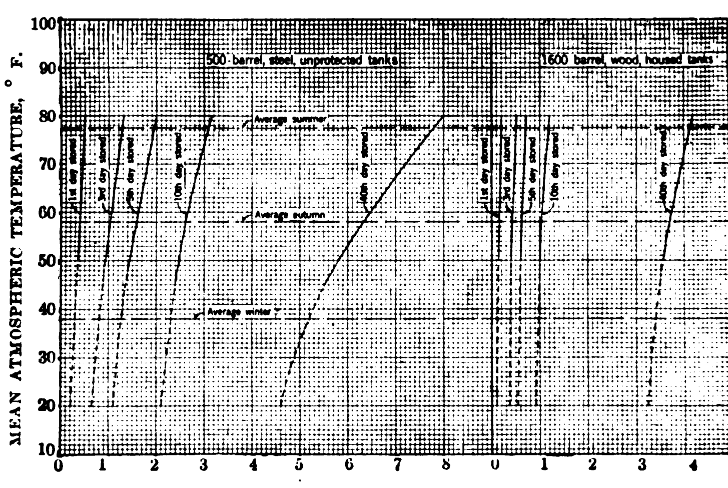


FIGURE 18.—Variation of percentage of volume lost from 500-barrel unprotected steel tanks and 1,600-barrel housed wood tanks with variation of mean oil temperature.

lease storage under different temperature conditions. The average time of storage on the lease (five days), the three general groups of tanks, and the determination of what is considered an average tank have been discussed on preceding pages.

METHOD OF RUNNING A TEST.

Table 1 (see p. 14) gives the data kept on a lease-storage test. As soon as possible after the tank had been filled the first data were taken, including the date and hour of filling the tank, its depth and temperature, and the date and hour that the readings were taken. All tank connections were carefully examined to see that no oil was leaking into or out of the tank. Similar inspection was made each time that the volumetric readings were taken, that is, daily for five days following the initial readings and thereafter at intervals of 10 days until 40 or 45 days had elapsed. At each taking of volumetric readings a 2-quart sample of the oil in the tank was taken in the manner described previously.

DESCRIPTION OF TESTS.

Table 11 shows the general scope of the tests under this heading. An examination of it will give the types of storage that have been covered.

CLASSIFICATION.

Tests were made with 40 tanks. More than one test of the same class was made, and the results shown are consequently a composite of all the tests in that class. In determining the class in which any test belonged, the size and the type of the tank, whether it was protected or not, the season of the year, and the degrees Baumé and source of the oil were taken into consideration. With the exception of the degrees Baumé of the oil, these all had to be exactly the same. In classifying oil by gravity some leeway was allowed. For instance, an oil of 36° B. would be in the same class as oil of 38° B.

TABLE 11.—*Scope of lease-storage experiments covering 40 field tests.*

Tanks used.			Seasons.	Length of experiments.	Oil used.	
Size.	Material.	Protection.			Range.	Source.
Bbl.				*Days.*	° *B.*	
250	Steel	Housed	Summer	10	46	Oklahoma, Kansas.
250	...do	None	Summer, autumn, winter	45	34-37	Do.
500	...do	Jacketed	.....do	45	34-37	Do.
500	...do	None	.....do	45	34-37	Do.
1,600	Wood	Housed	.....do	45	35	Do.

PERCENTAGE OF VOLUME AND ACTUAL VOLUME LOST.

For presenting the percentage of volume and the actual volume lost a number of comparisons have been made, as shown in Table 12, where, for the convenience of the reader, the points of difference are italicized. The results are shown in the form of curves.

A discussion of the different ways in which the losses are presented appear on page 27. The curves for each class will be discussed in detail. To present the results in the four ways noted (actual volume lost, percentage of volume lost, actual value lost, and percentage of value lost) for all nine classes would necessitate a large number of nearly similar curves. Therefore, for each class only the percentage of volume lost and the actual volume lost, in barrels, are given. In covering the actual value and percentage of value lost fewer comparisons have been made.

Table 12.—*Classification for comparing percentage of volume and actual volume lost.*

[Items italicized are the variables.]

Illustrative figure.	Designation of comparison.	Tank.			Season.	Tank.			Season.	Tank.			Season.
		Size.	Kind.	Protection.		Size.	Kind.	Protection.		Size.	Kind.	Protection.	
		Bbls.				*Bbls.*				*Bbls.*			
20	*A*	250	Steel	None	*Summer*	250	Steel	None	*Fall*	250	Steel	None	*Winter.*
21	*B*	500	Steel	None	*Summer*	500	Steel	None	*Fall*	500	Steel	None	*Winter.*
22	*C*	500	Steel	Jacket	*Summer*	500	Steel	Jacket	*Fall*	500	Steel	Jacket	*Winter.*
23	*D*	1,600	Wood	Housed	*Summer*	1,600	Wood	Housed	*Fall*	1,600	Wood	Housed	*Winter.*
24	*E*	*250*	*Steel*	*None*	Summer	*500*	*Steel*	*None*	Summer	*1,600*	*Wood*	*Housed*	Summer.
25	*F*	500	Steel	*Jacket*	Fall	500	Steel	*None*	Fall				
26	*G*	500	Steel	*Jacket*	Winter	500	Steel	*None*	Winter				
27	*H*	*500*	*Steel*	*Jacket*	Fall	*1,600*	*Wood*	*Housed*	Fall				
28	*I*	250	Steel	*Housed*	Summer	250	Steel	*None*	Summer				

As summer gradually becomes autumn, and autumn gradually becomes winter, it is impossible to get a period of 30 or 40 days

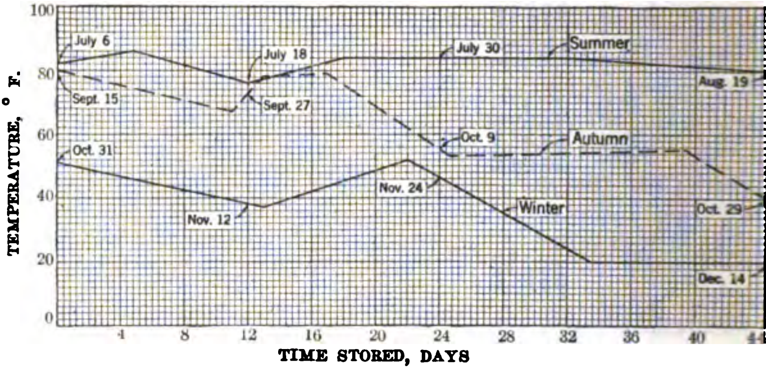


FIGURE 19.—Mean oil temperatures at which lease-storage tests were run for summer, autumn, and winter, applying to figures 20 to 22.

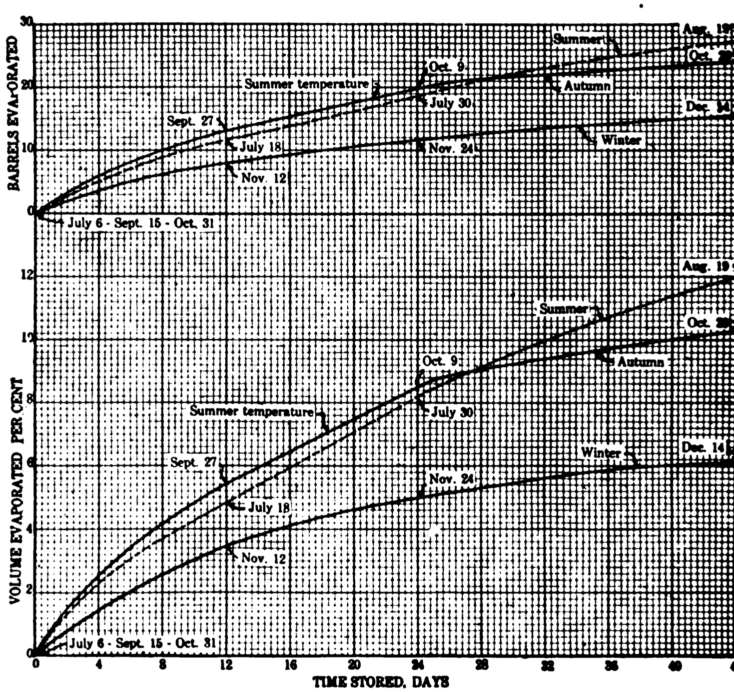


FIGURE 20.—Comparison *A*. Barrels evaporated and percentage of volume evaporated from 250-barrel unprotected steel lease-tanks during summer, autumn, and winter. "Summer temperature" is indicated on the "autumn" curve, because the evaporation during the last part of September was greater than for the first few days (see fig. 19).

that represents exactly any single season. Figure 19 shows the average oil temperature of the tests covering classes *A*, *B*, and *C*.

250-BARREL UNPROTECTED STEEL TANKS—SUMMER, AUTUMN, AND WINTER.

Figure 20 shows the results of tests covering class *A*. Not until October 10 does the lower temperature of autumn begin to affect the rate of evaporation, and though the average temperature about November 10 is 40° F., or very close to the average winter temperature for the Mid-Continent field, the percentage of volume lost is only slightly less than that in July and September when the temperature was about 78° F. The winter test showed a loss of 3.1

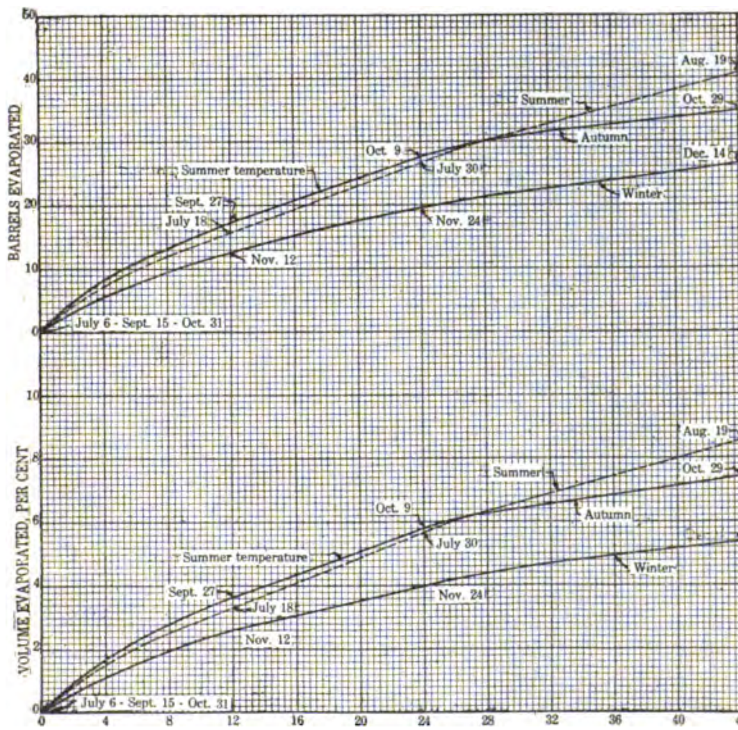


FIGURE 21.—Comparison *B*. Barrels evaporated and percentage of volume evaporated from 500-barrel unprotected steel lease-tanks during summer, autumn, and winter. See note on figure 20 concerning "summer temperature."

per cent after an exposure of 10 days, whereas the two tests during the hot season showed an average loss of 4.5 per cent. This shows that the rate of evaporation does not decrease as rapidly as the decrease in temperature. Another point worthy of note is that from December 4 to December 14, although the temperature averaged 20° F., the oil continued to lose through evaporation. During those 10 days, after having been already exposed for 34 days, the oil lost 2 barrels, or 0.25 per cent, of its original volume.

500-BARREL UNPROTECTED STEEL TANKS—DIFFERENT SEASONS.

Comparison *B* is shown in Figure 21. These curves give data similar to those for comparison *A*, and the same effects are found from the tests. The two summer curves do not coincide exactly because they are the results of two entirely different tests, but they are close enough to check each other. For the temperatures at which these tests were made, see figure 19.

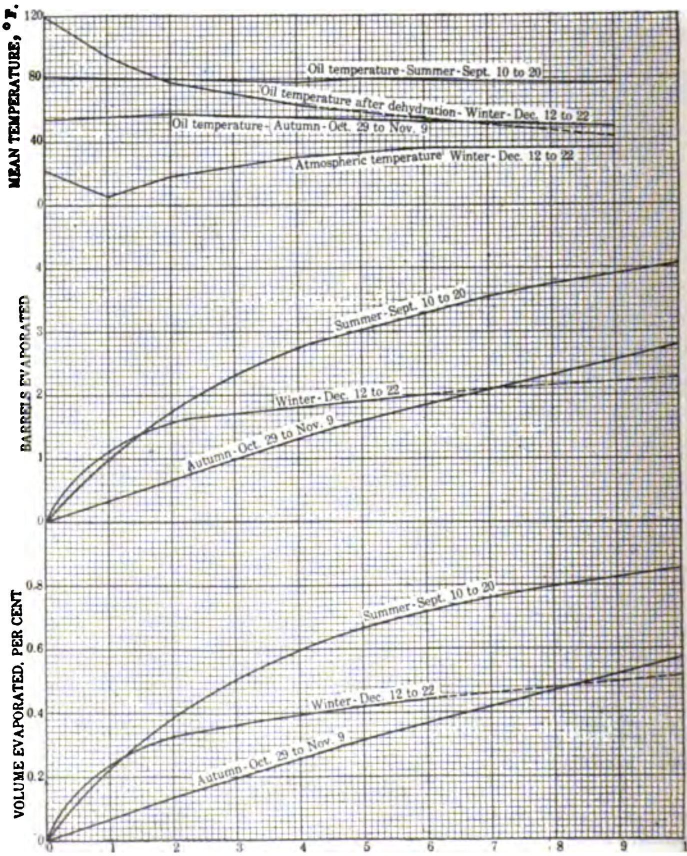


FIGURE 22.—Comparison *C*. Barrels evaporated and percentage of volume evaporated from 500-barrel jacketed steel tanks during summer, autumn, and winter and respective mean temperatures of oil.

500-BARREL JACKETED STEEL TANKS—DIFFERENT SEASONS.

Figure 22 shows comparison *C*—500-barrel jacketed steel tanks in summer, autumn, and winter. The temperatures of the oil for these various tests are shown in figure 19. The loss in autumn was less than for the first six days of winter, because the temperature of the oil at the start of the winter experiment was 120° F., the oil having passed through a dehydration plant in that experiment. The slow approach of the oil temperature and the atmospheric temperature shows the effect of the air-tight jacket about the tank, for the higher temperature of the oil, regardless of the much lower temperature of the atmosphere outside, caused greater evaporation loss than that in the autumn test. As soon as the oil in the winter test had approached the temperature of the autumn test, the rate of evaporation became much slower. The autumn test shows a very slow rate of evaporation, and the curve representing this rate is almost a straight line. In summer, when the rate of evaporation is nearly twice as rapid, the curve flattens as time goes on.

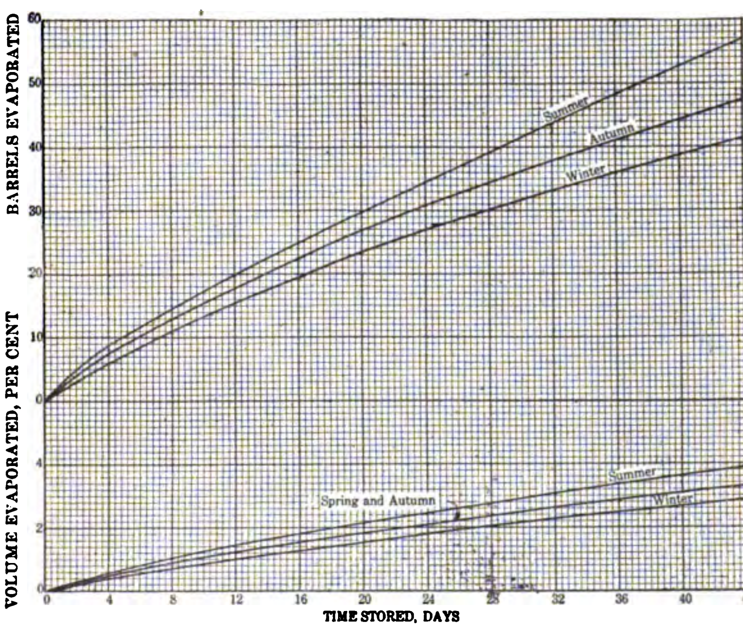


FIGURE 23.—Comparison *D*. Barrels evaporated and percentage of volume evaporated from 1,600-barrel housed wood tanks during summer, autumn, and winter.

A very important point to notice in comparing figure 22 with figure 20 or 21, is this: The percentage of loss in five days in autumn is less than one-half of that in summer for jacketed tanks. In unprotected 500-barrel tanks, the percentage of loss on the fifth day in winter is as much as seven-tenths of that in summer (see fig. 21, p. 55). The conclusion from these observations is that exposure to the wind affects greatly the rate of evaporation loss, regardless of the temperature.

1,600-BARREL HOUSED WOOD TANKS—DIFFERENT SEASONS.

Figure 23 shows the results of the tests noted in comparison *D*. The temperature may be found in figure 19 (see p. 54). The 1,600-

barrel wood tank tested is like that shown by figure 14 (see p. 46). The percentage of loss in this wood tank is decidedly lower than in the steel tank, not because the material is wood, but because the tank is housed and therefore partly protected from air currents.

COMPARISON OF 250 AND 500 BARREL UNPROTECTED STEEL AND 1,600-BARREL HOUSED WOODEN TANKS.

