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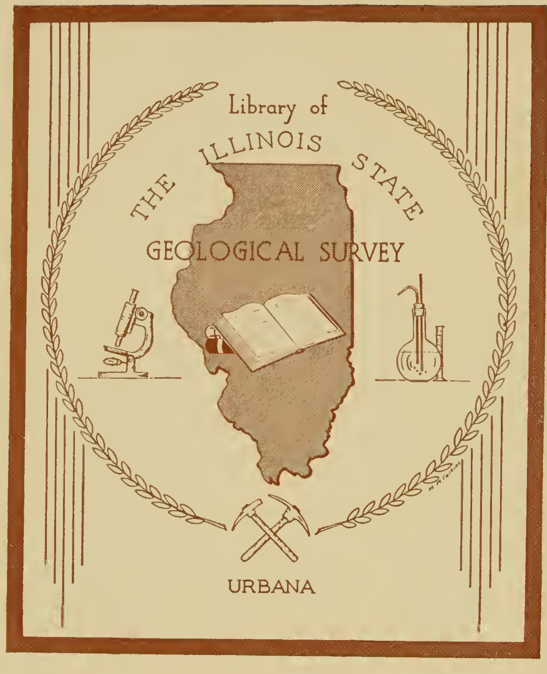
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BULLETIN NO. 71

USE OF ILLINOIS COAL
FOR PRODUCTION OF
METALLURGICAL COKE

BY

F. H. Reed, H. W. Jackman, O. W. Rees,
G. R. Yohe, and P. W. Henline

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Mechanical Engineering, SEICHI KONZO, M.S., *University of Illinois*

Topographic Mapping in Cooperation with the United States Geological Survey.

This report is a contribution of the Geochemistry Section.

Aug. 1, 1946

PERSONNEL

Below is given a complete list of all who were employed on the work of Project WPB-75 for all or part of the period July 1, 1943–June 30, 1945.

Supervisors

Frank H. Reed, *Chemist in Charge*
H. W. Jackman, *Chemical Engineer*
O. W. Rees, *Analytical Chemist*
G. R. Yohe, *Organic Chemist*
P. W. Henline, *Chemical Engineer*

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J. E. DeVries, *Research Assistant, Laboratory*
D. M. Fort, *Assistant Chemist, Laboratory*
J. H. Hanes, *Research Assistant, Pilot Plant Operation*
H. N. Hazelkorn, *Research Assistant, Laboratory*
H. S. Levine, *Research Assistant, Laboratory and Pilot Plant Operation*
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L. S. Miller, *Research Assistant, Pilot Plant Operation*
Elizabeth Mills, *Secretary*
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M. A. Rebenstorf, *Research Assistant, Laboratory*
W. G. Tilbury, *Assistant Chemist, Laboratory*
W. F. Wagner, *Assistant Chemist, Laboratory Supervisor*

Non-Technical Personnel

J. C. McCullough, *Research Associate*
W. J. Retzolk, *Laborer*

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USE OF ILLINOIS COAL FOR PRODUCTION OF METALLURGICAL COKE

BY

F. H. Reed, H. W. Jackman, O. W. Rees, G. R. Yohe, and P. W. Henline

INTRODUCTION

Purpose of Investigation

THIS PROJECT was planned, set up, and conducted for the purpose of saving transportation. Midwestern by-product coke ovens in the Chicago and St. Louis areas use annually from 12 to 15 million tons of bituminous coals which are transported 500 to 700 miles from the Appalachian coal fields of Pennsylvania, West Virginia, and eastern Kentucky. Approximately two-thirds of this coal is high-volatile bituminous.

The critical transportation problem confronting the nation in 1943, and the growing scarcity of the best Appalachian coking coals, prompted the Illinois Geological Survey to propose a research program in which would be studied the coking properties of blends of low-sulfur, high-volatile Illinois coal with the high- and low-volatile coals from the eastern fields. Such blends containing Illinois coal, if substituted for the all-eastern blends normally coked, would result in important transportation savings.

War Production Board Contract with Illinois State Geological Survey

To investigate this problem of producing metallurgical coke from Illinois coals, the Illinois State Geological Survey, through the University of Illinois, entered into a contract with the Office of Production, Research and Development of the War Production Board on July 1, 1943, for a six-month period. This contract was renewed January 1, 1944, July 1, 1944, and January 1, 1945. The contract terminated on June 30, 1945. Since this date, the project has been continued by the Illinois State Geological Survey under the sponsorship of the State of Illinois.

Acknowledgments

This study was made possible through the cooperation of the Office of Production, Research and Development of the War Production Board, Washington, D. C. Valuable counsel was received from A. C. Fieldner, U. S. Bureau of Mines, in the initiation of this project. M. D. Curran, Coal Carbonizing Company, furnished fabricated steel for oven construction and for coke and by-product testing. Walsh Refractories Corporation furnished firebrick, bonding mortar, and refractory insulating brick. Without the extensive cooperation of Koppers Company, Inc., and Inland Steel Company, it would have been impossible to compare the results of experimental work with those of commercial operation.

The Coal Division of the Illinois State Geological Survey has given valuable advice on the location of Illinois coals to be used in this study. The following companies have been generous and cooperative in furnishing samples of coal: Bell and Zoller Coal Mining Co., Walter Bledsoe and Co., Chicago, Wilmington and Franklin Coal Co., Consolidated Coal Co., Franklin County Coal Corp., Inland Steel Co., Koppers Co., Inc., Old Ben Coal Corp., Peabody Coal Co., Pocahontas Fuel Co., Sahara Coal Co., W. G. Sutton Co., Troy Domestic Mining Co.

To all of these organizations and individuals we express our sincere appreciation.

SUMMARY

Summary and Conclusions

As a result of the tests made with Illinois coals which, on the basis of chemical composition and immediate availability in quantity, are the most promising for metallurgical coke production, the following conclusions may be drawn.

1) Illinois No. 6 seam coal from the Franklin County low-sulfur area can be used continuously in blends with eastern coals in modern slot-type coke ovens for the production of coke which is practical for use in commercial blast furnaces. The extent to which Illinois coal can be used to replace eastern high-volatile coal for this purpose is dependent primarily upon the economics of each individual application. Experimental pilot plant tests and commercial full-scale operation have shown that up to 75 percent of this coal may be used satisfactorily.

2) Such use of Illinois coal in metallurgical coke plants of the Chicago and St. Louis areas does result in sizeable transportation savings.