Comparison *E* shows the difference between 250-barrel, 500-barrel unprotected steel, and 1,600 barrel housed wooden tanks for the sum-

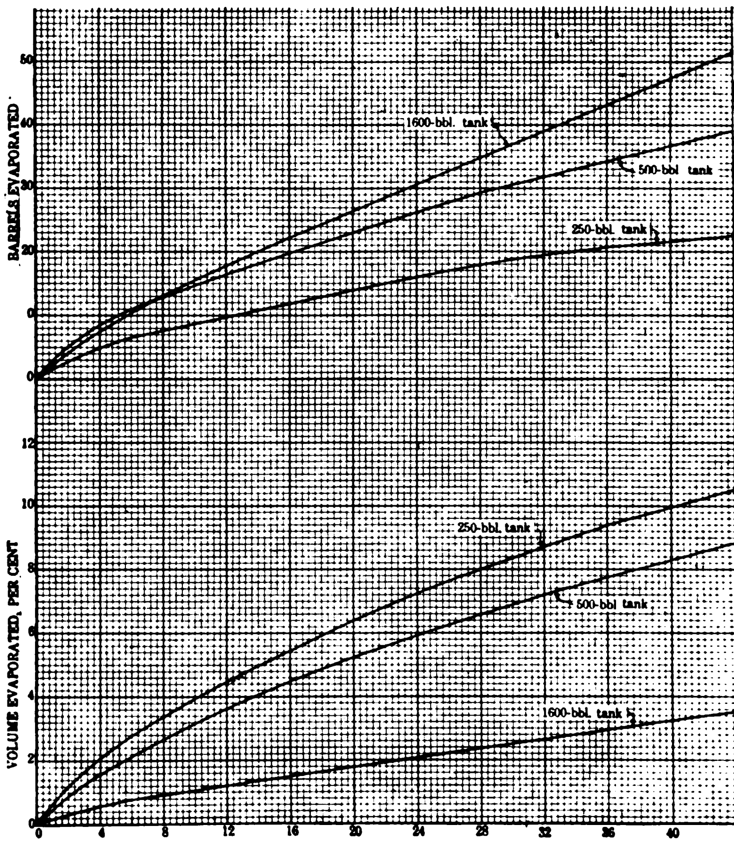


FIGURE 24.—Comparison E. Barrels evaporated and percentage of volume evaporated from 250 and 500 barrel unprotected steel tanks and 1,600-barrel housed wood tanks in summer.

mer. In figure 24 it is noted that the per cent volume lost from 1,600-barrel wooden housed tank is only about one-third of that lost from either a 250 or 500 barrel tank. The number of barrels lost for the same period of time, however, is greater for a 1,600-barrel tank. very important feature of the curves representing the 250 and 500 barrel tanks is that the per cent volume lost from a 250-barrel tank is not much greater than the per cent volume lost from a 500-barrel tank. This is due to the fact that as compared to a 250-barrel tank a 500-barrel tank of crude oil contains twice as much of the very light products which evaporate at a rapid rate. As soon as the lightest fractions of a 250-barrel tank have evaporated the rate is slowed down. When the same number of barrels have been evaporated from the 500-barrel tank as from the 250-barrel tank there still remains in the 500-barrel

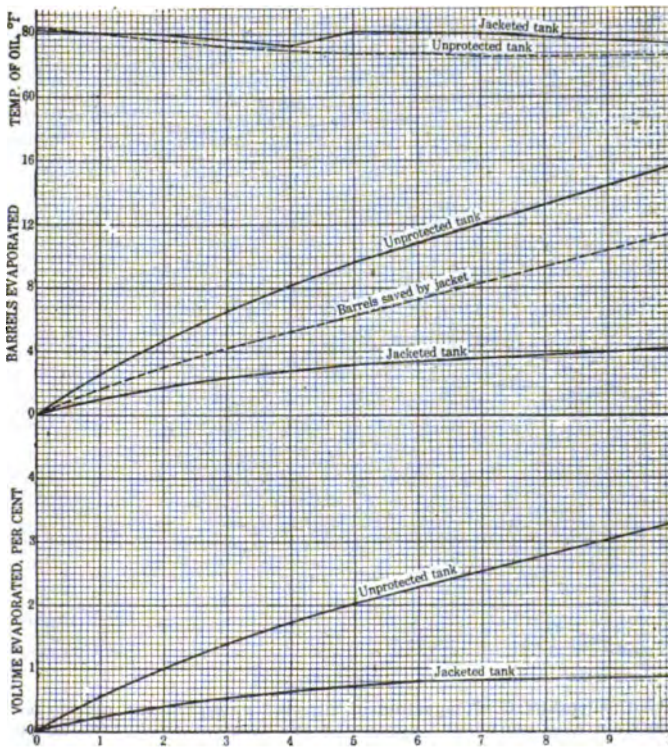


FIGURE 25.—Comparison *F*. Comparison of barrels evaporated and percentage of volume evaporated from 500-barrel unprotected and jacketed steel tanks in autumn.

tank the same quantity of fractions above the point to which the 250-barrel tank has evaporated.

COMPARISON OF JACKETED AND UNPROTECTED STEEL TANKS.

Comparison *F*, illustrated by figure 25, shows the value of protecting tanks from wind and free circulation of air. The center curve under "barrels evaporated" shows in the dashed line the number of barrels that are saved by the construction of the jacket, amounting to 6.2 barrels of gasoline saved in five days. As crude oil this has a value of $19.20 at $3.00 per barrel.

Comparison *G*, which is shown in figure 26, is similar to comparison *F*, except that the latter is for autumn, whereas the former is for winter. Even when the temperature is very low the jacketed tank still shows a decided saving over the unprotected one, proving clearly that wind and free circulation of air have much more to do with the rate of evaporation of crude oil than temperature. The surface of the oil in a jacketed tank is always still; in one that is unprotected the surface of the oil is constantly rippling.

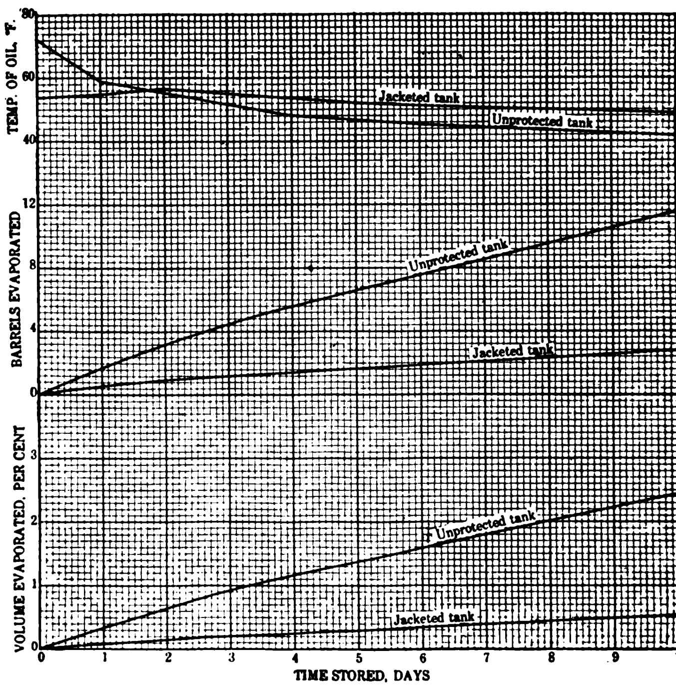


FIGURE 26.—Comparison *G*. Comparison of barrels evaporated and percentage of volume evaporated from 500-barrel unprotected and jacketed steel tanks in winter.

COMPARISON OF JACKETED AND HOUSED TANKS.

In comparison *H* (see fig. 27) the evaporation from a single 500-barrel jacketed steel tank and that from a 1,600-barrel housed wood tank have been compared, both as to per cent volume lost and barrels lost. The number of barrels lost by one 500-barrel jacketed tank has been multiplied by three in order to give a fair comparison to the barrels lost on a 1,600-barrel tank. The three 500-barrel jacket tanks in this case store the same volume as the 1,600-barrel tank, namely, about 1,430 barrels. Moreover, the area exposed in a wooden tank is 151 square feet, whereas in the three 500-barrel tanks the area is 165 square feet. The areas are, therefore, nearly the same. The results, then, should give a satisfactory comparison of jacketed and housed tanks, for the temperatures as shown in figure 25 are almost identical. The loss from tanks of either type seems to be practically the same for the first five days. However, as time lengthens to 44 days, the comparison of volume lost is much less for the jacketed than for the 1,600-barrel tank. By the forty-fourth day the volume lost from three jacketed tanks is 25 barrels. For the 1,600-barrel tank, the loss is 57 barrels, a saving of 32 barrels by the jacket.

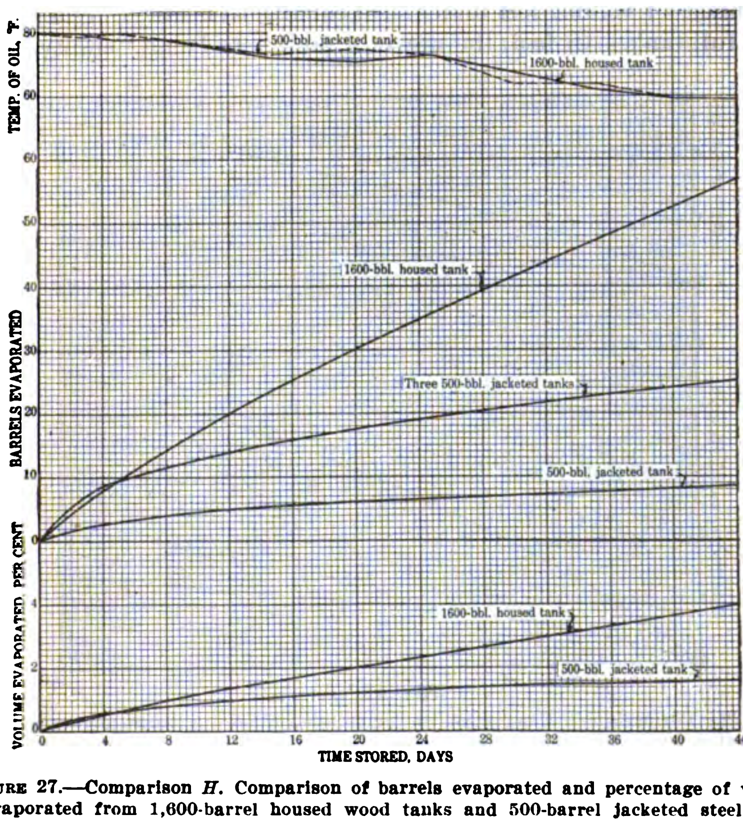


FIGURE 27.—Comparison *H*. Comparison of barrels evaporated and percentage of volume evaporated from 1,600-barrel housed wood tanks and 500-barrel jacketed steel tanks in autumn.

This is additional proof that air circulation is the main factor in evaporation, for the loose housing allows more air circulation than does the jacketed tank, even though both are shaded.

COMPARISON OF HOUSED AND UNPROTECTED STEEL TANKS.

Comparison *I* (see fig. 28) shows evaporation from jacketed and unprotected 250-barrel steel tanks in summer. The only difference between the tanks is that one class has a house similar to the housing of the wooden tank shown in figure 14 (p. 46). The value of such housing is shown when these figures are observed. In 10 days the saving due to the housing has been 7.6 barrels. For further discussion see page 87.

LOSS BY SO-CALLED EMPTY TANKS.

When a lease tank has been emptied by the pipe-line company, approximately 1 foot of oil and B. S. remains in the tank, and is subject to loss by evaporation. Tests were made which show that the percentage of volume lost under such conditions is much higher than for a full tank. In fact, the nearer a tank is to being "empty," the

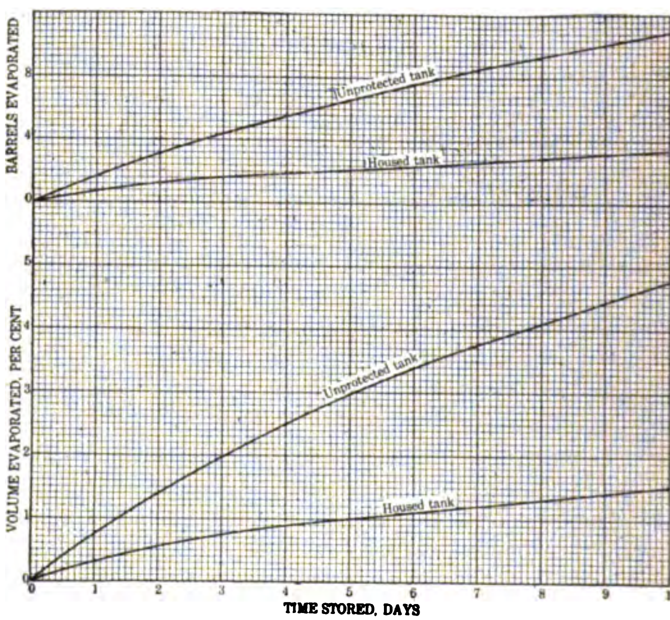


FIGURE 28.—Comparison *I*. Comparison of barrels evaporated and percentage of volume evaporated from 250-barrel housed steel tanks and from 250-barrel unprotected steel tanks during the summer.

greater will be the percentage of volume lost, though the actual barrels lost are smaller; therefore, a producer will suffer greater proportional loss from a large number of partly full tanks than from a smaller number of full ones.

ACTUAL VALUE AND PERCENTAGE OF VALUE LOST.

For the sake of simplicity, another set of comparisons has been made to show the actual value and the percentage of value lost. Table 13 gives these comparisons in brief.

250-BARREL UNPROTECTED TANKS.

Figure 29 shows comparison *J*, which is the effect of evaporation on 250-barrel tanks for the average season of the year. As discussed

TABLE 13.—*Classification for comparing actual and percentage of value lost.*

Illustrative figure.	Designation of comparison.	Size.	Season.	Loss shown.
		Bbls.		
33	J	250	Average.....................	Actual value and percentage of value.
34	K	500	.....do.....................	Do.
35	L	1,600	.....do.....................	Do.

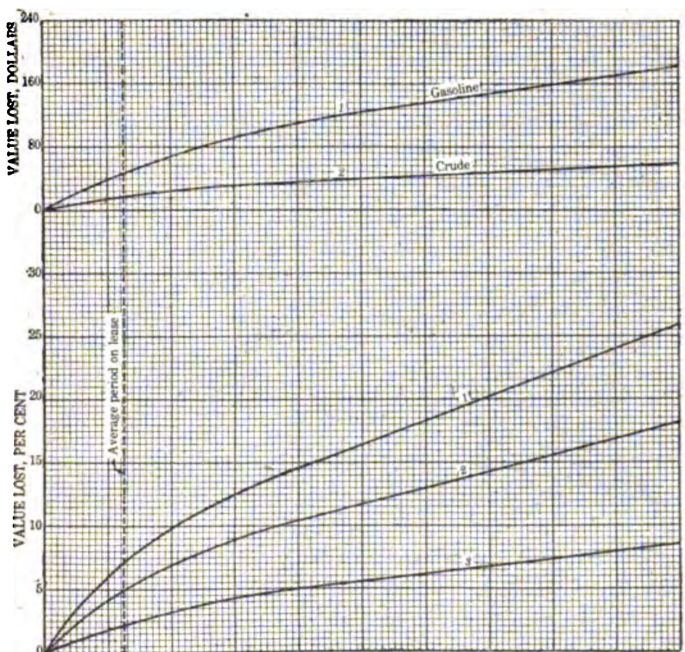


FIGURE 29.—Comparison *J*. Actual value lost by 250-barrel unprotected steel tanks for the average season, considered as loss as gasoline at 22 cents per gallon and loss as crude at $3 per barrel. Percentage of value lost by similar tanks, considered as loss as gasoline at 22 cents per gallon v. crude at $3 per barrel, loss as gasoline at 22 cents per gallon v. refined products at $4.28 per barrel, and loss as crude v. crude.

in Part I, the percentage value lost has been calculated as loss as gasoline at 22 cents per gallons versus crude at $3 per barrel, loss as gasoline at 22 cents per gallon versus refined products at $4.28 per barrel, and loss as crude versus crude. These losses are shown in figure 29 by curves 1, 2, and 3. The actual value lost has been shown as crude and as gasoline.

500-BARREL UNPROTECTED AND 1,600-BARREL HOUSED TANKS.

Figure 30 shows comparison *K*, and figure 31 comparison *L*.

PERCENTAGE OF VALUE AND VOLUME LOST ON THE LEASE IN THE MID-CONTINENT FIELD.

The percentage of value and of volume lost by the average (750-barrel) lease tank for the average season is presented graphically in figure 32. This shows the percentage of value lost for the three bases already described and the percentage of volume lost from an aver-

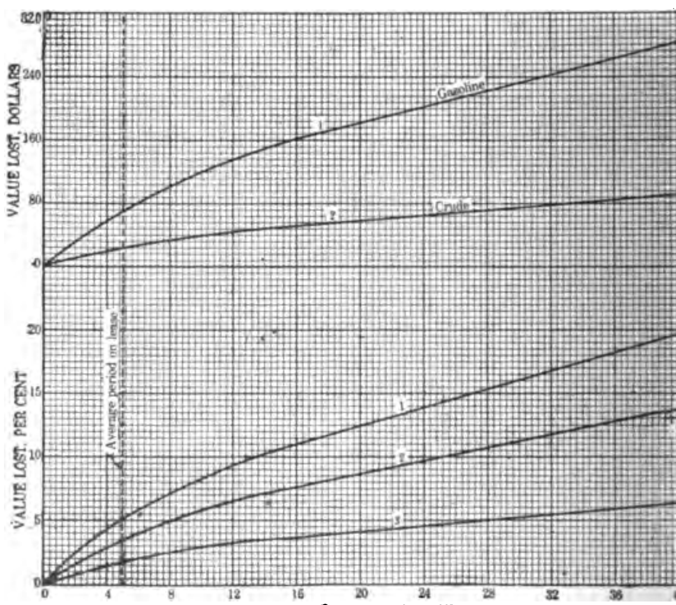


FIGURE 30.—Comparison *K*. Actual loss from 500-barrel unprotected steel tanks for the average season considered as loss as gasoline at 22 cents per gallon and loss as crude at $3 per barrel. Percentage of value lost by similar tanks, considered as loss as gasoline at 22 cents per gallon v. crude at $3 per barrel, loss as gasoline at 22 cents per gallon v. refined products at $4.28 per barrel, and loss as crude v. crude.

age lease tank by seasons for any period of storage to 40 days in the Mid-Continent field. Data for plotting the percentage of value lost were taken from Table 15 with the application of the percentage of value factors previously described in Part I.