3) Cokes of satisfactory physical and chemical properties can be made from blends containing up to 75 percent or more of Illinois No. 5 seam coal from the limited low-sulphur area in Saline County.

4) Cokes with equally good physical properties can be made using other No. 5 seam coals of medium sulfur content from Saline and Williamson counties. These coals and others similar to them are worthy of consideration as small percentage constituents of coal blends.

5) Illinois coal fines should not be used for coking. Fusain tends to concentrate in the fines, and the tendency to weather is increased by the large surface area. No lower limit on screen size, as prepared at the mine, has been determined, but in actual applications no size smaller than ⅜ inch has been recommended or used for coking.

6) Sized and cleaned Illinois coal can be safely stocked without hazard of spontaneous combustion.

7) Consideration of all weathering test data obtained to date on Illinois No. 6 seam coals indicates that where prepared sizes of such coals are to be used as not over 25 percent of the total coal blend, storage of from three to six months is allowable. Likewise, where as much as 80 percent of this Illinois coal is to be blended with a fluid medium-volatile coal (such as that tested in this work), six months storage may have no detrimental effects on the physical properties of the coke.

8) Due to the extensive use of cleaning plants in the low-sulfur area, the coal shipped from this area is very uniform in preparation and composition, and coals from the mines of the various producing companies are interchangeable.

9) The bulk density of Illinois coal when charged to coke ovens is almost identical with that of eastern coals. However, due to the higher inherent moisture content of the Illinois coal, a correspondingly lower yield of coke is obtained.

10) In general, the low-sulfur Illinois coals tested in this program become less fluid during carbonization than do the higher ranking eastern high-volatile coking coals. Our tests have shown that the coke structure of an Illinois-Pocahontas coal blend may be improved by including a portion of a more fluid eastern high-volatile coal in the blend or by substituting certain medium-volatile coals for the low-volatile Pocahontas coal that is normally used in production of metallurgical coke.

These conclusions have been reached through laboratory investigations, pilot plant carbonization of experimental coal blends, and cooperation with commercial producers of metallurgical coke.

The Koppers Company, Inc., at its plant in Granite City, Illinois, has carbonized Illinois coal blends since April 1944, and as of the date of this report was coking a blend containing 65 percent of No. 6 seam Illinois coal mined within 80 miles of the plant. At the expiration of this contract, Koppers Company had carbonized 228,107 tons of Illinois coal which represented a transportation saving of 2,326,700 car miles, not including return of the empty cars to the mines.

The Inland Steel Company of East Chicago, Indiana, has cooperated actively and had made commercial coke oven and blast furnace tests on coal blends containing No. 6 seam Illinois coal. Other producers of blast furnace and foundry cokes in the Chicago and St. Louis areas have shown keen interest in the progress of this program. It seems quite probable that this interest will result in a continued increase in the use of Illinois coal for metallurgical coke.

HISTORICAL REVIEW

Early Tests on Illinois Coals in Metallurgical Coke Ovens

Although Illinois coal was not being used in the production of metallurgical coke at the initiation of this project, it was known that certain areas of this state produced coal of sufficiently low sulfur content and uniform chemical composition to be used for this purpose.

The use of Illinois coal in by-product coke plants is not without precedent. During the first world war, southern Illinois coal was used for production of blast furnace fuel in the Chicago area. The use of this coal was discontinued at the close of the war, due to the large reserves of the more strongly coking eastern coals then available.

In the spring of 1918, the Bureau of Standards supervised the coking of 4800 tons of midwestern coal, mostly from Franklin County, Illinois, in Roberts type ovens at Canal Dover, Ohio. Although the breeze was high (8.1 percent of the coke), and the ovens did not produce sufficient coke to operate the 500-ton blast furnace except by admixture of 30-50 percent of other coke, the furnace superintendent was of the opinion that he could operate satisfactorily and at full capacity with this coke alone.[1] (See References to Publications, p. 62.)

A detailed description of tests involving the use of 7600 tons of Orient coal (Illinois No. 6 seam, Franklin County) in Koppers ovens at the coke plant of the Minnesota By-Product Coke Company at St. Paul, Minnesota, has been published by the Bureau of Standards in cooperation with the Bureau of Mines.[2] Chemists of this company and of the Koppers Company commented favorably upon the coke from Illinois coal as a blast furnace fuel. It was reported to carry a normal basic burden well, to burn faster than the regular coke, and to increase the iron tonnage from the furnace, which operated with the regular coke at about 175-185 tons per day, to an average of 198 tons per day for the test period. Work was also done on the coking of blends of Illinois coal with eastern coals, and as a result of these tests and others by the Bureau of Mines, Fieldner and coworkers stated in regard to the Orient coal that "on blending with 25 percent of low-volatile coal, however, it makes an excellent metallurgical or domestic coke."[3]

Use of Illinois Coal in Roberts Ovens

Following these early tests, the Roberts coke oven plant at Granite City, Illinois,[4] produced coke of metallurgical quality from 1921 until 1935, using from 85 to 100 percent of southern Illinois coal. Illinois coals from Franklin and the surrounding counties were carbonized. The coke produced was used in blast furnaces at this plant. It was reported to be faster burning than eastern coke, to have good burden-bearing qualities, and to produce basic iron consistently with low coke consumption. Best results were obtained when blending from 10 to 15 percent Pocahontas with the Illinois coal.

Other Tests on Illinois Coals

In 1942, Illinois coal was tested in the Carnegie-Illinois Steel Corporation plant at Gary, Indiana. The results of these tests have not been published.

No attempt is made here to review all work done on coking of Illinois coals. Laboratory and small-scale carbonization of these coals by various processes has been done by Parr at the University of Illinois, Fieldner and others at the U. S. Bureau of Mines, Thiessen at the Illinois State Geological Survey, and others. Results of these tests have been cited by Thiessen.[5]

IMPENDING DEPLETION OF BEST EASTERN HIGH-VOLATILE COALS

In all of these tests with Illinois coal, it appears that satisfactory metallurgical coke has been made. The availability of quantities of high quality eastern coking coals has resulted, however, in a return to the use of eastern coal. Eastern coking coals in general are of higher rank than Illinois coals, and as such have a lower moisture content, and in many cases stronger coking properties.