In Table 15 (see p. 68) the average for the year for the fifth day of storage (determined as the average period of storage on the lease) is 1.46 per cent, representing the average volume lost by all the oil produced in the Mid-Continent field during storage on the lease alone. This does not include losses in passing through flow tanks and in filling the lease tanks or losses during pipe-line or tank-car distribution. Table 14 has been compiled from this figure for average percentage of volume and from the U. S. Geological Survey data on production in the Mid-Continent field during 1919.

TABLE 14.—*Loss in the Mid-Continent field by five days' storage on the lease, 1919.*

Season.	Mid-Continent production.	Average volume lost.	Actual volume lost.			Value lost.	
						As crude.	As gasoline.
	Barrels.	*Per cent.*	*Barrels.*	*Gallons.*	*Cubic feet.*		
January, February, and December.............	45,000,000	1.14	513,000	21,540,000	2,880,000	$1,539,000	$4,740,000
March, April, May, October, and November....	78,400,000	1.40	1,098,000	46,120,000	6,170,000	3,294,000	10,150,000
June, July, August, and September............	72,200,000	1.80	1,298,000	54,520,000	7,290,000	3,894,000	11,990,000
Whole year........	195,600,000	....	2,909,000	122,180,000	16,340,000	8,727,000	26,880,000

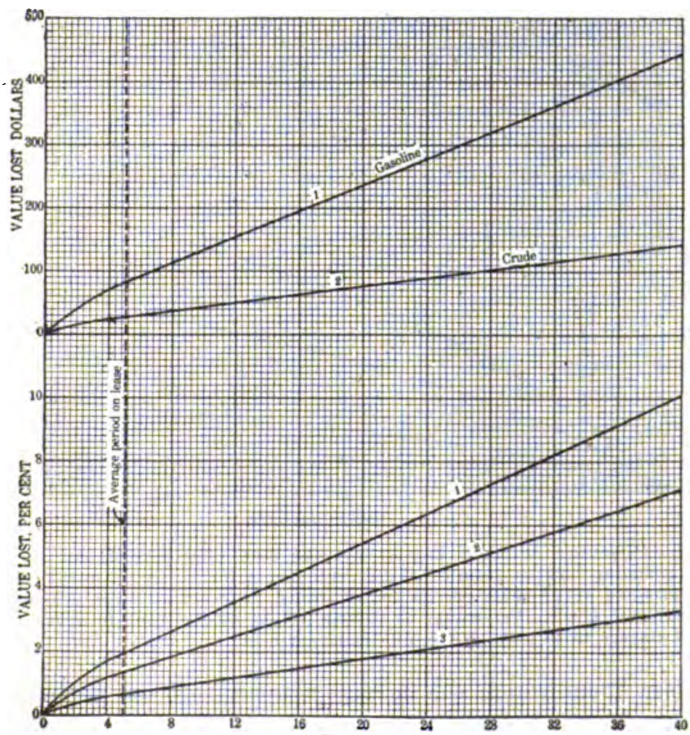


FIGURE 31.—Comparison *L*. Actual value of loss from 1,600-barrel housed wood tanks, including loss as gasoline at 22 cents per gallon and loss as crude at $3 per barrel. Percentage of value lost by similar tanks, including loss as gasoline at 22 cents per gallon v. crude at $3 per barrel, loss as gasoline at 22 cents per gallon v. refined products at $4.28 per barrel, and loss as crude v. crude.

As the volume thus lost is gasoline, it is given the value of that commodity, assumed to be 22 cents per gallon. This shows that, from a production of 195,600,000 barrels in 1919 the actual volume lost was 2,909,000 barrels or 122,180,000 gallons of highest grade gasoline. Considered as crude at $3 per barrel this volume has a value of $8,727,000, but as gasoline at 22 cents per gallon it has a value of $26,880,000.

The loss during lease storage in this one field represents 3 per cent of the total gasoline—four billion gallons—produced in the United States during 1919, and equals more than one-third of the total gasoline recovered in the natural-gas gasoline industry.

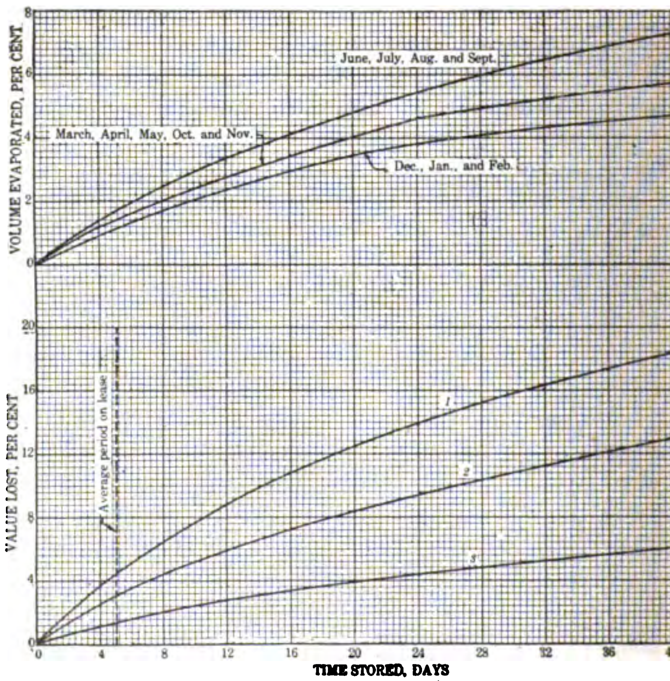


FIGURE 32.—Percentage of value lost by average tank (750 barrels) for the average season, including loss as gasoline at 22 cents per gallon v. crude at $3 per barrel, loss as gasoline at 22 cents per gallon v. refined products at $4.28 per barrel, and loss as crude v. crude. Percentage of volume lost by similar tank by seasons for any period of storage to 40 days on the Mid-Continent field.

The data from which the curves representing the percentage of volume lost by the average tank for each of the three seasons noted were calculated have been presented in Table 9. For example, this table shows that the 250-barrel size constitutes 31.78 per cent of the total tankage. After five days of storage at the average summer temperature, a tank of this size loses 2.8 per cent. Similarly, the proportion of the loss attributable to a 500-barrel and to a 1,600-barrel tank may be determined, each representing its proportion of the total loss by the "average tank." The sum of the three percentages so determined gives 100 per cent of the loss by the average tank for the season under consideration. The average per cent volume lost for any other season and any other period of storage may be determined in a similar manner. Results of such proportioning and averaging are shown in Table 15, under "Average tank."

CONDENSED DATA ON THE THREE PRINCIPAL TYPES OF TANKS.

Table 15 shows in condensed form results on the three main groups of tanks, giving percentage of volume, actual volume, and actual value lost through evaporation for varying periods of storage. It is certain that all the percentages shown in this table are very conservative. They are believed to represent the average condition in the Mid-Continent field.

TABLE 15.—*Percentage of volume, actual volume in barrels, and value in dollars lost as crude in various types of lease storage.*

Tank.		Percentage of total tankage.	Volume lost on—					Barrels lost.					Value lost as crude at $3 per barrel.				
Kind.	Size.		1st day.	3d day.	5th day.	10th day.	40th day.	1st day.	3d day.	5th day.	10th day.	40th day.	1st day.	3d day.	5th day.	10th day.	40th day.
SUMMER. [June, July, August, and September.]																	
	Bbl.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*										
Steel	250	31.8	0.80	1.93	2.8	4.55	10.90	1.9	4.6	6.7	10.9	26.2	$5.70	$13.80	$20.10	$32.7	$78.70
Do	500	33.4	.52	1.27	1.97	3.11	7.74	2.5	6.2	9.7	15.2	37.8	7.50	18.60	29.10	45.60	113.40
Wood	1,600	34.8	.20	.50	.7	1.18	3.67	3.0	7.5	10.5	17.7	55.1	9.00	22.50	31.50	53.10	165.30
Average	750	....	.50	1.21	1.79	2.90	7.33	3.8	9.1	13.4	21.7	55.0	11.40	27.30	40.20	65.10	165.00
AUTUMN AND SPRING. [March, April, May, October, and November.]																	
Steel	250	31.8	0.58	1.42	1.96	3.55	8.06	1.4	3.4	4.7	8.5	19.4	$4.20	$10.20	$14.10	$25.50	$58.20
Do	500	33.4	.41	1.03	1.60	2.68	6.20	2.0	5.0	7.8	13.1	30.4	6.00	15.00	22.40	39.30	91.20
Wood	1,600	34.8	.16	.43	.63	1.07	3.21	2.4	6.5	9.4	16.0	48.2	7.20	19.50	28.20	48.00	144.60
Average	750	....	.38	.95	1.38	2.39	5.75	2.8	7.1	10.3	17.9	43.1	8.40	21.30	30.90	53.70	129.30
WINTER. [December, January, and February.]																	
Steel	250	31.8	0.42	1.09	1.65	3.00	6.1	1.0	2.6	4.0	7.2	14.7	$3.00	$7.80	$12.00	$21.60	$44.10
Do	500	33.4	.30	.82	1.30	2.32	5.22	1.5	4.0	6.4	11.4	25.5	4.50	12.00	19.20	34.20	76.50
Wood	1,600	34.8	.12	.40	.57	.99	2.93	1.8	6.0	8.6	14.9	44.0	5.40	18.00	25.80	44.70	132.00
Average	750	....	.28	.76	1.16	2.07	4.70	2.1	5.7	8.7	15.5	35.2	6.30	17.10	26.10	46.50	105.60

YEAR.

Steel	250	....	0.61	1.51	2.16	3.75	8.52	1.5	3.6	5.2	9.0	20.4	$4.50	$10.80	$15.60	$27.00	$61.20
Do	500	....	.42	1.06	1.65	2.73	6.46	2.1	5.2	8.1	13.4	31.6	6.30	15.60	24.30	40.20	94.80
Wood	1,600	....	.16	.45	.64	1.00	3.28	2.4	6.8	9.6	15.0	49.2	7.20	20.40	28.80	45.00	147.50
Average	750	....	.39	.99	1.46	2.48	6.01	2.9	7.4	10.9	18.6	45.1	8.70	22.20	32.70	55.80	135.30

GENERAL DISCUSSION OF LEASE-STORAGE EXPERIMENTS.

In reviewing the lease-storage experiments, the fact that appears most striking and significant is that the protection of tanks by some device eliminating the circulation of air will decrease the evaporaton loss one-half to two-thirds, the actual saving being dependent upon the efficiency of the device. Evidently, a tank should never be filled with an overshot connection, and the oil should be taken off the lease as soon as possible after the tank is filled.

EVAPORATION LOSSES DURING STORAGE IN 37,000 AND 55,000 BARREL STORAGE TANKS.

East of the Rocky Mountains, about 80,000,000 barrels of oil is held in storage in large tanks, practically all of the oil produced being thus held for varying lengths of time. The losses by evaporation during such storage are, therefore, important.

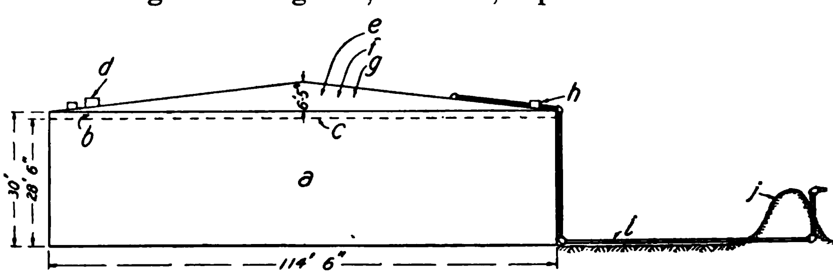


FIGURE 33.—Average conditions during storage in large steel tanks: *a*, 55,000-barrel steel tank; *b*, space allowed for expansion of oil in summer; *c*, level, average when full; *d*, opening for swing pipe; *e*, average volume of vapor above oil, 33,510 cu. ft.; *f*, average variation in temperature of vapor=25° F during 24 hours; *g*, average breaths of vapor=1,870 cu. ft. a day; *h*, 2 to 4 hatches 8-inch diameter; *i*, 6-inch pipe; *j*, fire wall.

LOCATION OF TESTS.

There was difficulty in finding a place where much oil was stored for great lengths of time, inasmuch as the consumption of the United States is somewhat greater than production and importation combined. However, such a place was found in the new Texas fields, where facilities for transporting the oil from the field were not adequate. There 80 tanks, mainly of the 55,000-barrel size, were obtained and records were kept for a period of 10 months.

EVAPORATIVE CONDITIONS IN 55,000-BARREL TANKS.

Figure 33 is a sketch which shows the principal features of such a tank, described by Bowie.[4] These large tanks are supposed to be gas tight. With very few exceptions, however, they are not,

[4] Bowie, C. P., Oil-storage tanks and reservoirs with a brief discussion of losses of oil in storage and methods of prevention: Bull. 155, Bureau of Mines, 1917, 73 pp.

for the air has easy access at many points, such as hatch openings and swing-pipe openings, leaks around the edges of the roof, and often in the top of the roof itself. Many of these tank roofs leak rain but most of them do not, although at many such leakage hides much of the evaporation loss. Owing to the expansion and contraction of the air and vapor above the oil with variations of temperature, the tank alternately forces out and takes in a large volume of gasoline vapor and air during 24 hours. This is called breathing. A large pipe shown at the right in figure 33, conducts the vapors a short distance from the tank, in order to decrease the fire hazard, especially during thunderstorms. One of the theories on tank fires during thunderstorms is that lightning ignites the column of vapor rising from the oil and the burning vapor ignites the oil in the tank. With an average variation in temperature during 24 hours of about 25° F., and the assumptions shown in the figure, the "breathe" would be 1,876 cubic feet a day. When a tank is filled in winter a considerable space is always left at the top for the expansion of the oil during the following summer.

METHOD OF MAKING TESTS.

In order that more accurate results might be attained, a tank was gaged in three places and the average of the three gagings taken as the depth of oil in the tank at a stated instant. This procedure eliminated personal errors in reading the tape or recording. For temperature determination the points examined were 5, 15, and 25 feet from the bottom, or 6, 16, and 26 feet from the bottom. Samples taken from representative tanks at the beginning of each test, and periodically thereafter, were distilled by the standard method and used as a check on the volumetric readings.

RESULTS OF TESTS..

The results presented here are evolved from composite data on a number of tanks in each class, the classes being determined by size, color, and date of filling. In this way, tanks of the same size and color could be compared for evaporation loss from oil of different ages. Table 16 shows the resulting classification. Observe that class D is one year older than class A. Figure 34 gives the volume lost per tank from one test for classes A, B, C, and D; it shows that the oldest oil evaporates more slowly than the freshest oil, or that which is one year younger. Oils of intermediate ages show rates of evaporation falling between these two limits. Class A represents the loss of oil during its first year of storage. This curve, when continued, shows a loss of 3 per cent for the first year. Class D represents the loss from a similar oil during its second year which, when continued, equals 2.1 per cent. In other words, during the first two years of such storage the oil would lose about 5.1 per cent of its original volume.

This oil is of the type found near Ranger, Tex. Its gravity when it enters the tank is 40° B, its gasoline content about 31 per cent, having an end point in a straight distillation of the crude, of 392° F. Figure 38 shows the distillation record of a typical Ranger oil. By examining classes A, B, and C in figure 34 the reader will see that although the difference in age, four months, between B and C and A and B is the same, the increase in rate of evaporation between A and B is greater than the increase between B and C. In other words, the evaporation loss is larger for the fresh oil.

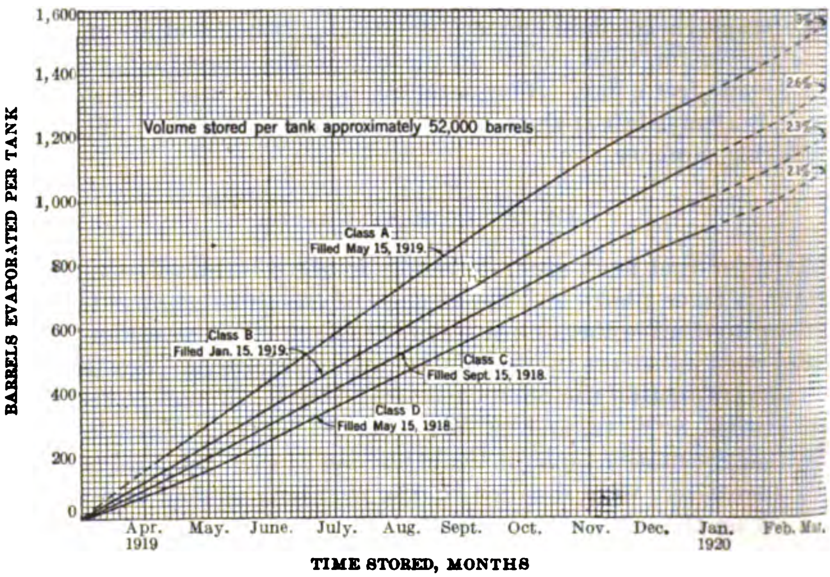


FIGURE 34.—Comparison of the rates of evaporation of oils of different ages. First test.

TABLE 16.—*Classification of 55,000-barrel tanks.*

Number of figure.	Class.	Color.	Date filled.	Number of figure.	Class.	Color.	Date filled.
34.......	A	Black.............	May 15, 1919	53.....	E_1	White..............	Mar. 15, 1919
34.......	B	.....do............	Jan. 15, 1919	52.....	E_2	Red................	June 21, 1919
34.......	C	.....do............	Sept. 15, 1919	52.....	F	.....do.............	Mar. 18, 1919
34.......	D	.....do............	May 15, 1918	52.....	G	.....do.............	Sept. 10, 1919

Figure 35 embodies the result of very careful tests at several 55,000-barrel tanks over a period of three months. Here, again, the rate of loss is less for the older than the fresh oil. The rate for oil of intermediate age is between the two.