The continued use of eastern coals, and especially their increased use in World War II, has seriously reduced the reserves of the better coking coals. Many of the remaining coals are higher in ash and sulfur. During the first ten months of 1942 in the Chicago district, the average analysis of by-product coke showed an increase in ash of 0.72 percent. The increase in the St. Louis-Western district was 0.68 percent. Both ash and sulfur continued to increase during the war years, and this tendency has been accelerated by the increased use of mechanical mining equipment.

With this growing scarcity of the better eastern coking coals, it is becoming more important to locate other sources of high-volatile coal to use in production of metallurgical coke in the midwestern area. The low-sulfur coals of Illinois offer one possible solution.

ILLINOIS HIGH-VOLATILE COALS

Illinois has larger reserves of high-volatile bituminous coal than any state east of the Rocky Mountains; only Colorado exceeds Illinois in reserves. Although Illinois coals can all be classed as coking, unfortunately, with the exception of certain areas, most of these coals are too high in sulfur to be used for metallurgical coke production at this time.

The principal low-sulfur coal area of Illinois centers in Franklin County and extends to portions of the surrounding counties. In this area, washed and sized No. 6 seam coal is obtained containing from 0.7 to 1.2 percent sulfur. Fifteen of the principal mines in this area have the capacity to produce more than 50,000 tons of coal per day.

In Saline County, southeast of Franklin County, there is a limited area of No. 5 seam coal containing 0.7 to 1.0 percent of sulfur in the washed sizes, and large deposits of coal containing 1.7 to 2.2 percent sulfur. This is the highest rank coal mined commercially in Illinois.

Other smaller areas of relatively low-sulfur coal are located in Vermilion, Woodford, and Madison counties.

The Franklin County low-sulfur coal area lies about 300 miles south and a little west of Chicago, and 80 to 100 miles southeast of St. Louis. Both Franklin and Saline counties are well provided with railroads, having several routes to each of these industrial districts. The proximity of this Illinois coal to the midwest coking plants favors its use because of the short rail haul and low freight rates.

APPROACH TO PROBLEM

The problem of investigating the coking properties of Illinois coal has both technical and economic aspects. It is necessary first to determine whether or not suitable coke can be produced, and next to develop the economics of the process. The comparison of costs of coking Appalachian coals alone or in combination with Illinois coals in any given plant can be determined only by commercial operation over an extended period. The suitability of the coke for blast furnace operation, the yield of coke from the coal, and the amount and value of the by-products are important factors which must be considered. Freight rates and cost and uniformity of coal must be considered also in determining the overall economic picture. However, experimentation with various blends of coal in commercial coke ovens is costly, and it interferes with regular production. Consequently, only a minimum of such experimentation is conducted.

The first step in the present program was, therefore, the design and construction of a small scale slot-type coke oven in which coal blends could be carbonized under conditions approximating those obtained in commercial ovens. The coke produced under these conditions should have physical and chemical properties directly comparable to those of coke produced commercially from the same coal blend.

An experimental oven of 500 pounds coal capacity was built. Its operation was standardized by coking coal blends that were being used at the time in commercial ovens, and comparing experimental results with those from average commercial operation. Blends containing Illinois coals were then carbonized in the experimental oven and their coking properties were determined. This experimental oven was connected with the by-product recovery train formerly used in our experimental work with the sole-flue oven.[6] Tar and gas were collected and evaluated.

Early pilot oven tests indicated that the Illinois coals tested had different plastic properties than the eastern high-volatile coking coals normally used in coke production. This necessitated special studies on the technique of blending Illinois coals with coals from other areas, and laboratory tests involving plastic studies of both Illinois and eastern coals were made. Data obtained have been applied successfully to coal blending procedure in our pilot oven studies.

Early in the experimental program, it became possible to cooperate with commercial producers of metallurgical coke who had an interest in using Illinois coal in their plants. Through these valuable connections, certain blends of Illinois coal, after preliminary pilot plant tests, have been carbonized in commercial ovens over extended periods of time, where their behavior in plant equipment, their yields of coke and by-products, and the economics of their extended commercial use were studied. These cooperative studies have played a valuable part in carrying out this project.

COAL SAMPLES

Samples of Illinois coals for pilot plant and laboratory tests were collected at the mines in the desired screen sizes under the supervision of a member of our staff. Special care was taken to collect these samples in increments over a sufficiently long period of time to cover the entire working area of the mine. The coal samples were brought in our truck directly to the laboratory and used within a few days in order to avoid possible oxidation in storage.

Eastern coals for blending with Illinois coals were obtained largely from the plants of the Koppers Company at Granite City, Illinois, and the Inland Steel Company of

East Chicago, Indiana. The coals were sampled from cars in such a way as to be representative, and were also brought to the laboratory by our truck.

LABORATORY TESTS AND ANALYSES

Coals collected in the above manner were prepared for analyses in the laboratory by approved methods. Analytical determinations were made on individual coals and on coal blends by standard A.S.T.M. methods for proximate analysis, sulfur, B.t.u.[7] and Free Swelling Index (F.S.I.).[8] An ultimate analysis[7] was also made on one sample of coal from most of the mines tested.

The cokes produced in the pilot oven were analyzed by standard A.S.T.M. methods for proximate analysis, sulfur, B.t.u. and ash fusion.[7] Physical tests were made, also by standard A.S.T.M. methods, for shatter test,[9] tumbler test,[10] apparent and true gravities, and porosity.[11] All these results are tabulated completely in tables 31 and 32.

Plasticity studies on coals, carbon and hydrogen determinations on cokes, and analyses of coal and coke ashes are presented in the section entitled "Special Tests."

Details of laboratory work on tar are presented under the section entitled "By-Products," and in tables 34 and 35 of Appendix A. Special methods of tar analyses are described in Appendix B.

PILOT PLANT COKE OVEN

The primary objective in design of the experimental slot-type coke oven[12] was to construct a unit which would duplicate essentially a small section of a commercial oven, and in which the process of coking would be controlled rigidly. Only in the width of the oven was an attempt made to duplicate any dimension of a commercial oven. The average width for most commercial ovens ranges from 13 to 21 inches. The actual width of the experimental oven is 14 inches. The oven was designed so that it could be operated to give the same heat penetration (average width of oven in inches divided by coking time in hours) and final coke temperature as obtained in commercial practice.

Figure 1 shows this oven being discharged and the coke being quenched. The uniform oven wall temperature up to the top of the charge and the slightly cooler space above for gas collection are apparent.

Design of Oven

Figure 2 is a diagrammatic sketch of the oven showing detailed cross-sectional views from front and side. As in all slot-type ovens, heat is applied from vertical flues on both sides of the oven chamber (fig. 2, 1). The inside of the chamber is designed to have approximately ¼ inch taper in width. Due to small irregularities in the shapes received, the oven as constructed averages 14 inches in width and has very nearly parallel walls. The coal space in the oven chamber is 36 inches in length, 35 inches in depth, and holds approximately 10 cubic feet of coal per charge.

The side walls (4) and floor (5) of the oven are made of silicon carbide tile, 2 inches thick. Each side wall consists of a single tile, and the floor is formed from two tiles laid end to end with an overlapping joint. The walls are anchored at the back of the oven and left free to expand vertically and horizontally. They are held in place at the top and bottom by the surrounding brickwork, and are further supported on each side by two rows of long firebrick (6) which touch the oven walls and are, in turn, strengthened by steel angles (7) running the full length of the outside walls of the oven. These supporting firebrick are spaced from front to back of the flues, leaving 4.5 inches between bricks, so that approximately 50 percent of the flue space is left open (fig. 3, section C-C). These flue openings are staggered in the two rows of supporting brick in each flue. This leaves the three sections of each flue closely interconnected and allows the heat to equalize from top to bottom of each oven wall. The oven chamber is surrounded on the sides and top by vermiculite insula-

FIG. 1.—Discharging and quenching coke from slot-type experimental oven.

tion (8). This insulation acts not only as a heat baffle but, being soft, as a cushion against thermal expansion or swelling pressures which otherwise might crack the silicon carbide walls.

The top of the oven chamber (9) is cast of refractory concrete. Coal is charged through a 6-inch pipe (10) extending through the casting, and a 6-inch blank flange (11) serves as a charge hole cover.

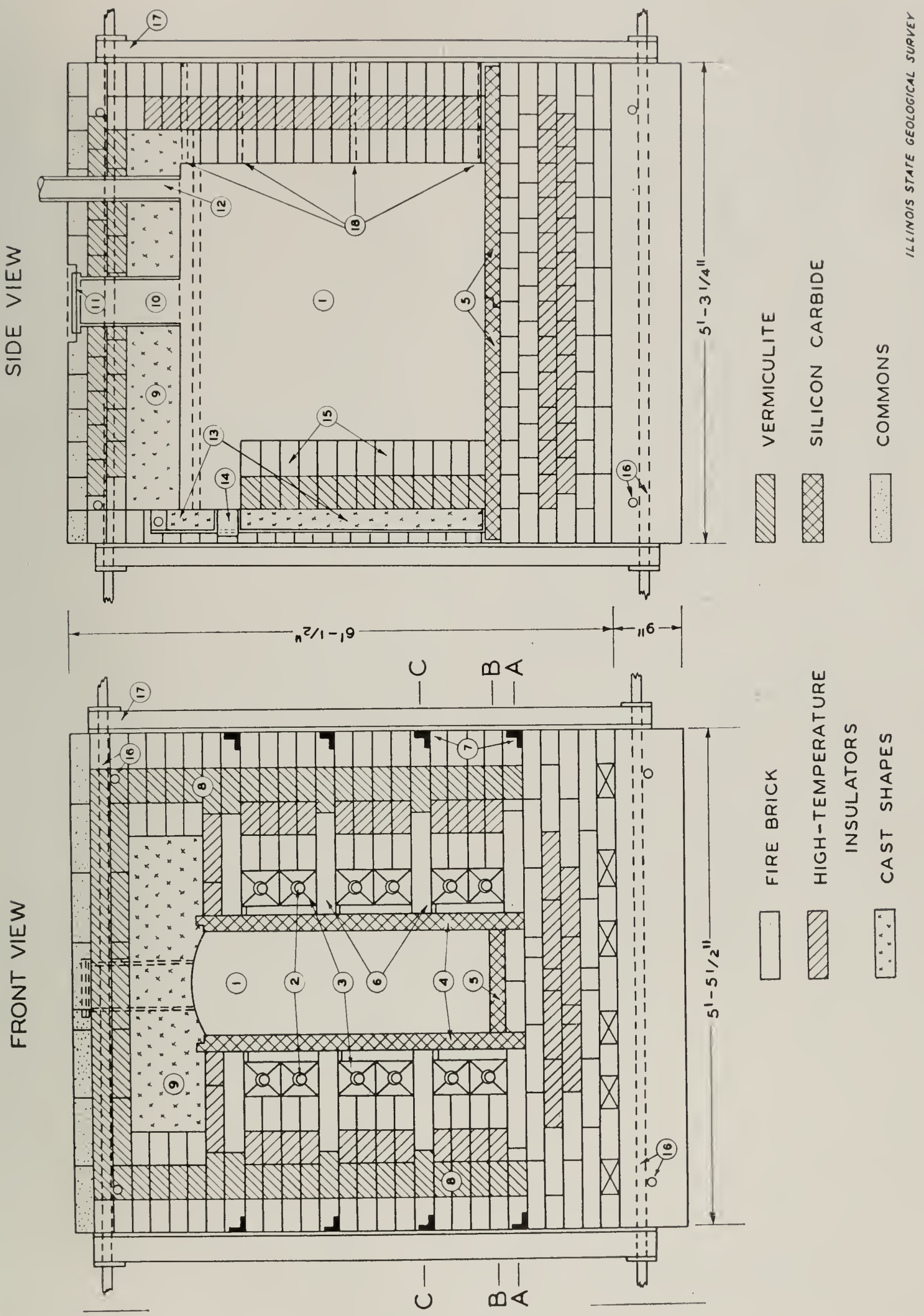

FIG. 2.—Sketch of slot-type experimental coke oven.