Figure 36 gives the combined loss by evaporation from 30 tanks storing 1,440,235 barrels. In one year the loss was 32,100 barrels of gasoline, with a value of $297,000 as gasoline at 22 cents per gallon or $96,300 as crude at $3 per barrel. This represents a yearly loss

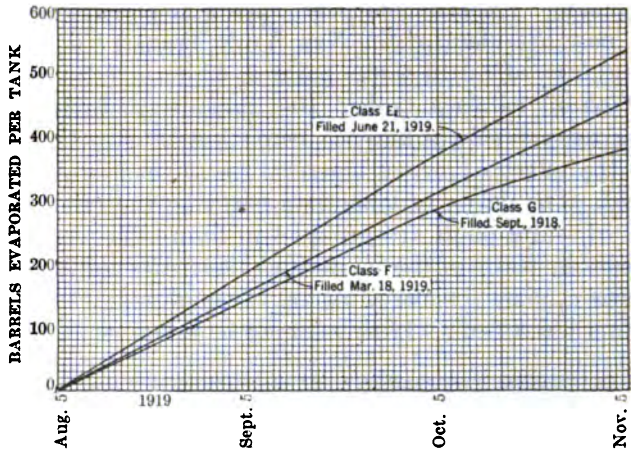


Figure 35.—Comparison of the rates of evaporation of oils of different ages stored in 55,000-barrel tanks. Second test.

of $9,900 as gasoline or $3,210 as crude for each 55,000-barrel tank. The oil tested was of various ages, one year and less. The total vol-

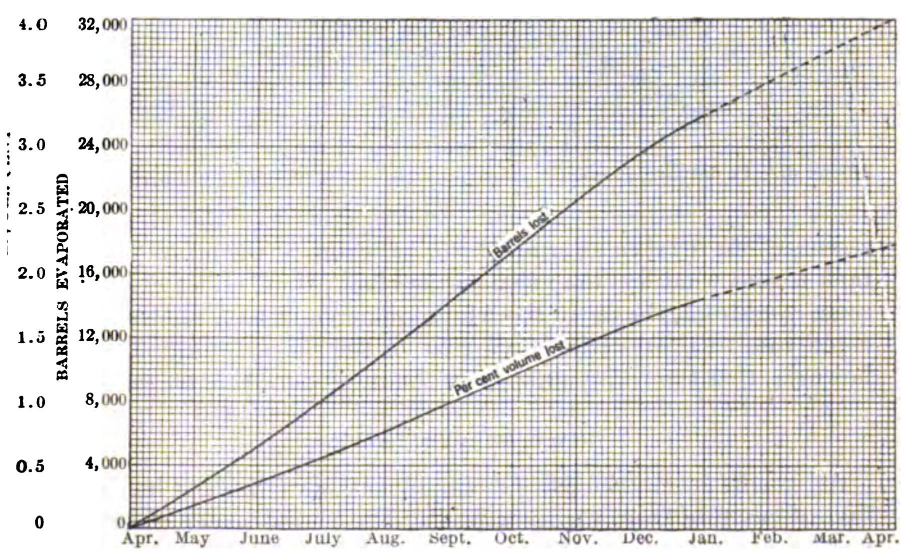


Figure 36.—Results of test made on 1,440,235 barrels stored in standard steel 55,000-barrel tanks showing loss from evaporation. Age of oil, 1 year and less.

ume lost in a year was 2.23 per cent. All tanks that showed any leakage were eliminated from this summation.

COMPARISON OF WHITE AND BLACK TANKS.

Whether tanks should be painted white to decrease evaporation is an old problem. Experiments performed a few years ago by D. S. Bushnell, now president of the New York Transit Co., proved that the temperature of oil in tanks painted white is 8 to 10° F. lower than that of oil in black tanks. Red tanks were little better than black, the temperature difference being but 2° F. In these tests, however, the effect of lower temperature on evaporation was not determined. The only available data covering the relative value of black and of white paint are grouped in figure 37. A small difference appears in favor of the white tank, statistics indicating that in nine months a 55,000-barrel white tank would save 85 barrels more of oil than a black tank. If this saving be taken as gasoline it rep-

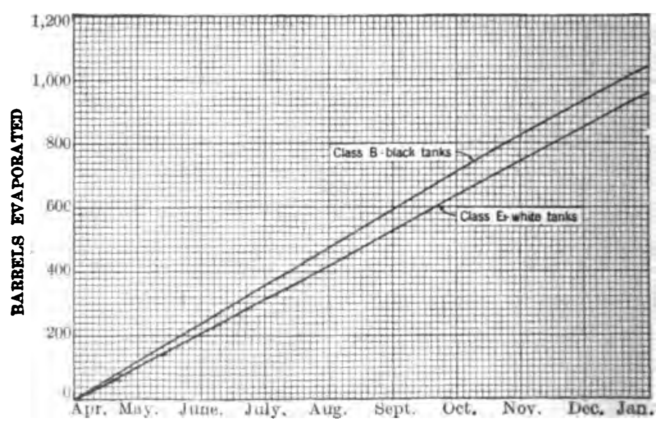


FIGURE 37.—Comparison of volume evaporated from black and from white 55,000-barrel tanks.

resents $785; if taken as crude, $255. The age of the oil in the white tank is somewhat less than that in the black; thus, under exactly the same conditions, the oil in the white tank should have shown a more rapid rate of evaporation than that in the black tanks. It seems, however, that the white tanks more than overcame this tendency.

CHECK BY DISTILLATIONS.

All results from volumetric measurements were checked by distillation of samples from the same tank. The period under observation was two months, but even for so short a period the percentage of volume lost was quite evident. The gravity of the oil fell 0.2° B.—from 39.2° B. to 39.0° B.—and the gravity of the portion lost was 82° B. These results checked very closely those from measurements in the field.

All of the oil placed in the 80 large tanks under observation came from the same general horizon in the same field, hence it was nearly uniform in quality, with about the same specific gravity when fresh from the well. Composite results of distillations from numerous samples taken on the same date and covering the three classes A, B, and D are shown in figure 38. Assume the oils to be, respectively, identical at the start of storage. From January 15 to May 15, 1919, there was 1 per cent volumetric loss; from May 15, 1918, to May 15, 1919, there was 3.6 per cent, which approximately checks the 3 per cent loss determined by the field test and shown in figure 34 for

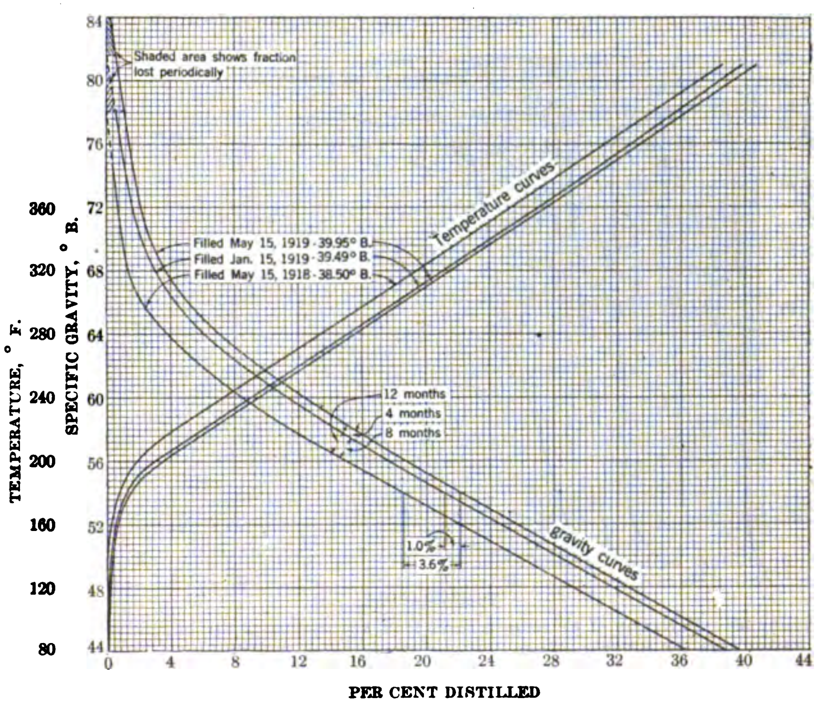


FIGURE 38.—Composite results of distillations of oil of different ages in 55,000-barrel tanks, showing the effect of evaporation. Samples of Ranger crude taken on July 30, 1919, four from each age.

class A. The gravity of the portion lost varied from about 84° B to 78° B.

MISCELLANEOUS DATA ON LARGE TANKS.

OIL TEMPERATURES THROUGHOUT TANK.

In order to ascertain the difference in the temperature of the oil in the tank, temperatures were taken on the bottom and at 1, 2, 5, 10, 15, 20, and 25 feet from the bottom. In addition, temperatures were taken at the surface, 6 inches below the surface, and in the vapor above the oil. These data for different dates and different average temperatures of the oil are shown in figure 39. The average temperature of the oil may be only about 86° F., whereas the temperature of the surface may be 95° F. or even higher, this surficial heating being caused by the sun's rays beating upon the dark metal roof. On a hot summer day the temperature of the vapor above the oil may be as high as 125° F. With the coming of cooler weather, this great difference between average temperature and surface temperature decreases. In summer the comparatively cool bottom is caused by a small depth of B. S. which does not circulate and is kept cool by the ground.

Data were gathered (see fig. 40) showing the changes of temperature in the oil and in the air space above the oil in a 55,000-barrel

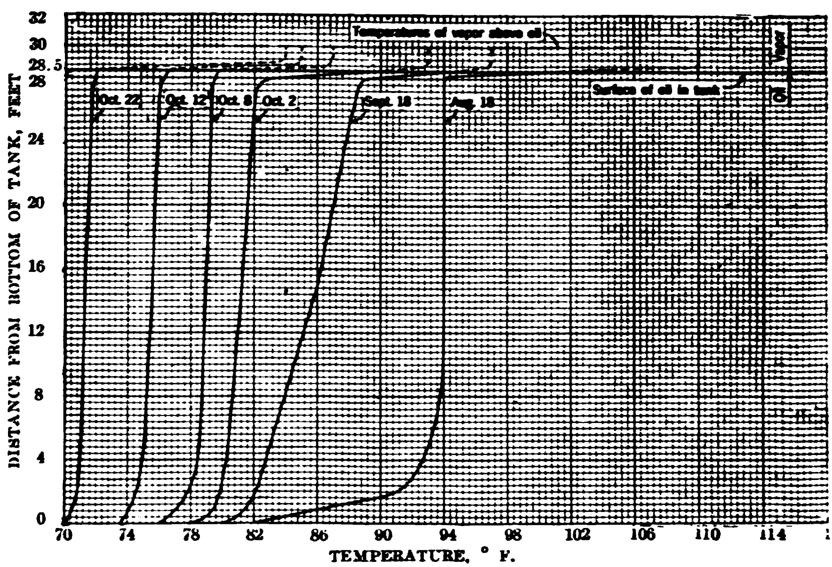


FIGURE 39.—Variation of oil temperatures from the bottom to the oil surface in a 55,000-barrel tank for summer and autumn. Corresponding temperature of mixture of vapor and air above oil. Clear days—3 o'clock p. m.

tank throughout an average summer day. For the vapor, the maximum temperature difference was 35° F., which is higher than the average for the year. Such difference of temperature makes it easy to see why the rate of evaporation may be much higher than it has been thought to be. A surface temperature of 102° F. is common for a few hours each day during the three or four summer months. This high temperature of the surface oil is caused by that of the vapor.

POSSIBLE ACCURACY OF OBTAINING OIL TEMPERATURES.

The expansion of oil with rise of temperature and the daily variation of 1.5° F. for the whole tank show how necessary it is to get accurate temperatures at the time of gaging, as the actual volume of oil in the tank under consideration varied approximately 40 barrels during that day.

A test was designed to show the possible accuracy of taking temperatures with thieving thermometers of the type described on page 24. Two such thermometers were used. They were lowered at the same instant to the desired depth, each being handled and read by a different man, and all operations being simultaneous. The thermometer could not be read closer than 0.2° F., but readings were estimated to the nearest 0.1° F. The comparative results are given in Table 17,

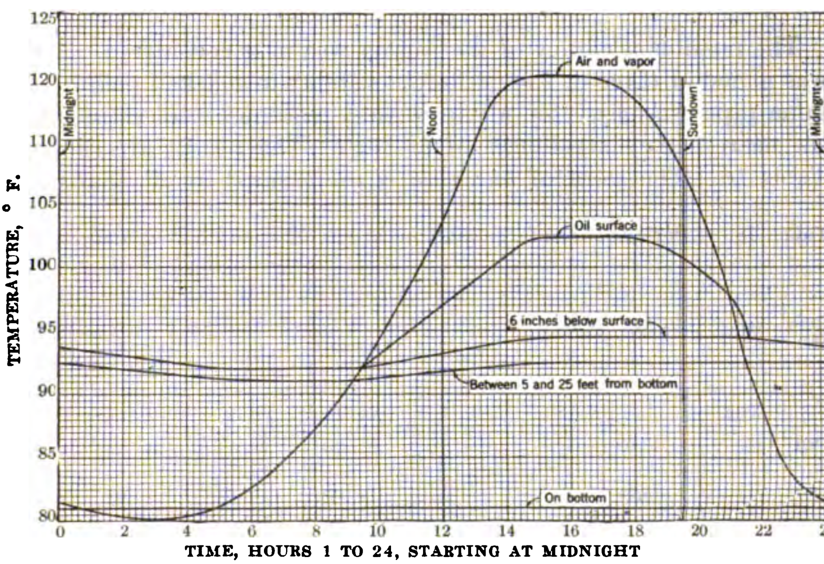


FIGURE 40.—Oil and vapor temperatures throughout the day for 55,000-barrel steel tank, Aug. 11, 1919.

TABLE 17.—*Temperature comparisons in 55,000-barrel tanks with thieving thermometers, showing possible accuracy.*

Tank No.	Hatch.	Date.	Hour.	5 feet.		15 feet.		25 feet.		Average.	
				Thermometer D.	Thermometer A.	Thermometer D.	Thermometer A.	Thermometer D.	Thermometer A.	Thermometer D.	Thermometer A.
		1919.		°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
921.........	A	Oct. 2	12.00	81.7	81.5	82.2	82.0	82.7	82.5	82.2	82.0
922.........	A	...do..	13.45	81.9	82.0	82.7	82.8	83.7	83.5	82.8	82.8
881.........	A	...do...	15.00	82.2	82.0	83.2	82.9	83.7	83.2	83.0	82.7
922.........	B	Oct. 3	14.15	82.1	82.0	82.5	82.7	83.4	83.2	82.7	82.6
922.........	C	...do...	14.30	82.0	82.1	82.5	82.9	83.2	83.5	82.6	82.8
922.........	D	...do...	15.00	81.6	82.0	82.5	82.8	83.2	83.2	82.4	82.67
924.........	A	Oct. 5	14.15	82.0	82.0	82.5	82.7	82.6	82.9	82.3	82.5
924.........	B	...do...	14.40	81.9	82.1	82.5	82.7	82.8	82.8	82.4	82.5
924.........	C	...do...	15.00	82.1	82.2	82.5	82.6	83.1	83.3	82.6	82.6
924.........	D	...do...	15.15	82.1	82.1	82.6	82.6	83.1	83.0	82.6	82.7
Average..	....	....	....	82.0	82.0	82.5	82.7	83.2	83.11	....	....

which shows that in only one reading were the observed temperatures 0.5° F. apart. In two readings they were 0.4° F. apart; in four readings, 0.3° F. apart; and in the other readings, 0.2° F. or less. The columns of the average of the three depths show a maximum difference of 0.3°F., and a usual difference of 0.2° F. or less. With the thieving thermometer and ordinary care, the average temperature of the tank should be determinable to 0.3° F., or, with more readings, to 0.2° F., which would give a possible error of 5 barrels in a full tank.

POSSIBLE ACCURACY OF MEASURING OIL DEPTH.

The possible accuracy of the gaging was next considered. A tank was gaged at three or four different hatches at marked points. The same tape was used for all work and readings were estimated to the nearest one-sixty-fourth of an inch. The results are shown in Table 18. The work of one man is represented by *X*, that of the other by *Y*. The maximum difference of the average columns is one thirty-second of an inch, representing 4 barrels.

TABLE 18.—*Readings showing possible accuracy of gaging a 55,000-barrel tank.*

Tank No.	Date.	Hour.	Position.	Work of *X*.[a] Depth.		Work of *X*.[a] Average depth.		Work of *Y*.[a] Depth.		Work of *Y*.[a] Average depth.		Difference, *Y*−*X*.	
				Ft.	*In.*	*Ft.*	*In.*	*Ft.*	*In.*	*Ft.*	*In.*	*In.*	*Bbl.*
	1919.												
			A	28	4 [illegible]			28	4 [illegible]				
921	Oct. 2	12.00	B	28	3 [illegible]	28	3 [illegible]	28	3 [illegible]	28	3 [illegible]	+1/64	2.4
			C	28	3 [illegible]			28	3 [illegible]				
			A	28	4 [illegible]			28	4 [illegible]				
881	...do.....	15.00	B	28	4 [illegible]	28	4 [illegible]	28	4 [illegible]	28	4 [illegible]	−1/64	2.4
			C	28	4 [illegible]			28	4 [illegible]				
			A	27	5 [illegible]			27	5 [illegible]				
924	...do.....	15.50	B	27	5 [illegible]	27	5 [illegible]	27	5 [illegible]	27	5 [illegible]	+1/64	2.4
			C	27	5 [illegible]			27	5 [illegible]				
			A	28	[illegible]			28	[illegible]				
919	Oct. 3	12.30	B	28	[illegible]	28	[illegible]	28	[illegible]	28	[illegible]	+1/32	5.0
			C	26	[illegible]			28	[illegible]				
			A	26	10 [illegible]			26	10 [illegible]				
889	...do.....	10.40	B	26	8 [illegible]	26	9 [illegible]	26	8 [illegible]	26	9 [illegible]	+1/64	2.4
			C	26	9 [illegible]			26	9 [illegible]				
		13.45	A	28	7 [illegible]			28	7 [illegible]				
922	...do.....	14.15	B	28	7 [illegible]	28	7 [illegible]	28	7 [illegible]	28	7 [illegible]	0	0
		14.30	C	28	7 [illegible]			28	7 [illegible]				
			A	28	3			28	2 [illegible]				
929	...do.....	3.45	B	28	2 [illegible]	28	2 [illegible]	28	2 [illegible]	28	2 [illegible]	−1/64	2.4
			C	28	2 [illegible]			28	2 [illegible]				

[a] *X* represents one man, *Y* another.