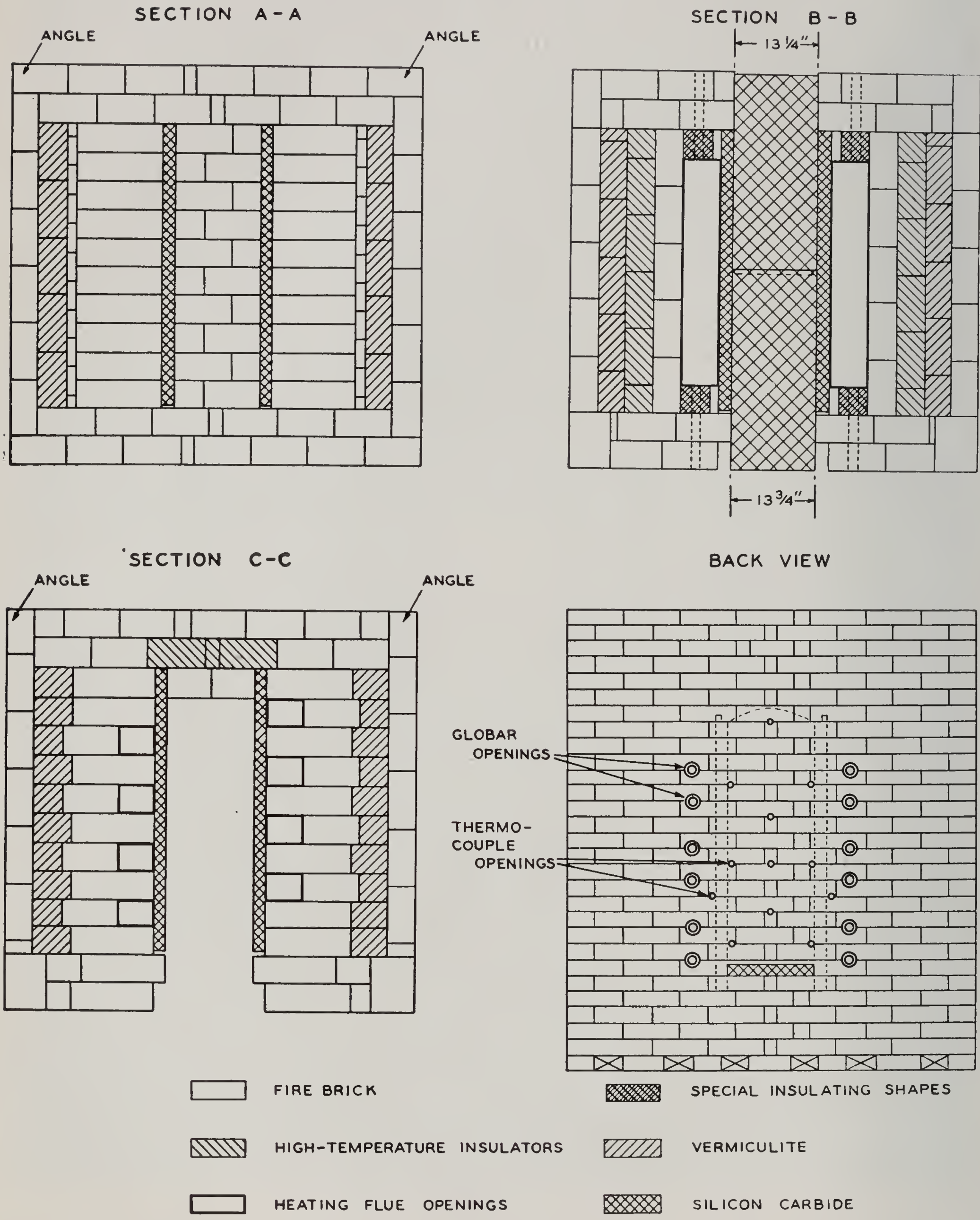

FIG. 3.—Details of slot-type oven construction.

Gas escapes from the oven through a 3-inch pipe (12) extending through the top and connected to the by-product recovery equipment. The back of the oven chamber consists of permanent brickwork, whereas the front is covered by a refractory concrete door (13) which is raised or lowered by a chain hoist and is mudded into place before the oven is charged. After charging, the coal is leveled through a rectangular opening (14) in the door located 35 inches above the chamber floor. This level bar opening is then bricked and mudded. Between the door and the coal charge a temporary brick wall (15) (9 inches in depth) extends from the floor to the coal level. This wall, which consists of one layer of firebrick next to the charge and one layer of insulating brick next to the door, is removed before a coke charge is pulled, and is replaced immediately after the oven is discharged. The oven structure is held together by tie rods (16) extending through the top brickwork and foundation. These rods are anchored to heavy buckstays (17) at each corner of the oven.

Figure 3 gives more details of the oven brickwork construction. Horizontal sections A-A, B-B, and C-C, which refer to figure 2, show the brick arrangement just below floor level, at the oven floor, and at a plane between the lower and middle flue sections. The back view shows the arrangement of the openings for heating units and thermocouples into the heating flues and the oven chamber. Thermocouples are never placed in all of the holes shown during any one run, but the holes are built into the oven to be available when and if desired.

Temperature Control

Accurate control of the temperature and heating rate of the coal is maintained by regulation of the Globar heating units which are powered from a three-phase 230-volt 60-cycle source through a 50 kv.-amp. tap transformer as shown in the wiring diagram of figure 5. Six AT type Globar brand nonmetalic heating elements (2, fig. 2), 67 inches long and having a middle heating section 36 inches in length and 1.25 inches in diameter, designed to carry a capacity load of 100 amperes at 136 volts, are placed horizontally in each flue and spaced as shown so that heat may be applied uniformly from top to bottom of the oven walls. The two Globars in each top flue section are connected in series, and the two units thus formed are connected in parallel across one secondary of the transformer. Globars in the center and bottom flue sections are connected in a similar manner across the other two secondaries. In this way there are formed three independently variable single-phase circuits. Temperatures in the two vertical flues are controlled separately by two Wheelco Capacitrols connected to thermocouples in the center flue sections adjacent to the oven walls. These units actuate the secondary circuits from the transformer (see fig. 5). The even heating of the walls that is hereby obtained, together with the high heat conductivity of the silicon carbide tile, results in a very uniform application of heat to the oven charge; these factors are believed to be responsible for the uniformity of the coke produced.