COMBINED ERROR IN OBTAINING VOLUME OF OIL IN TANK.

Tables 17 and 18 show that the combined error of gaging and temperature is 9 barrels. From this it can be said positively that the difference in volume of a single 55,000-barrel tank full of oil can be determined within 15 barrels when volumes are calculated for

60° F. if sufficiently careful means be used to gage temperatures and depths.

VOLUMETRIC VARIATION OF VAPOR ABOVE OIL.

Table 19 shows what the volumetric variation of the vapor above the oil is for different depths of oil. It is estimated that 250,000 cubic feet of a mixture of air and gasoline vapor are expelled when a 55,000-barrel working tank on a pipe line is filled. If this vapor is 20 per cent gasoline vapor, at 35 cubic feet per gallon the loss is 1,428 gallons, or 34 barrels, or 0.062 per cent of the full tank of oil. In other words, with most light oils the filling of a 55,000-barrel tank costs 34 barrels of gasoline, valued at $102 as crude or $314 as gasoline.

EVAPORATION LOSSES IN TRANSFERRING OIL FROM LEASE TO REFINERY BY TANK CAR.

Ordinarily the production from many leases and producing companies is so mixed early in the journey to the refinery that it is difficult to find at a refinery the oil from a single lease or combination of leases unmixed with oil from other leases. Such unmixed oil, however, was found at two refineries and data regarding it were collected.

TABLE 19.—*Volume of air above oil in a 55,000-barrel tank and its thermal expansion for various conditions.*

Depth of oil.	Volume of air above oil.	Expansion.			
		Per ° F.	Per 10° F.	Per 20° F.	Per 30° F.
Feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
30	22,320	42	420	848	1,260
29	32,630	62	620	1,240	1,860
28½	37,790	72	720	1,440	2,160
27	53,250	101	1,010	2,020	3,030
26	63,560	121	1,210	2,420	3,630
25	73,870	140	1,400	2,800	4,200
20	125,420	238	2,380	4,760	7,140
15	177,020	336	3,360	6,720	10,080
10	228,520	434	4,340	8,680	13,020
5	280,320	532	5,320	10,640	15,978

FIRST TEST.

LAYOUT.

The first of these tests deals with oil of 40° B. from the Mervine field near Ponca City, Okla. The daily production, only 200 barrels, is run from the lease every other day, being stored there in 250-barrel tanks until a day's run of about 400 barrels is obtained. It is pumped through 14 miles of 3-inch covered pipe line and emptied into a 7,000-barrel steel tank by overshot connections. From this 7,000-barrel tank the course of the oil divides. Part of the oil is pumped into tank cars (see Pl. II, *B*, p. 33) and hauled 100 miles to a refinery, where it is pumped into a large steel tank. The rest of the oil in the 7,000-barrel tank is pumped one-fourth of a mile through a 6-inch covered pipe line to another large steel tank, capacity 10,000 barrels, at the refinery. Where possible, the loss at each stage was determined, as from lease tanks to pipe-line tank, pipe-line tank to tank car, en route to refinery, and tank car to refinery tank. The loss from pipe-line tank to refinery tank through pipe was considered separately under the heading "Filling a large steel tank with bottom connections."

RESULTS.

Table 20 shows the apportionment of losses in "lease to refinery" test. There are at least four reasons for the large percentage of

TABLE 20.—*Results of first test—lease to refinery.*[a]

Stage of handling.	Time elapsed.	Volume lost.
	Days.	*Per cent.*
Lease to pipe line tank	1	6.32
Pipe line to tank car	3/8	.30
Tank car en route	13	.63
Emptying tank car	1/4	.50
Total	14 5/8	7.75

[a] No loss from well to end of lease storage is included. Gravity of oil at well, 41° B.

volume lost from lease to pipe-line tank. First, the volume of oil handled is small; second, this is held in two 250-barrel exposed tanks during the time that it is being taken from the lease, and the loss during this time is charged to the whole process of gathering. Third, the period of time needed for emptying the two 250-barrel tanks—that is, for handling 400 barrels—is about 24 hours. This means that a very small stream is falling an average distance of 13 feet into a large tank, which allows considerable evaporation, although it has a steel roof. Fourth, the area of this large receiving tank is great compared to the volume of oil that enters at any one period. These facts help to account for an average loss of 50.4 barrels, or 6.3 per cent, in running 800 barrels. Two tests made over this part of the layout checked each other very closely.

SECOND TEST.

LAYOUT.

The second test was with the oil from the Garber field in Oklahoma. This oil has a much higher gravity than the average

Oklahoma oil, because it contains a large proportion of medium gravity gasoline. It has a comparatively small proportion of the very light fractions. Although the gasoline content at the lease tank is as high as 50 per cent, with an end point of 392° F., the first 1½ per cent distilled shows a gravity of 83.3° B., whereas Kansas oil of 37° B. gravity shows for the first 1½ per cent distilled a gravity of 79° B. At 6 per cent over, the gravity of the Garber distillate is 72° B., whereas that of the Kansas oil is 68° B. These facts and others presented in Part III show that an evaporation test of this light oil gives a basis for comparison with the average oil of the Mid-Continent field.

Figure 41 is a sketch of the layout for this test. The oil from four leases was brought to a central pumping station and from there carried through 3 miles of covered 3-inch pipe line. At that point

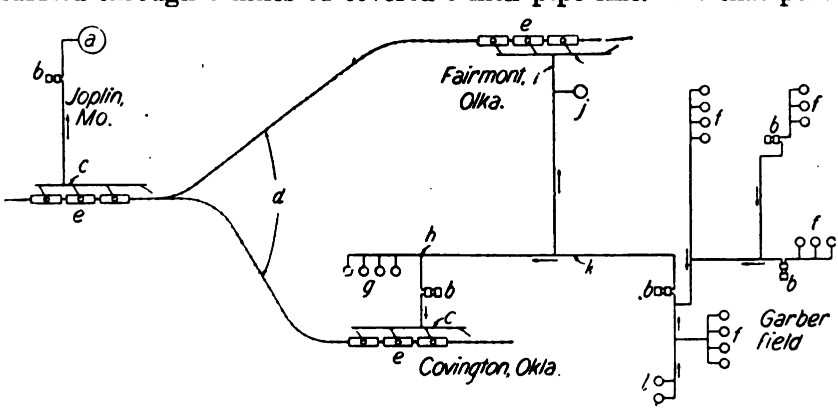


FIGURE 41.—Layout for determining evaporation loss in handling oil from lease to refinery by tank car. Second test: *a*, 1,500-barrel steel tank at refinery; *b*, pump; *c*, loading rack; *d*, 200 miles railroad; *e*, tank cars; *f*, 250-barrel covered steel lease tanks; *g*, 100-barrel unprotected steel gathering tanks; *h*, 2½ miles 3-inch covered pipe; *i*, 7 miles 3-inch unprotected pipe; *j*, 500-barrel unprotected steel gathering tank; *k*, 3 miles 3-inch covered pipe; *l*, 250-barrel unprotected steel leased tank.

part of it went through 7 miles of 3-inch exposed line, and the remainder went through 2½ miles of 3-inch covered line. Whichever way it went, the oil was either stored in steel tanks for a short period or pumped directly into tank cars. These cars were hauled 150 miles to the refinery, where the oil was pumped into a 15,000-barrel steel tank. The loss was determined at each stage of progress and checked by samples taken on the lease, at the pipe-line gathering tanks, and in the tank cars. Accurate measurements of volume were made at each movement of the oil.

FIELD WORK.

The field work does not consider any of the losses to which the oil was subjected before it left the lease; they are shown from distillations or representative samples taken at successive points in the journey from the well. After leaving the well the oil passed through a gas trap kept under suction, and the gasses separated went to a compression gasoline plant. From the gas trap the oil splashed into a flow tank and from that it splashed by overshot connections into lease tanks. The reader should note that the average over-all time that a barrel of oil was under consideration in the field test was only eight and one-third days. A special test showed that the volume of dissolved gas carried by the oil in the lease tank was very small, only 0.11 per cent of the volume. (See Part III.) Any wild gas in

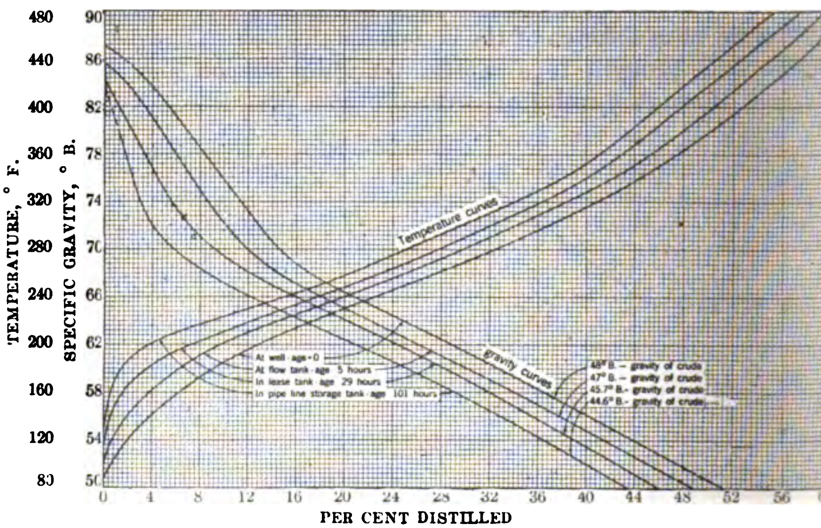


FIGURE 42.—Effect of evaporation as shown by distillation curves on second "lease to refinery" test.

the oil at the well was removed by the vacuum in the gas trap. Consequently, the loss shown as evaporation is a recoverable fraction.

RESULTS FROM DISTILLATIONS.

Samples were taken at several wells closely representative of the average production. At the flow tank another sample, representing even more closely the average production of the lease, was taken. At the same time, another sample was collected at the lease storage tank after it had stood full for 24 hours. Subsequently, another sample was taken at the pipe-line storage tank at the railroad. Results of distillation tests of these samples appear in Table 21. Figure 42 is a striking diagram illustrating the ravages of evaporation on light oils when handled as they are at present.

TABLE 21.—*Results of second test showing percentage of volume lost by evaporation during movement of oil from well to refinery.*

Stage of handling.	Change of °B. of crude.		Time elapsed.	Per cent volume lost.			
				By formula.	Graphically.		By field test.
	From—	To—			Gravity curves.	Temperature curves.	
			Days.				
Well to flow tank	48.0	47.0	$\frac{5}{24}$	3.0	2.6	2.6	(a)
Flow tank to lease tank	47.0	45.7	1	4.0	2.5	2.1	(a)
Lease tank to pipe-line tank	45.7	44.6	4	3.7	3.0	2.6	2.9
Pipe-line tank to tank car	......	......	¼	......	......	......	.3
Tank car en route	......	......	4	......	......	......	.5
Tank car to refinery tank	......	......	¼	......	......	......	.5
Total—lease tank to refinery tank	......	......	8½	......	......	......	4.2
Total—well to pipe-line tank	48.0	44.6	$5\frac{5}{24}$	10.7	8.1	7.3	......
Total—well to refinery tank	......	......	9½	......	9.4	8.6	9.0

a Undetermined.

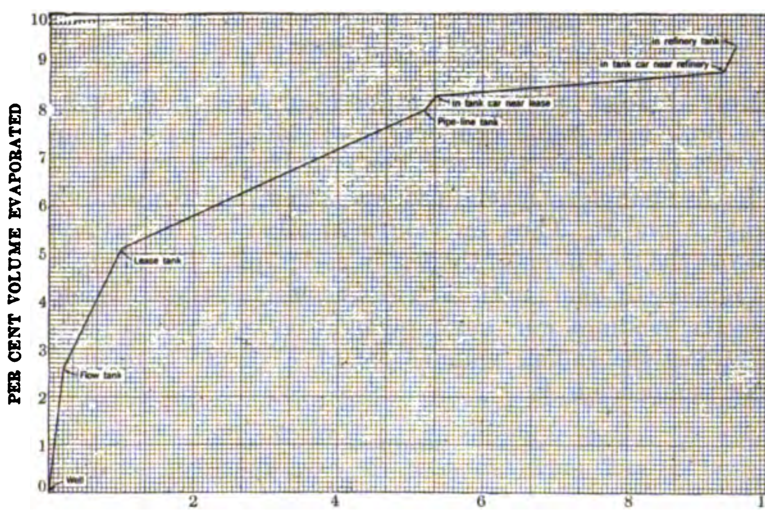


FIGURE 43.—Percentage of volume lost by oil through evaporation, by stages, from well to refinery. Second test.

DISCUSSION OF RESULTS.

The percentage of volume lost from the well to the refinery shown in Table 21 and figure 43 has been obtained by combining the results of the distillations and the field measurements. These data show that oil evaporates rapidly at first, but gradually slower. A tank car evidently gives the best condition of storage, because it is fairly air-tight. When oil is moved from one tank to another the rate of evaporation is rapid.

Naturally, the greatest single loss is in gathering the oil from the lease tanks to the pipe-line tanks, because of the exposure during filling and while standing in unprotected steel tanks. The loss in filling the tank car is less than in emptying it—0.3 per cent as compared to 0.5 per cent—because the area of oil exposed in the car is very much smaller than that exposed in the large receiving tank. All of the loss at a large receiving tank during the emptying of the tank car is charged to the volume of oil emptied from the car. The over-all loss from lease to refinery under these conditions of storage and transportation (exclusive of losses on the lease) is 4.5 per cent. This figure is believed to be very nearly correct. Figure 61 (p. 106) compares the results of distillation tests of average Mid-Continent oil and Garber oil.

EVAPORATION LOSSES IN FILLING A 10,000-BARREL STEEL TANK.

METHOD OF TEST.

Before the tests to determine evaporation losses in filling a 10,000-barrel tank were begun care was taken to see that all connections were full of oil. To this end, the centrifugal pump was started, run for five minutes, and stopped, and a gage and temperature taken at tanks A and B. Thus, the volume of oil at 60° F. was accurately known at the beginning of the test in each tank. The pump was run for a number of hours until tank A was nearly empty. Immediately volumetric readings were again taken at tanks A and B. Had there been no loss the volume pumped out of A should have equaled the volume pumped into B.

RESULTS.

Table 22 shows that the loss in this test was three-tenths of 1 per cent, volumetrically. There was loss by evaporation from the tank that was being emptied as well as from the tank that was being filled. These losses were added and charged to the volume of oil that changed place, thus giving a basis for estimating the loss in main-line pumping stations when the oil is pumped into and from working tanks. The oil handled had a gravity of 39° B. and was about 25 days old at the beginning of the test. It had passed through the lease tanks and had been gathered by the pipe line into tank A.

In filling the tank there was a loss of 12 barrels, worth $36 if considered as crude, or $111 if considered as gasoline. This percentage of volume lost checks similar experiments made elsewhere.

TABLE 22.—*Results of test—filling a 10,000-barrel tank, Aug. 21, 1919.*

Item.	Start.	Finish.
Hour	8.40 a. m.	8.15 p. m.
Tank 1:		
Volume standing in tank ... barrels	5,379.7	1,295.5
Volume pumped out ... do		4,084.2
Tank 2:		
Volume standing in tank ... do	3,101.4	7,173.6
Volume pumped in ... do		4,072.2
Loss ... do		12.0
Loss ... per cent		0.3
Value lost:		
As crude, at $3 per barrel ... dollars		36
As gasoline, at 22 cents per gallon ... do		111
Gasoline v. crude ... per cent		0.92

GENERAL DISCUSSION OF ALL RESULTS.

APPORTIONMENT OF LOSS—WELL TO REFINERY.

Table 23 shows the apportionment of the average losses sustained by crude oil in the Mid-Continent field on its journey from the well to the refinery for the year. These losses are based on all the information gathered in this work. The percentage of volume lost at two of the points, for example, at the flow tank, has necessarily been estimated. The loss in filling a lease tank was shown in two tests, made in summer, to be approximately 1.6 and 2.3 per cent. For the entire year the loss would be somewhat less; hence an average of 1 per cent is taken. The loss in the flow tank will certainly be as great as the loss in filling the lease tank, for the oil is fresher and the conditions are nearly the same. The average for lease storage is the result of numerous experiments and is believed to be very conservative. The percentage shown for the gathering system is based upon tests, due allowance being made for the test having been run in summer. It is believed that the transportation loss, estimated from information on filling large tanks and transportation by tank cars, is somewhat greater than the table shows. The loss on tank farms is calculated from the tests and from data on how long oil is ordinarily stored in large tanks.

TABLE 23.—*Apportionment of the loss sustained by crude from the well to the refinery.*

Location of loss.	Per cent volume evaporated.				Source of information.
	Summer.	Autumn and spring.	Winter.	Average.	
Flow tank	1.2	1.0	0.8	1.0	Estimated with help of lease tank test.
Filling lease tank	1.2	1.0	.8	1.0	Test.
Lease storage	1.8	1.4	1.2	1.5	Do.
Gathering	1.3	.9	.8	1.0	Do.
Transportation	1.2	.9	.8	1.0	Estimated with help of tank-car tests and of filling large tank.
Tank farms	.9	.7	.6	.7	Test.
Total	7.6	5.9	4.9	6.2	

Table 24 shows the monthly production and stocks of the Mid-Continent field for part of 1918 and 1919, as given by the U. S. Geological Survey. All the stocks are continually changing location, but it is approximately true that the oil is held in storage for a period determined by dividing the stocks by the total production, the resulting average being 5.1 months. From the experiments on large tanks, the figure of 0.7 percentage of volume lost for a storage period of 5.1 months seems conservative. The total of 6.2 per cent represents the loss to which a barrel of oil is subjected in all of the stages covered by Table 24.

This figure of 6.2 per cent, when applied to the 196,000,000 barrels produced in the Mid-Continent field, gives the yearly evaporation bill of 12,152,000 barrels, or 510,000,000 gallons, which was just about one and one-half times the total gasoline output of the natural-gas gasoline industry in the whole United States during 1919.

The determination of losses on main lines is most difficult. Lack of time and opportunity prevented thorough examination of this problem, which will be taken up later.