Temperatures inside the oven are recorded by a four-point recorder actuated by thermocouples inserted through the back of the oven chamber (fig. 2, 18). Three thermocouples are located just inside the silicon carbide wall near the top, center, and bottom of the coal charge, and extending horizontally to the center of the oven. A fourth is placed in the exact center of the coal charge, and a fifth, located in the gas space above the coal, is made to record by manipulation of a double-throw switch. A

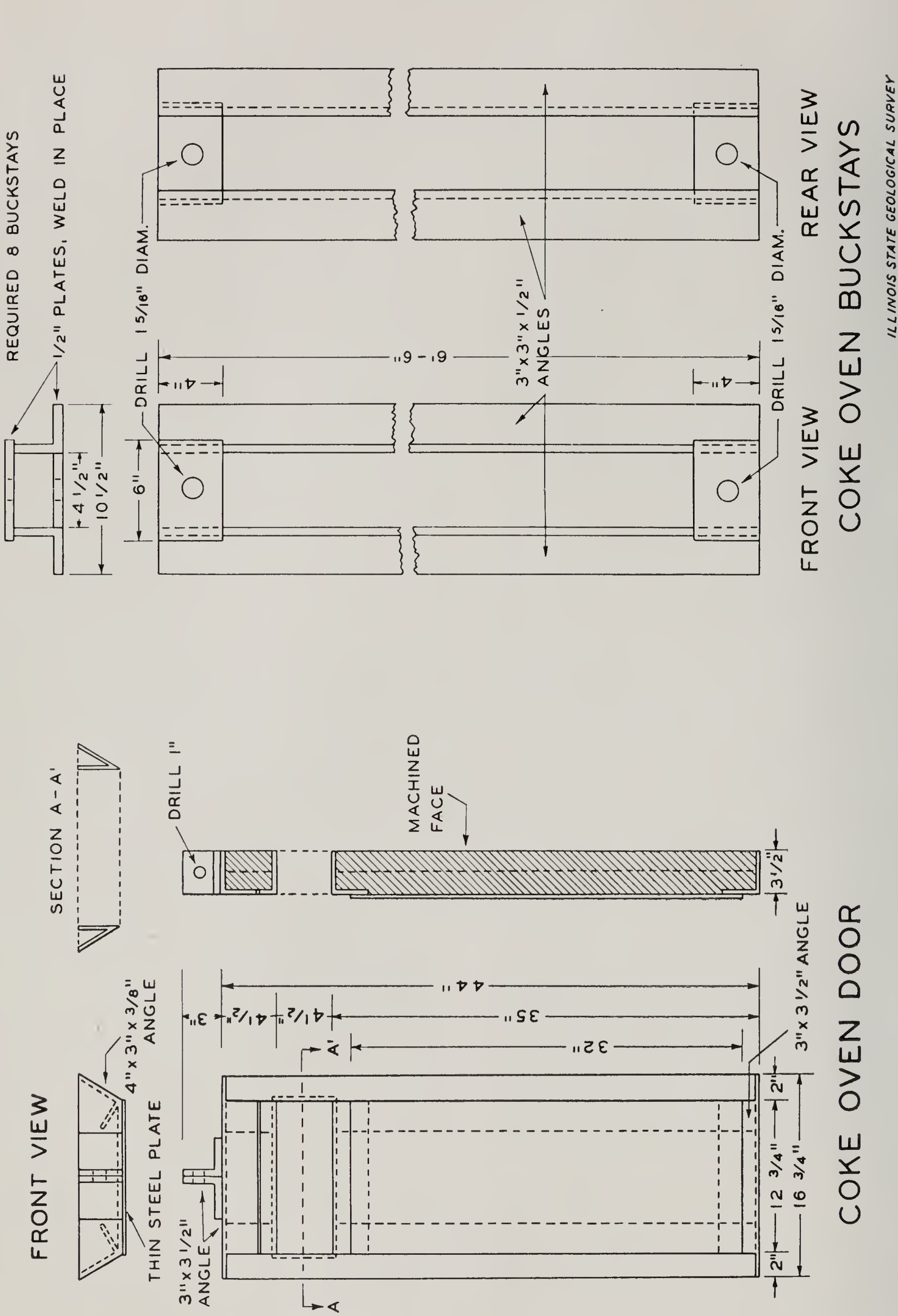

Fig. 4.—Door and buckstays for slot-type oven.