TABLE 24.—*Average time of storage of crude by pipe-line companies, Mid-Continent field.*

Month.	Marketed production.	Stocks.	Average months stored.
1918.	*Barrels.*	*Barrels.*	
September	13,998,000	89,120,000	6.36
October	14,988,000	87,095,000	5.8
November	13,784,000	83,275,000	6.0
December	13,115,000	30,047,000	6.1
1919.			
January	15,027,000	80,252,000	5.3
February	13,211,000	78,107,000	5.9
March	14,629,000	79,183,000	5.4
April	14,048,000	79,567,000	5.7
May	14,492,000	77,652,000	5.3
June	16,613,000	80,511,000	4.9
July	18,680,000	85,421,000	4.6
August	18,251,000	81,454,000	4.5
September	18,649,000	82,868,000	4.4
Average			5.1

DECREASE OF EVAPORATION LOSS.

Results of the tests show that by protecting lease tanks from circulation of air the amount of evaporation can be reduced one-half to two-thirds and perhaps more, depending upon the quality of the protection. Housing a steel tank reduces evaporation about one-half. An approximately air-tight jacket around a steel tank decreases evaporation even more.

VALUE OF PROTECTING TANKS.

Table 25 gives a comparison of the value of housing 250-barrel tanks and jacketing 500-barrel steel tanks. It is seen that, even though the jacket on a 500-barrel tank costs $360, the saving attained will pay for it in less than 3½ months, whereas the house for the 250-barrel tank pays for itself in 2$\frac{6}{10}$ months. These figures seem to show that housing was more valuable than the jacketing. This, however, is not the case, for the jacket on a 500-barrel tank is saving $19.20 every five days, whereas the house is saving only $13.80 every five days.

TABLE 25.—*Saving attained by protection of tanks by housing or jacketing.*

	Value of crude lost.	Saved (by protection) per 5 days.	Saving per month.	Cost of protection.	Time needed to pay for protection.
500-barrel steel tank:					*Months.*
Unprotected	$29.10	$19.20	$105.20	$360.75	3.43
Jacketed	9.90				
250-barrel steel tank:					
Unprotected	20.40	13.80	82.80	215.00	2.6
Housed	6.60				

CONCLUSIONS.

At present the most practicable way of reducing evaporation loss is to make the tops of all tanks gas tight and to keep them under a slight pressure, regulated by automatic valves. To make the roofs of steel tanks gas tight would be easy. Oil should be forced into a tank through the bottom and not through overshot connections. Where piping is already installed for a gasoline plant, all tanks should be connected to this system and kept under suction. Practically 100 per cent of the evaporation loss could be saved in this way. Whether it would pay better to put in a gasoline plant than to protect the tanks and keep the gasoline in the oil is a problem that each producer should work out for himself. Any man who handles crude oil has an evaporation problem. He should determine the amount lost and take steps to eliminate as much of the loss as possible. As the demand for petroleum products becomes stronger and prices rise again the need of preventing evaporation will be brought to his attention more and more.

ADDITIONAL WORK ON EVAPORATION.

Additional work on evaporation should proceed in two directions. One of these is toward getting further data on losses, especially in working tanks and main pipe lines. The other is toward determining the most efficient and most economical apparatus for eliminating evaporation.

Losses by evaporation benefit no one. If there is excessive evaporation on the lease before the pipe line takes the oil, the pipe-line company will have less evaporation because of its handling a less volatile oil, but the producer should not suffer a large volumetric loss and the refiner a large qualitative loss in order that the pipe-line company may have a smaller evaporation loss.

The chief evaporation losses must be eliminated by the producer, because they occur while the oil is on the lease. The expense and trouble of reducing these losses should be repaid either by a better price for a better quality of crude or by the producers saving the oil vapors and marketing them as gasoline.

PART III.—SCIENTIFIC DATA ON THE EVAPORATION OF PETROLEUM PRODUCTS.

VAPOR PRESSURE.

The vapor pressure of a liquid is the pressure that the vapor from the liquid will set up in a vacuum before evaporation ceases, or it is the partial pressure that the same liquid would set up in a closed vessel containing air. For the same liquid this pressure varies, rising with increase of temperature. Hence vapor pressure determines the proportion of gasoline vapor that a given volume of air will take up. The lighter the fraction distilled from a crude oil, the greater is its vapor pressure. It can not be said that all gasolines of higher Baumé gravity have higher vapor pressures, provided the gasolines are from different crudes, because gravity is not an exact criterion of the composition of gasolines. In general, however, it is true that the vapor pressures of gasolines vary with the Baumé gravity, especially if the gasolines are made from the same crude.

TABLE 26.—*Vapor pressure, in millimeters of mercury, of gasolines of different gravities and percentage of gasoline vapor for saturating air at different temperatures.*

Temperature.		73° B.		69° B.		64° B.		61° B.		56° B.		Water.	
		Vapor pressure.	Vapor for saturation.	Vapor pressure.	Vapor for saturation.	Vapor pressure.	Vapor for saturation.	Vapor pressure.	Vapor for saturation.	Vapor pressure.	Vapor for saturation.	Vapor pressure.	Vapor for saturation.
°*F.*	°*C.*	*Mm.*	*P. ct.*	*Mm.*	*P. ct.*	*Mm.*	*P. ct.*	*Mm.*	*P. ct.*	*Mm.*	*P. ct.*	*Mm.*	*P. ct.*
32	0	110	14.5	58	7.6	41	5.4	25	3.3	22	2.9	5	0.7
41	5	135	17.8	66	8.7	55	7.2	32	4.2	29	3.8	7	.9
50	10	162	21.3	82	10.8	62	8.2	40	5.3	34	4.5	9	1.2
59	15	194	25.5	100	13.2	74	9.7	52	6.8	38	5.0	13	1.7
68	20	235	30.9	121	15.9	88	11.6	64	8.4	42	5.5	17	2.2
77	25	279	36.7	148	19.5	106	14.0	77	10.1	47	6.2	24	3.2
86	30	337	44.3	177	23.3	129	17.0	93	12.2	55	7.2	32	4.2
95	35	397	52.3	215	28.3	157	20.7	113	14.9	66	8.7	42	5.5

Table 26, compiled from data published by Burrell and Boyd,[5] shows the vapor pressures of gasolines of different gravities and the

[5] Burrell, G. A., and Boyd, H. F., Quantity of gasoline necessary to produce explosive vapors in sewers: Tech. Paper 117, Bureau of Mines, 1916, 18 pp.

percentage of gasoline vapor necessary to saturate air of different temperatures. The data apply only to the commercial gasolines used. Note that the vapor pressures of gasoline are much higher than those of water, which is one reason why gasoline evaporates so much more rapidly.

Figure 44 shows the percentage of gasoline necessary for saturation of air as the gravity of the gasoline varies. It is shown for temperatures ranging from 32° F. to 86° F. When tanks breathe, the percentage of gasoline vapor in the mixture forced from the tank has direct bearing on the volumetric loss through evaporation. If the breathing can be minimized, the evaporation from a tank will necessarily be lessened, for then the mixture of vapor and air under the roof rapidly becomes saturated and evaporation stops. When some of the mixture is forced out and pure air drawn in, the balance is disturbed; evaporation begins and continues until the mixture is again saturated with gasoline vapor.

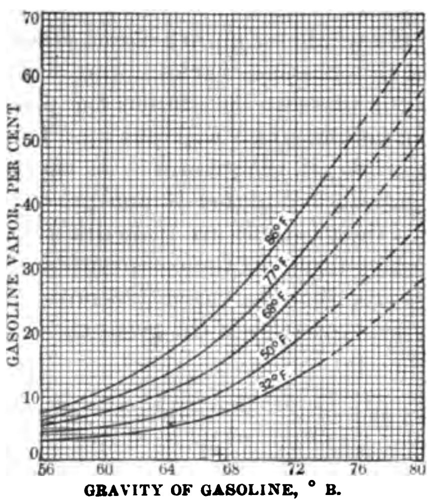


FIGURE 44.—Variation of percentage of gasoline vapor necessary for saturation of air at different temperatures as ° B. of gasoline varies.

LATENT HEAT OF EVAPORIZATION.

When a liquid evaporates, a large amount of heat is absorbed from the surroundings to supply the latent heat of evaporation of the liquid. Naturally, the greater the amount of heat necessary for this, the slower will be the rate of evaporation. A comparison of water and gasoline shows that the latent heat of vaporization of water is 970 B. t. u. per pound, whereas for gasoline it is about 135 B. t. u. per pound.[6] It is thus seen that only one-eighth as much heat would have to be supplied for vaporizing gasoline as for vaporizing water. Here is another reason why the light fractions of petroleum evaporate so rapidly. As evaporation implies the absorption of heat from the surrounding medium, its effect is to cause cooling. The less the cooling, the more rapid will be the evaporation.

[6] Landolt, Hans, and Börnstein, Richard, Physikalisch-chemische Tabellen: Berlin, 1894, p. 350.

CONVECTION CURRENTS IN OIL.

Convection currents in tanks of oil result from two principal causes. The first is the change in temperature of the oil at any point. If this point is below the surface and the temperature there increases, the warmer oil rises. At unprotected steel tanks, the sun beating on the steel heats it rapidly. This heat is transmitted by conduction through the steel to the film of oil inside, which immediately starts to rise.

The second reason for convection currents is evaporation of the lighter fractions at the surface and the consequent lowering of the gravity of the oil there. This oil, becoming heavier, begins to sink and its place is taken by the lighter oil just below. Calculation shows that 1 per cent evaporation of light gasoline from crude has approximately the same effect on the specific gravity of the crude as a 5 to 8° F. change in temperature. Ordinarily, the temperature in a large tank decreases toward the bottom, tending to create a condition of stability. Were it not for the heating or cooling of the sides of the steel tank, the movement of the oil would depend upon the evaporation at the surface, and the convection currents would tend to be directly vertical.

VISCOSITY.

Viscosity decreases the movement of lighter oil from the bottom to the top, and, therefore, has some effect on the rate of evaporation of a crude. It is believed, however, that the viscosities of the light Mid-Continent crudes considered in this investigation, although not uniform, do not differ enough to affect their rates of evaporation materially. In very heavy oils of small gasoline content, viscosity would tend to retard the rate of evaporation much more than in light, less viscous oils.

CONDITIONS TO BE ATTAINED TO DECREASE EVAPORATION.

Crude oil exposed to the air continues to evaporate for a long time. When the mixture of air and vapor at the surface of the oil is nearly pure air, as it is when wind blows across the surface freely, the rate of evaporation is most rapid. As the proportion of vapor in the vapor-air mixture above the oil increases, the rate of evaporation decreases. When the mixture finally contains as much of the vapor as it can possibly hold under given temperature and pressure conditions, that is, when it is saturated, evaporation ceases. The oil in a tank with a gas-tight cover evaporates until the air under the roof is saturated. If no fresh air enters this mixture of air and vapor, evaporation ceases. In practice, however, temperature changes cause expansion or contraction of gas under the roof, and the tank "breathes."

Evidently the temperature of the gas under the roof should be kept as nearly constant as possible. To practically eliminate evaporation, therefore, it is necessary to confine the space above the oil in a tank and to keep that space at a constant temperature, or a variable pressure, then the only evaporation loss will be that necessary to saturate the space above the oil.

To accomplish this, tank roofs should be absolutely gas-tight, with automatic pressure valves. Some tanks containing very volatile products should also be protected from the sun in some manner.

CHANGES IN OIL AND IN THE PART LOST BY EVAPORATION.

A number of results follow the evaporation of crude oil. First the gravity of the crude becomes heavier with the escape of the lighter fractions. Second, as evaporation continues the fraction that is actually being evaporated becomes heavier and heavier. Third, the boiling point of the evaporating fraction rises as the gravity becomes heavier. Fourth, the average specific gravity of the fractions lost by evaporation increases.

Data concerning the above effects of evaporation on three standard types and one special type of tanks—250 and 500 barrel unprotected steel tanks, 500-barrel jacketed steel tanks, and 1,600-barrel housed wood tanks—in summer, with the gravity of oil ranging from 35 to 37° B., may be assembled in four groups, according to the effect on degrees Baumé of crude, the effect on the degrees Baumé of the fraction evaporating, the effect on the boiling point of the fraction evaporating, and the effect on the degrees Baumé of the portion lost. Note that different effects are shown for the same group of tanks. A study of the difference in effect between one kind of tank and another will give the relative values of each type in eliminating evaporation.

Moreover, it is desired to indicate the destructive effect of evaporation on the gasoline content of crude.

SOURCE OF DATA.

The results under the heading have been taken from the field experiments shown in Part III. Data enough to show these results were taken on every test. To print all of them in this bulletin would require too much space, consequently they have been classified as shown above.

EFFECT ON GRAVITY OF CRUDE.

As oil evaporates, that is, as the lighter fractions escape, its Baumé gravity necessarily becomes heavier. Data on this increase for several oils under various conditions of storage, presented in figure 45, show that the oil stored in 250-barrel unprotected steel tanks suffers the

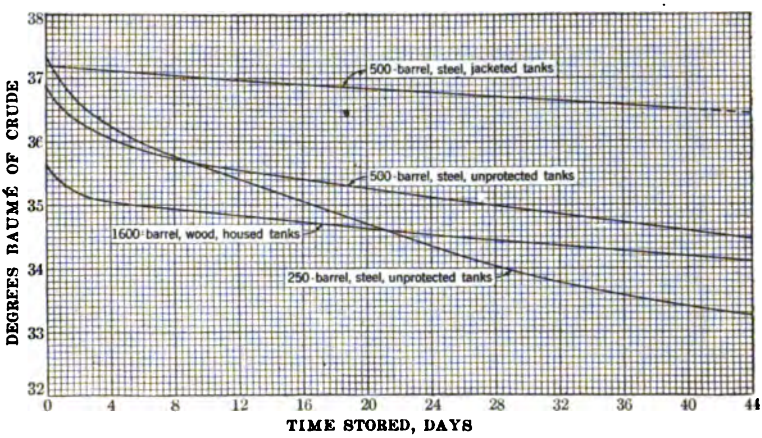


FIGURE 45.—Drop in °B. gravity of crude stored in different kinds of tanks—summer.

greatest loss in Baumé gravity, whereas that stored in a 500-barrel jacketed steel tank suffers the least. These data bear out the rela-

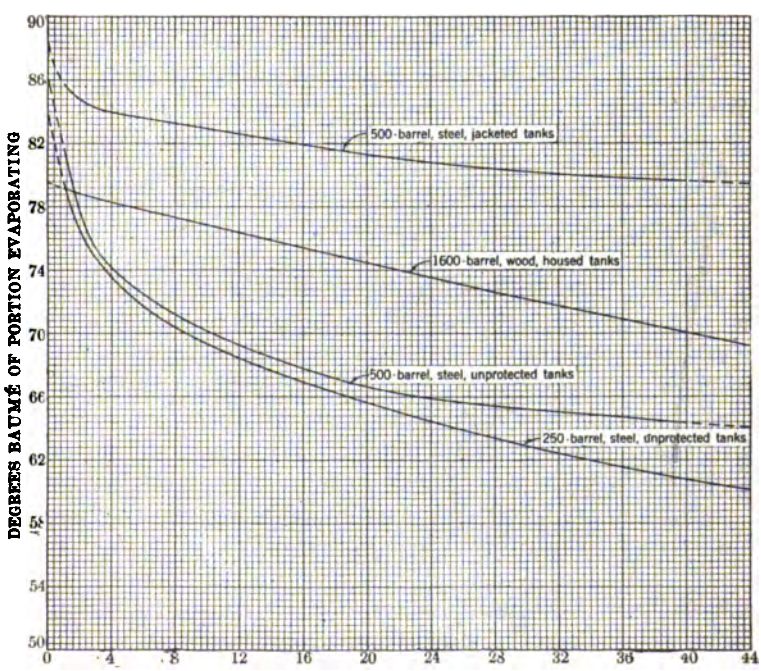


FIGURE 46.—°B, gravity of fraction evaporating for tanks of various kinds—summer.

tive volumetric losses shown for these classes of storage in Part II of this report.

GRAVITY OF FRACTION EVAPORATING.

Figure 46 shows the degrees Baumé of the fraction that is evaporating for crudes under various conditions of storage. "Fraction"

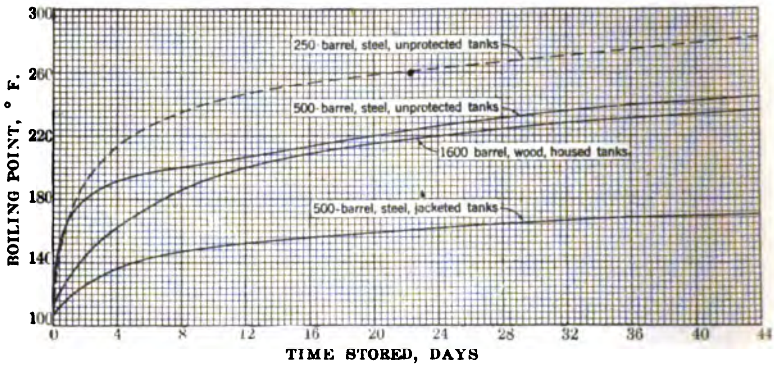


FIGURE 47.—Boiling points of fractions evaporating from tanks of various kinds—summer.

does not refer to a pure hydrocarbon, but to a mixture of hydrocarbons within comparatively narrow limits. Here again it is seen

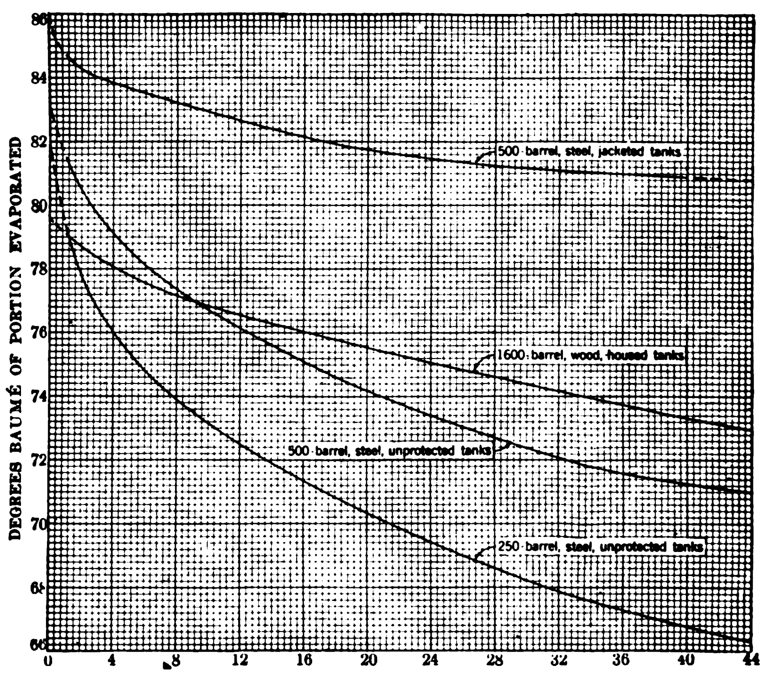


FIGURE 48.—°B. gravity of the portion which has evaporated from tanks of various kinds—summer.

that heavier fractions were in process of evaporating from the 250-barrel steel tank than from the 500-barrel jacketed steel tank. These fractions in the 250-barrel tank were not only heavier but the volume evaporated was greater, which is added proof of the economy of protecting tanks against air circulation.