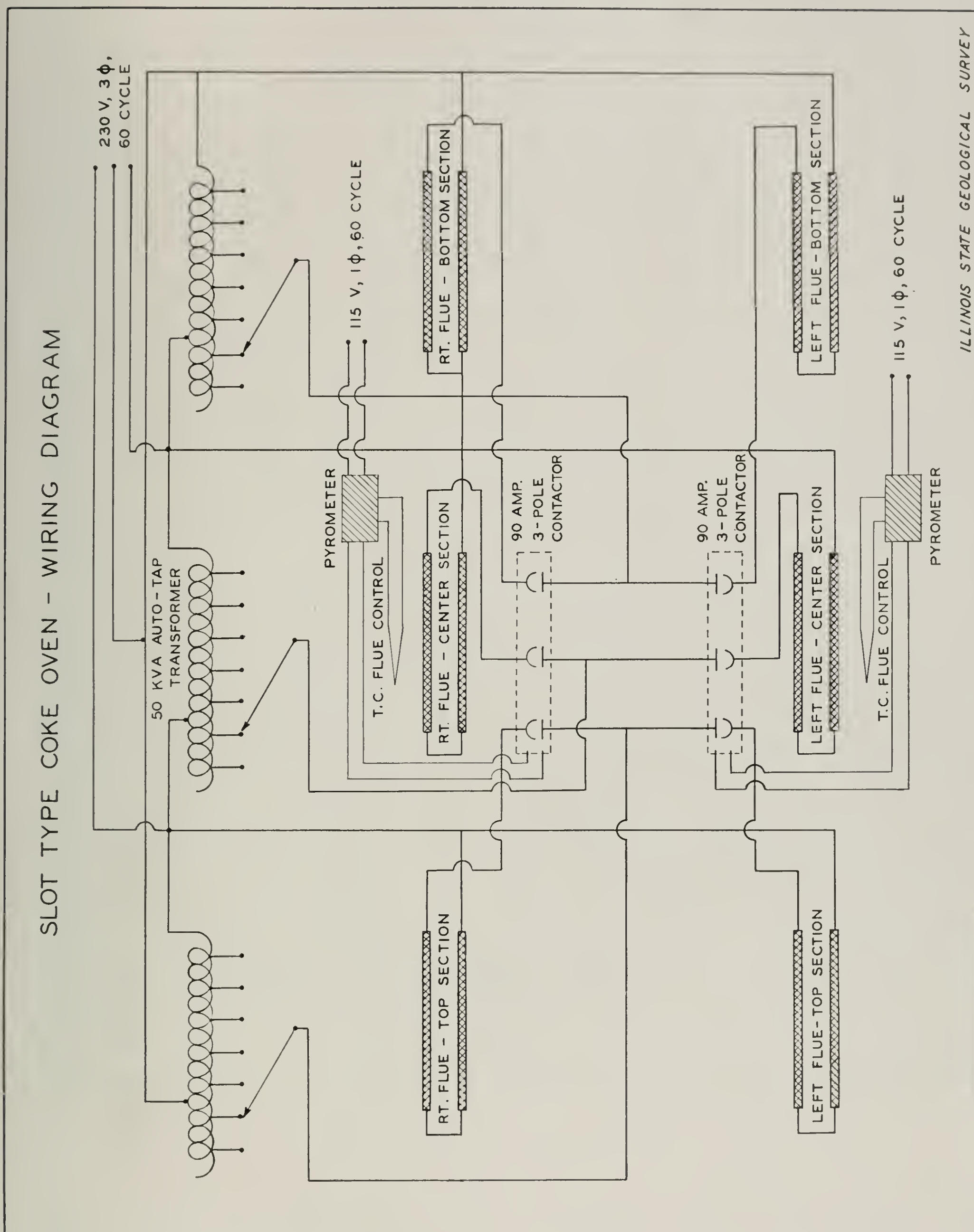

Fig. 5.—Slot-type coke oven, wiring diagram.

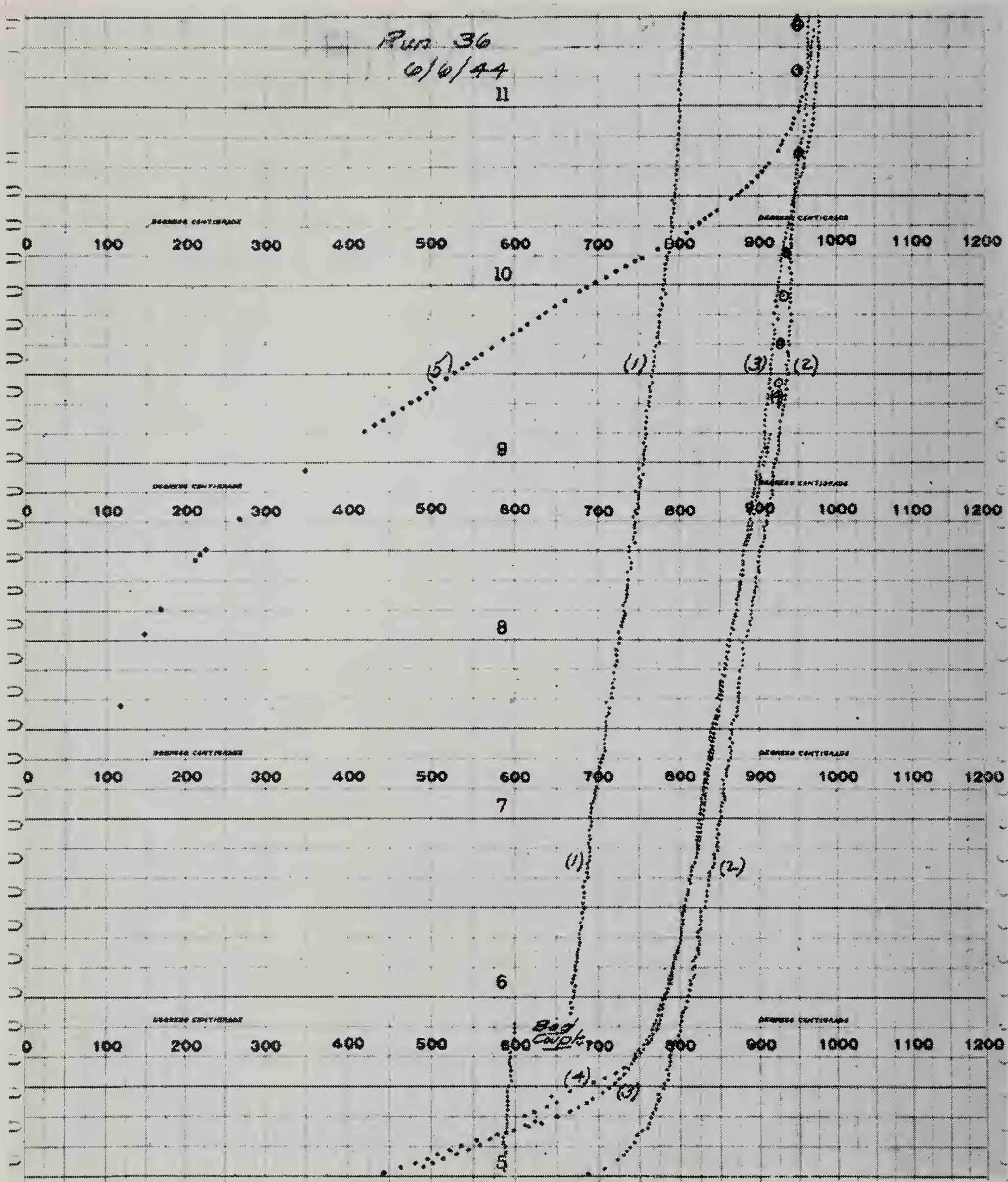

FIG. 6.—Time-temperature recording chart.

typical time-temperature chart is shown in figure 6. Curve (1) was recorded by the thermocouple just below the gas riser in the gas space; curves (2), (3), and (4) represent respectively the temperatures at the top, middle, and bottom of the charge next to the side wall, and curve (5) indicates the temperature at the exact center of the coal charge. It is seen that the coke next to the oven wall increases in temperature uniformly throughout the coking period, and that the center of the charge remains constant at about 100° C. for the first six hours, then increases rapidly and finally reaches the temperature of the coke at the side wall.