BOILING POINT OF FRACTION EVAPORATING.

The boiling points of the fractions evaporating are shown in figure 47 for the same conditions of storage that have been utilized as noted above. This was determined in a manner similar to the method for finding the degrees Baumé of the fraction evaporating. The boiling point of the fraction evaporating from the 250-barrel exposed steel tank is very much higher than the boiling point of the fraction evaporating from the 500-barrel jacketed steel tank, with the other types falling in between.

GRAVITY OF PORTION EVAPORATED.

As evaporation continues the gravity of the total part that has been lost from the start of the test becomes heavier, as shown in figure 48. It is seen that under the same conditions of storage, as previously described, in 39 days a 250-barrel exposed steel tank lost gasoline having an average gravity of 67° B. During the same period a 500-barrel jacketed steel tank lost gasoline of 81° B.

LABORATORY EVAPORATION TESTS.

COMPARISON OF RATES OF EVAPORATION OF PETROLEUM AND PURE GASOLINE FROM THE SAME PETROLEUM.

Laboratory tests were made to determine this relation. The purpose was to determine how much slower gasoline will evaporate in the crude in its natural state than distilled. Fractions were taken at 10 per cent intervals until the third 10 per cent cut was completed. Each of these cuts was exposed to the air under exactly the same conditions and at the same time. Enough of the original crude to give the volume of each of the above cuts was also exposed in a similar manner, and the evaporation of each was noted periodically. The results of these tests are shown in figures 49, 50, 51, and 52 and in Table 27.

The rate of evaporation of the crude is compared with the rate of evaporation of the first 10 per cent distilled, the ratio of the gasoline rate to the crude rate ranging from 1.61 to 2.23 and averaging 1.91. The very light gasoline evaporated practically only twice as fast when

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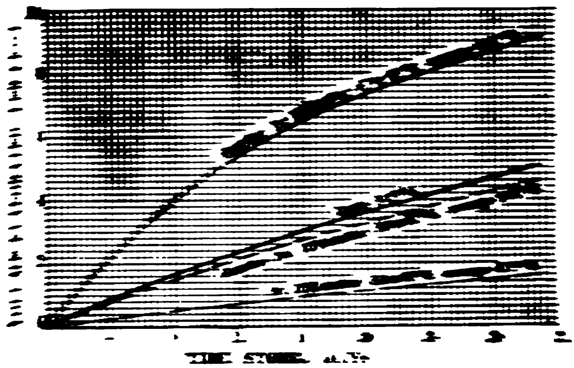

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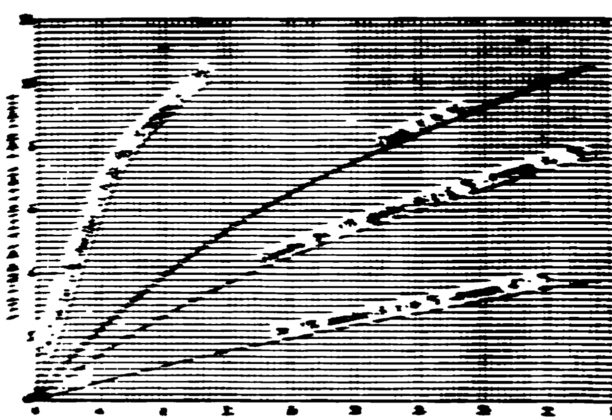

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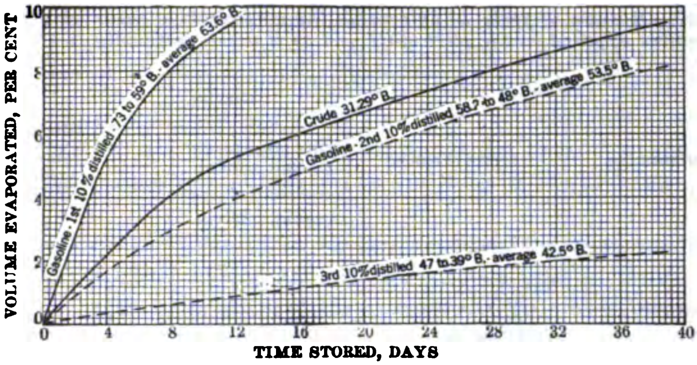

FIGURE 51.—Comparison of evaporation of crude from Coalinga, Calif., field and the gasoline and kerosene cuts from that crude exposed in pure state. First 10 per cent, second 10 per cent, and third 10 per cent distilled and crude exposed separately. All evaporative conditions identical.

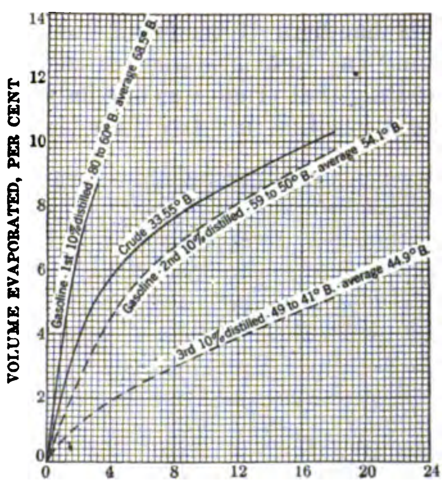

FIGURE 52.—Comparison of evaporation of crude from Coalinga, Calif., field and the gasoline and kerosene cuts from that crude exposed in pure state. First 10 per cent, second 10 per cent, and third 10 per cent distilled and crude exposed separately. All evaporative conditions identical.

TABLE 27.—*Results of tests to determine the comparative rates of evaporation of gasoline exposed in the pure state and as it exists naturally in the crude.*

Experiment No.	Source of crude.	Gravity.			Ratio of gasoline rate to crude rate.	Number of days.
		First 10 per cent of gasoline distilled.		Crude.		
		Average.	Range.			
		°*B.*	°*B.*	°*B.*		
1	Texas	67.3	76 to 63	40.0	2.04	
2	do	62	67 to 58	40.1	1.97	
3	do	61.5	71 to 58	37.4	2.23	
4	California	68.5	80 to 60	33.6	1.61	
5	do	63.6	73 to 59	31.6	1.82	
6	Kansas	62	67 to 58	34.9	1.79	
Average		64.1	72 to 59	36.2	1.91	

This ratio holds for gasoline above 60° B., such as tested. Here is a striking fact. If handlers of crude oil having a high gasoline content or containing any light gasoline realized that the loss from evaporation in handling that crude was one-half as great as the loss in handling the light gasoline in a free state they would see clearly

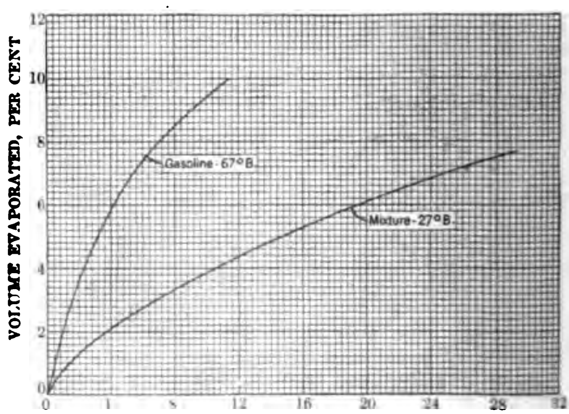

FIGURE 53.—Comparison of evaporation of pure gasoline and the same gasoline when blended with heavy lubricating oil in the ratio of 10 per cent gasoline to 90 per cent lubricating oil. All evaporative conditions are identical.

the necessity of taking better care of their crude. A comparison of the rates of evaporation of the crudes appears on a subsequent page.

EVAPORATION OF GASOLINE EXPOSED IN THE PURE STATE AND AFTER BLENDING WITH HEAVY LUBRICATING OIL.

The first 10 per cent distilled from a crude was mixed with a heavy lubricating oil of 22° B—the latter representing 90 per cent of the mixture—and was stirred thoroughly. This mixture was exposed in exactly the same manner as the pure gasoline. A number of such experiments were made with gasolines from different crudes. The results of these tests are shown in figure 53, which comprises composite curves for all the tests. In Table 28 the rate of evaporation of the mixture has been compared to the rate of evaporation of the pure gasoline.

Note in this table that the lubricating oil was heavier and in consequence had a higher viscosity than the crudes used in previous experiments. Note also that the ratio column of Table 28 is larger than that of Table 27. The result is that the gasoline in a mixture of high viscosity evaporates more slowly than similar gasoline in a mixture of lower viscosity. This same point is brought out in figure 54 by the separation of the two curves along the ordinates.

TABLE 28.—*Results of tests comparing the rate of evaporation of gasoline exposed in pure state and blended with lubricating oil.*

Experiment No.	Source of crude.	Gravity.			Mixture.		Ratio of gasoline rate to mixture rate of evaporation.
		First 10 per cent of gasoline distilled.		Lubricating oil.	Lubricating oil.	Gasoline.	
		Average.	Range.				
		°*B.*	°*B.*	°*B.*	*Per cent.*	*Per cent.*	
1	California	70.1	80 to 61	22	90	10	2.3
2	do	53.4	59 to 49	22	90	10	2.8
3	Texas	65.1	77 to 60	22	90	10	2.6
Average		62.9	72 to 53	22	90	10	2.57

RELATION OF THE GRAVITY OF GASOLINE TO THE RATE OF EVAPORATION OF THE ORIGINAL CRUDE.

In figure 54 one interpretation of results of the two preceding classes of experiments has been plotted.

In this figure the points from the "crude-gasoline" experiments show that the lighter the gravity of the gasoline, the nearer the rate of evaporation of the crude approaches that of the gasoline. In the "mixture-gasoline" experiments in the same figure, the same effect is noticed. The conclusion is that the more volatile the constituents of a crude oil, the more nearly will that crude evaporate at the rate of those constituents when exposed in a free state. In other words, the viscosity of the crude medium and the intimate mixing of the evaporating fractions with the whole volume of the crude reduce the rate of evaporation of the volatile fractions in the crude less and less as these fractions become more and more volatile.

EFFECT OF BLENDING LIGHT GASOLINE WITH HEAVIER PRODUCTS.

The first 10 per cent distilled from a crude was blended with heavier gasoline in one test and with mineral seal oil in another, and the rates of evaporation of the blends were compared with the

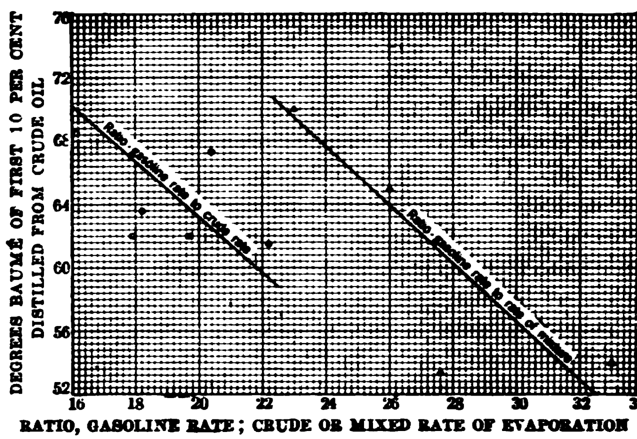

FIGURE 54.—Relation between the °B. of gasoline in a crude oil and the ratio of the rates of evaporation of (1) crude oil and the first 10 per cent of gasoline distilled therefrom; (2) gasoline and a blend of the same gasoline with heavy lubricating oil—10 per cent gasoline to 90 per cent lubricating oil.

rate of the pure gasoline, all evaporative conditions being the same. The results of these tests appear in figures 55 and 56. In both tests the pure gasoline evaporated little faster than when it was blended.

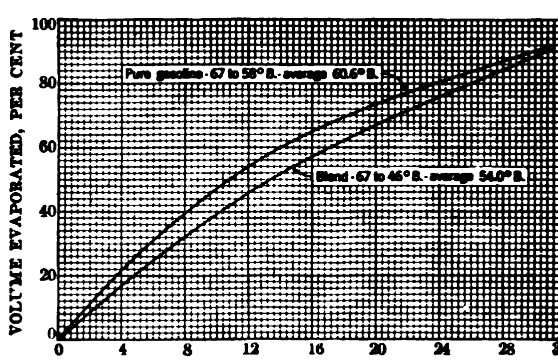

FIGURE 55.—Comparison of evaporation of 61° B. gasoline and the same gasoline blended with heavier cuts in the ratio of 33⅓ per cent of 61° B. gasoline and 33⅓ per cent of 53.6° B. and 33⅓ per cent of 47.9° B. cuts. All evaporative conditions are identical.

In Bulletin 88,[7] figures 12, 13, and 14 (see pp. 87–89), the authors show the results of experiments on "compression" natural-gas gaso-

[7] Burrell, G. A., Seibert, F. M., and Oberfell, G. G., The condensation of gasoline from natural gas: Bull. 88, Bureau of Mines, 1915, 106 pp.

line blended with naphthas which very closely resemble the results printed in this report. The gasolines used in the tests described in this bulletin are of the same quality as gasoline from the refinery. Gasolines obtained from natural gas contain much permanent gas dissolved in them.

RATE OF EVAPORATION OF GASOLINES DERIVED FROM CRUDES FROM DIFFERENT SOURCES.

The gravity of a liquid does not necessarily affect its rate of evaporation, the latter depending upon the boiling point or vapor pressure. In commercial gasolines, many of which are made by blending heavy fractions with very light casing-head fractions, it is well known that the gravity of the mixtures bears little relation to the boiling range, and hence the rates of evaporation. However, straight-run gasolines obtained by making narrow cuts from the crude have different gravities for the same boiling point, or, conversely, different boiling points for the same gravity, when the crudes come from different parts of the United States. Especially is this noted among Pennsylvania, Kansas, and California gasolines. A California straight-run gasoline has a much lower boiling range than a straight-run Pennsylvania gasoline of the same gravity.

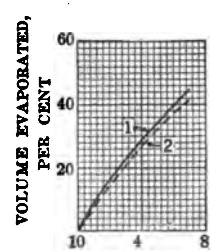

FIGURE 56.—A comparison of evaporation of gasoline of 66.9° B. to that of a blend of it with mineral seal oil in the ratio of 50 per cent mineral seal oil to 50 per cent gasoline. All evaporative conditions identical.

Therefore a third class of experiments was designed to compare the rates of evaporation of gasolines of approximately the same degrees Baumé, but derived from crudes of El Dorado, Kans.; Ranger, Tex.; and Coalinga, Calif. The results of these tests are shown in figures 57 and 58. Figure 57 compares the California and Texas and figure 58 the Kansas and Texas gasolines. These figures show that straight-run gasolines of nearly the same gravity and range of gravity, whether derived from the Texas or California crudes used, evaporate at nearly the same rate. The gravity of the California crude was 32° B., that of the Texas 40° B.

An important feature is brought out in figure 58. A straight-run gasoline from El Dorado, Kans., crude evaporates considerably slower (nearly one-half) than that from Ranger, Tex., crude, although both gasolines have practically the same average gravity and the same range of gravities of successive fractions. The gravities of the two crudes were 36 and 40° B., respectively.

In 1916 Rittman, Jacobs, and Dean tested commercial gasolines from many fields in the United States. In one test they subjected equal volumes of each sample to identical evaporative conditions and

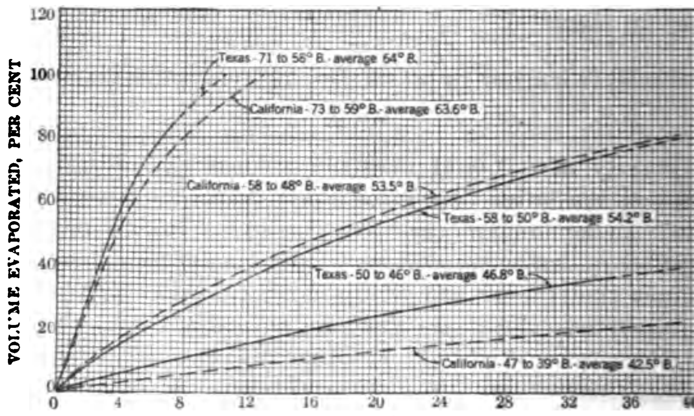

FIGURE 57.—Comparison of evaporation of gasolines from Ranger, Tex., and Coalinga, Calif., light crudes. All evaporative conditions identical.

recorded the percentage of the original volume which was lost.[a] Figure 59 shows that the California gasolines of the same gravity evaporate approximately twice as fast as those from the other fields.

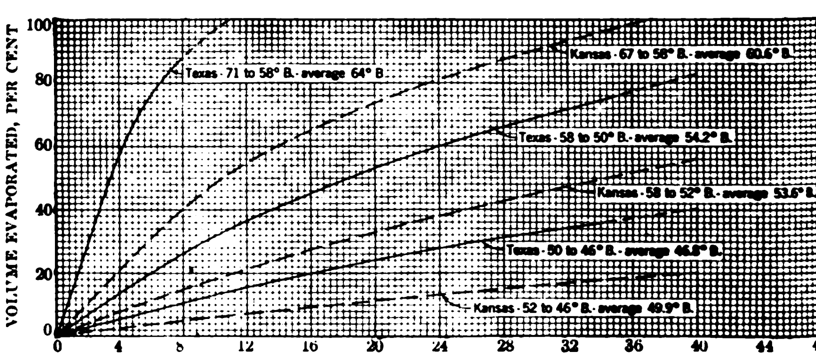

FIGURE 58.—Comparison of evaporation of gasolines from Ranger, Tex., and El Dorado, Kans., crudes. All evaporative conditions identical.

thus corroborating the work of the author and adding the Pennsylvania gasolines to the "slow" group. Some of the Pennsylvania gasolines contained very light casing-head gasoline, otherwise the

[a] Rittmann, W. F., Jacobs, W. A., and Dean, E. W., Physical and chemical properties of gasolines sold throughout the United States during the calendar year 1915: Tech. Paper 163, Bureau of Mines, 1916, p. 16.

Pennsylvania would be slower than the Kansas gasolines. Each curve represents the average result of all the tests made on the gasolines from that field.

CONCLUSIONS FROM LABORATORY TESTS.

The general conclusions from all these laboratory experiments are as follows: First, under the same conditions of evaporation, gasoline derived from light crude (not casing-head) will evaporate one-half as rapidly when in the crude as when in the pure state after distillation. Second, blending a gasoline with a very heavy viscous high-flash oil will decrease its rate of evaporation very much—by nearly two-thirds in tests in this report. Third, blending a gasoline that contains practically no "wild" fractions (that is, dissolved permanent gases) with heavy gasoline or with oils such as mineral seal oil will not decrease materially its rate of evaporation. Fourth, the source of the crude will serve to indicate the rate of evaporation of the derived gasoline as compared with that of gasoline from another source, provided fractions evaporating have the same gravity. Fifth, the gravity of crudes from widely separated fields is not a criterion of their relative rates of evaporation. Of these five conclusions the first is the most important.

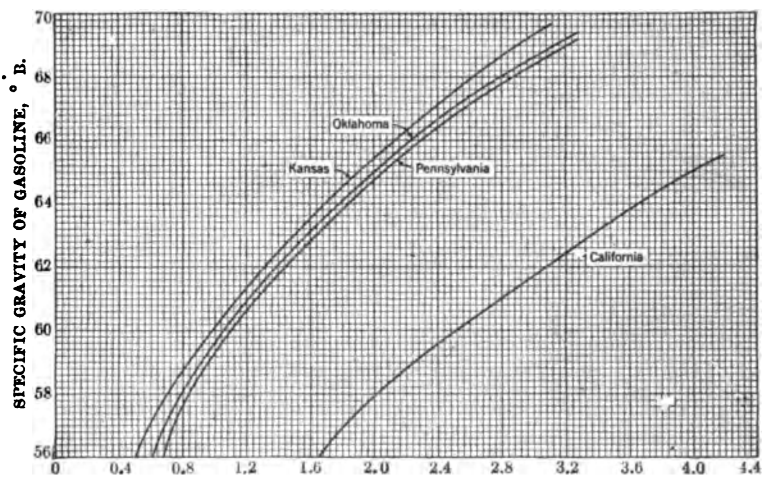

FIGURE 59.—Relative rates of evaporation of gasolines from different fields. All evaporative conditions are identical.

RATE OF EVAPORATION OF CRUDES FROM DIFFERENT SOURCES.

Whether a crude from Kansas evaporated at the same rate as one from Texas or California (all light crudes) was investigated in the laboratory, the rate of evaporation being studied carefully in conjunction with the "gravity–per cent distilled" curves of the three kinds of oil. The results shown in figures 60 and 61 represent the composite of a number of experiments on each oil. Naturally, it was very difficult to obtain from these widely separated fields three oils that would give practically the same "gravity–per cent distilled" curves.

The points of similarity between the crudes were: First, all were comparatively light, the heaviest being 31.7° B., the lightest, 37.4° B.; second, they all had a large percentage of gasoline—between 25 and 33 per cent; and third, the average gravity of the fraction that

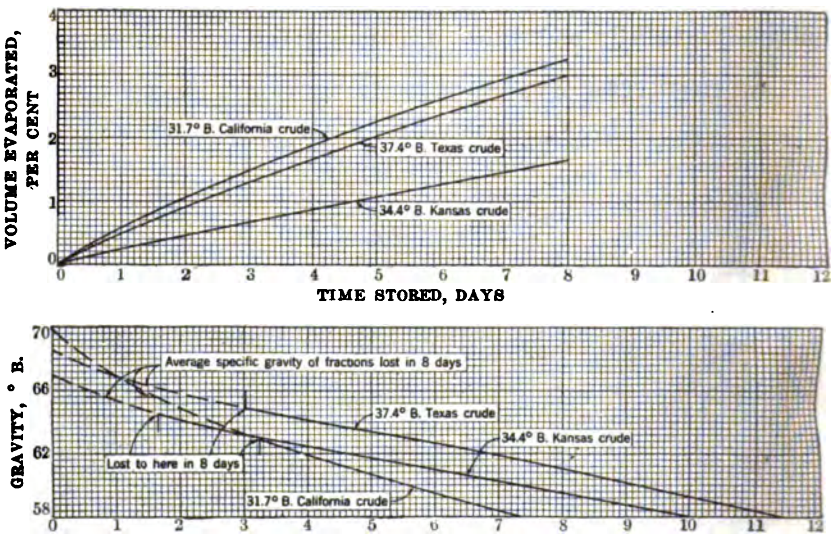

FIGURE 60.—Comparison of the rates of evaporation of El Dorado, Kans., Ranger, Tex., and Coalinga, Calif., crudes with distillation curves of each. Dashed parts of the latter show the respective portions lost in eight days.

evaporated from each crude during the period of observation was practically the same. With these points of similarity, the purpose was to determine the difference in their rates of evaporation under identical evaporative conditions.

How nearly identical were the distillation curves will be seen by observing those in figure 60.

The dashed part of the distillation curves shows the gravity of the portion of each oil evaporating during the period of eight days, and is the only part to be considered for these tests. Note that the gravity of the fraction evaporating from the California crude ranges from 69.9 to 62.9° B., and the evaporation curve for this oil indicates that its rate does not vary greatly between these gravities. The same conclusions may be drawn regarding the Texas and Kansas oils.

Compare first the Kansas and the California oils. The average gravity of the fraction lost by each during the eight days was 65.6° B. This fact and the fact that even between the gravity limits shown each crude has a nearly constant rate of evaporation, indicate that as far as concerns the rate of evaporation (from the natural crude) it is as if fractions of identical gravity have been compared. (Theoretically, this assumption is not absolutely true, but for practical purposes it is sufficiently close.) In eight days the California oil lost 3.25 per cent of its original volume and the Kansas oil lost 1.67 per cent. The conclusion is, then, that fractions from California crude evaporated 1.95 times as fast as fractions of the same gravity from Kansas crude. Similar observations taken within much narrower limits, or to the differentials, show approximately the same relation. It is reasonable to conclude, therefore, that the gravity of gasolines evaporating from crudes is not, by itself, a sure basis for comparing the evaporation loss from the crudes. This conclusion increases the complexity of the evaporation problem.

The crudes under consideration are as follows: Kansas crude of 34.4° B., from the El Dorado pool; Texas crude of 37.4° B., from the pools near Ranger; and California crude of 31.7° B., from the fields near Coalinga.

Compare the Texas and the Kansas crudes. The Texas crudes evaporated 1.8 times as fast as the Kansas crudes when fractions of practically the same average gravity (66.4 and 65.6° B.) were evaporating.

Compare the Texas and California crudes. They lose at about the same rate when fractions of practically the same gravity are evaporating, the California crude having a slightly faster rate.

The heaviest oil (California crude of 31.7° B.) evaporated faster than either the 37.4° B. Texas or the 34.4° B. Kansas crude, and the Texas crude of 37.4° B. evaporated much more rapidly than the Kansas crude of 34.4° B. Here again is proof that the gravity alone of an oil is not a criterion for estimating the rate of evaporation.

COMPARISON OF MID-CONTINENT OILS BY DISTILLATIONS.

Distillation tests afford a good basis for estimating the probable evaporation loss of two or more oils under like conditions. Figure 61 gives this information for Kansas, Oklahoma, and Texas oils.

When comparing these crudes, assume that evaporation starts with the 76° B. constituent and that the portions of the curve above that point are eliminated. If the rates of evaporation of all four oils between 76 and 72° B. are all nearly the same, this rate will hold fc the Kansas 34.1° B. oil while 0.6 per cent of its original volume evapc rates. This result is attained by subtracting the per cents at whic the "gravity" curve of this oil cuts the ordinates 72 and 76° B or 0.7 to 0.1=0.6 per cent. Similarly, 36 and 36.8° B. Kansas oils wil have this rate of evaporation for 1 per cent and 1.4 per cent of thei volumes, respectively. Texas and Garber oils will have this rat for 0.6 per cent and 2.3 per cent of their volumes, respectively. This figure, 2.3 per cent, shows why Garber oil will lose more than the others, because while it evaporates only at the rate of the others

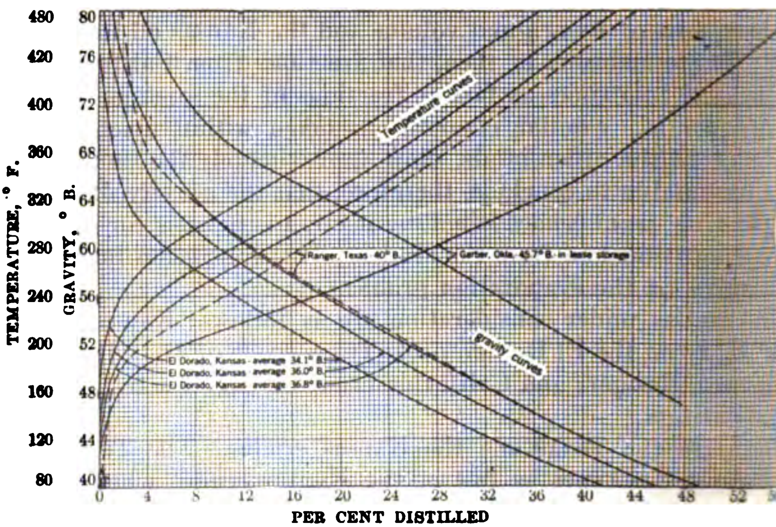

FIGURE 61.—Comparison of crude oils from El Dorado, Kans., Garber, Okla., and Range Tex., by distillations.

this rate of evaporation continues longer and results in the loss of a larger percentage.

PROPORTION OF GAS DISSOLVED IN OIL.

Two experiments were made to determine what proportion of the evaporation might be attributable to gas dissolved in the oil.

Any vapors that did not condense in the regular distillation apparatus were passed through absorption oil, and the portion not absorbed, "permanent" gas, was measured. The results are shown in Table 29. One sample represented the average oil of the Mid-Continent, having a gravity of 35.7° B.; the other was direct from a well in the Garber field, with a gravity of 48.2° B. It is a striking fact that the latter had less dissolved gas than the former. Evidently the enormous losses from evaporation are not "wild" gas but largely a recoverable product.

TABLE 29.—*Results of tests to determine the amount of gas in oil that is nonrecoverable by ordinary condensation.*

	Oil of 35.7° B.[a], El-Dorado, Kans.		Oil of 48.2° B. (unusually light) Garber, Okla.	
	Mineral seal.[b]	Gravity.	Mineral seal.[c]	Gravity.
	c. c.	*°B.*	*c. c.*	*°B.*
Before	200	36.9	200	36.8
After	203	36.9	[d]205	36.9

[a] About the average gravity of the samples tested.
[b] Gas not absorbed by mineral seal oil at atmospheric pressure=0.04 cu. ft.=3.4 c. c. liquid=0.23 per cent of sample distilled.
[c] Gas not absorbed by mineral seal oil at atmospheric pressure=0.02 cu. ft.=1.7 c. c. liquid=0.11 per cent of sample distilled. The gas not absorbed is regarded as permanent gas.
[d] The increase in volume of the mineral seal oil represents products that were not condensed but could be recovered by the absorption medium.

GENERAL CONCLUSIONS.

The principal conclusions drawn from the facts presented in this bulletin are as follows:

1. Evaporation during storage and handling causes one of the largest losses of crude petroleum between the well and the refinery. (See p. 86.)

2. From two-thirds to four-fifths of the evaporation loss may be eliminated by protecting oil from free contact with air. This protection will pay for itself in a short time.

3. The percentage of the original value lost by evaporation is two or three times the percentage of the original volume lost, because the fraction that escapes from the crude oil is the best gasoline and its value per unit of volume is two or three times that of the crude.

4. The maximum prevention of evaporation involves keeping the mixture of air and vapor above the oil at rest and as near a constant temperature, whether high or low, as possible. For example, if the mixture of air and vapor above the oil does not move very little more evaporation will take place at 115° F. than at 32° F., because the mixture will soon become saturated and then evaporation will cease. (See p. 91.)

5. The major part of evaporation loss, when the most valuable products escape, takes place on the lease when the oil is still fresh.

6. Oil is liable to evaporation loss, even after it leaves the lease.

7. Dehydration in open steaming tanks is the most flagrant example of the neglect of evaporation losses. Such plants should be made air-tight with valves for regulating pressures. (See p. 40.)

8. Overshot connections should never be used for filling a tank.

9. Even in winter, when atmospheric temperatures are low, oil in exposed lease tanks will lose more than one-half what it would lose during similar storage in summer.

10. Oil at the surface of 55,000-barrel tanks, where evaporation takes place, is subjected during a part of the day to temperatures much higher than the average temperature of all the oil in the tank. In summer these surface temperatures rise above 100° F. Evidently in such storage the loss by evaporation must be large. (See p. 76.)

11. For one who handles crude, evaporation is almost as insistent a problem as it is for the refiner who handles the gasoline obtained from this crude, because gasoline in the natural crude will evaporate approximately one-half as rapidly as it will after being distilled and stored as pure gasoline. (See p. 98.)

12. Light crude oil from the Ranger, Tex., fields evaporates about as rapidly as pure gasoline derived from El Dorado, Kans., crude, provided the gravity of the fraction evaporating is the same. This means that the evaporation problem of the producer or the operator of a pipe line handling the Texas crude is as important as that of the refiner handling the Kansas gasolines. (See p. 101.)

13. The evaporation problem of those who handle Ranger, Tex., or Coalinga, Calif., light crude, is twice as insistent as the problem of those who handle El Dorado, Kans., crudes.

14. The more volatile the gasoline contained in a crude, the more nearly will the rate of evaporation of the crude approach the rate of evaporation of the gasoline (stored in the pure state) distilled from the crude (see p. 99), evaporating conditions in both cases being the same.

15. The increasing demand for crude oil and gasoline is making this problem more and more insistent. In future it may be considered as illegal to waste oil brought to the surface, as it is now considered illegal to waste it underground.

16. So many conditions vary the rate of evaporation that to cover them all would require an almost unlimited amount of work. Each operator of a lease or pipe line should attack and solve his own problem.

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A limited supply of the following publications of the Bureau of Mines has been printed and is available for free distribution until the edition is exhausted. Requests for all publications can not be granted, and to insure equitable distribution applicants are requested to limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines.

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PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

BULLETIN 170. Extinguishing and preventing oil and gas fires, by C. P. Bowie. 1918. 44 pp., 19 pls., 4 figs.

BULLETIN 175. Experiment stations of the Bureau of Mines, by Van. H. Manning. 1919. 160 pp., 29 pls., 2 figs.

BULLETIN 201. Prospecting and testing oil, gas, and water-bearing strata, by R. E. Collom. 1922. In press.

BULLETIN 216. Bibliography of petroleum and allied substances, 1919–20, by E. H. Burroughs. In press.

TECHNICAL PAPER 38. Wastes in the production and utilization of natural gas, and methods for their prevention, by Ralph Arnold and F. G. Clapp. 1913. 29 pp.

TECHNICAL PAPER 42. The prevention of waste of oil and gas from flowing wells in California, with a discussion of special methods used by J. A. Pollard, by Ralph Arnold and V. R. Garfias. 1913. 15 pp., 2 pls., 4 figs.

TECHNICAL PAPER 45. Waste of oil and gas in the Mid-Continent fields, by R. S. Blatchley. 1914. 54 pp., 2 pls., 15 figs.

TECHNICAL PAPER 66. Mud-laden fluid applied to well drilling, by J. A. Pollard and A. G. Heggem. 1914. 21 pp., 12 figs.

TECHNICAL PAPER 68. Drilling wells in Oklahoma by the mud-laden fluid method, by A. G. Heggem and J. A. Pollard. 1914. 27 pp., 5 figs.

TECHNICAL PAPER 209. Traps for saving gas at oil wells, by W. R. Hamilton. 1919. 34 pp., 3 pls., 16 figs.

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TECHNICAL PAPER 247. Perforated casing and screen pipe in oil wells, by E. W. Wagy. 1920. 48 pp., 6 pls., 12 figs.

TECHNICAL PAPER 261. Oil camp sanitation, by C. P. Bowie. 1921. 31 pp., 3 pls., 4 figs.

PUBLICATIONS THAT MAY BE OBTAINED ONLY THROUGH THE SUPERINTENDENT OF DOCUMENTS.

BULLETIN 134. The use of mud-laden fluid in oil and gas wells, by J. O. Lewis and W. F. McMurray. 1916. 86 pp., 3 pls., 18 figs. 15 cents.

BULLETIN 148. Methods of increasing the recovery of oil from wells, by J. O. Lewis. 1917. 128 pp., 4 pls., 32 figs. 15 cents.

BULLETIN 155. Oil-storage tanks and reservoirs, with a brief discussion of losses of oil in storage and methods of prevention, by C. P. Bowie. 1917. 73 pp., 21 pls. 25 cents.

BULLETIN 158. Cost accounting for oil producers, by Clarence G. Smith. 1917. 123 pp. 15 cents.

BULLETIN 163. Methods of shutting off water in oil and gas wells, by F. B. Tough. 1918. 122 pp., 20 pls., 7 figs. 30 cents.

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