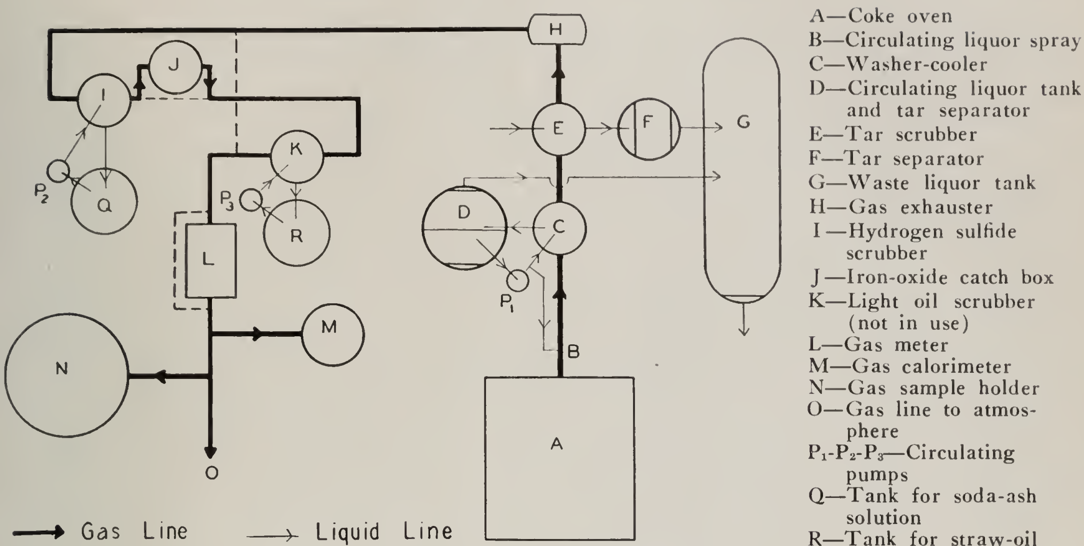

FIG. 7.—Flow diagram of coke oven and by-product recovery system.

By-Product Recovery

Equipment has been provided for the recovery of tar from the gas that is evolved during experimental coking runs. The gas is purified of hydrogen sulfide and metered. A representative gas sample is collected and the heating value determined. A flow diagram of the by-product recovery system is shown in figure 7.

Operation of Oven

In operating this experimental coke oven, the flue temperatures are controlled to give the same average heat penetration through the coal charge and the same final coke temperature as attained by commercial oven batteries. As the silicon carbide walls of the experimental oven have a higher thermal conductivity than the silica brick walls of large-scale ovens, it is possible to obtain approximately the same average heat penetration rate at much lower flue temperatures in the experimental oven than are required in commercial ovens. Results that duplicate closely those of commercial practice have been obtained by charging the oven at an initial flue temperature of 1600° F. and raising this temperature 30° per hour to a maximum of 1850° F. The coking time under these conditions is found to be 12.75 to 14 hours, or the average penetration is 1.10 to 1.0 inches per hour, depending upon such factors as bulk density, moisture content, and plastic characteristics of the coal. The final average coke temperature is 1770-1800° F.

Coking is usually continued until the temperature of the coke at the center of the oven has remained constant for 1½ to 2 hours, depending on the volatile matter desired in the coke. The original method, used with many of the experimental runs, was to discontinue coking when gas evolution dropped to a rate of fifty cubic feet per hour, but this method was found to give less consistent results. At the end of the run the oven is opened and the coke is pulled by hand and quenched with water. Yields of tar, gas, and coke are computed on the basis of the coal as charged to the oven.

Coking Results on Duplicate Samples

To check the operation of the oven and to determine how closely coking results can be reproduced, duplicate runs on two coal

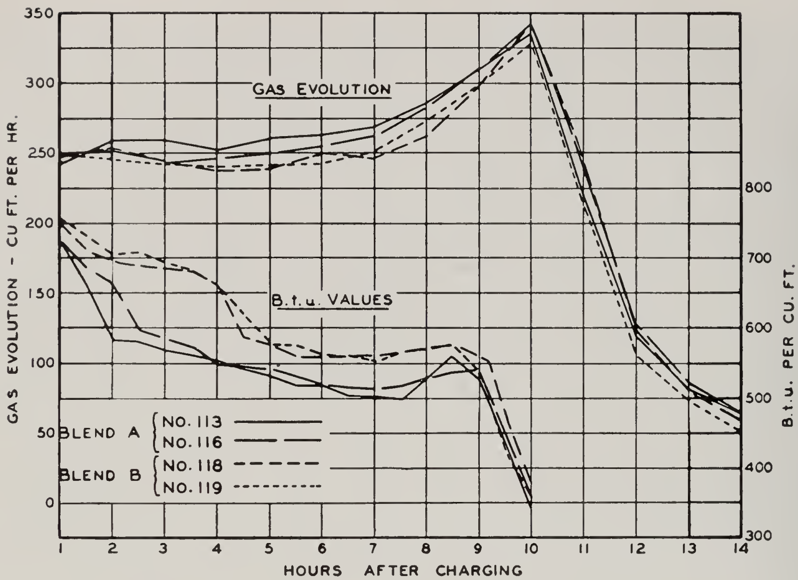

FIG. 8.—Gas evolution and B.t.u. value.

blends are shown in table 1. Note that coke yields check to within one-half percent. Of the physical tests, the closest checks are obtained on "Tumbler Stability," which is a test used extensively in the industry to evaluate coke quality. Satisfactory checks are also obtained on shatter test, coke sizing, and apparent gravity.

In figure 8 the data on gas evolution per hour and B.t.u. value are plotted from experimental data taken during these duplicate runs. B.t.u. values are not shown for the gas beyond the tenth hour. Gas evolved during the balance of the coking period is very high in hydrogen, and the calorimeter is not adjusted to read accurately in this low range. These curves are typical of the results obtained under normal operating conditions.

Because of the close control of operation possible with the experimental oven, which can not be realized in a gas-heated commercial size oven, the results on the experimental oven have been shown to be more dependable and more easily duplicated than those obtained from individual ovens of a commercial battery.

Comparison of Experimental and Commercial Results

A number of checks have been made between experimental oven runs and commercial plant operation on the same coal blends. Four series of comparisons are shown in our previously published paper.[12] It has been found that pilot oven results, which are obtained under uniform operating conditions on coals blended accurately by hand, do not necessarily check the results of individual commercial ovens, but do check average plant results over an extended period of time. Table 2 shows such a comparison between the average results of a 57-day test on a commercial oven battery and one experimental run made with the same coal blend in the pilot oven. The total coke yields are shown to be identical. However, as the commercial oven coke has rougher handling than the experimental coke, it undergoes more breakage, and the amount of furnace size coke is somewhat less and the fines are somewhat greater than are obtained from the pilot oven. Here again the "Tumbler Stability" checks very closely,

Table 1.—Duplicate Runs on Pilot Oven

	Blend A		Blend B	
	No. 113	No. 116	No. 118	No. 119
Coke analysis, %				
Volatile matter	1.2	1.1	1.7	1.6
Fixed carbon	90.9	91.3	92.1	92.1
Ash	7.9	7.6	6.2	6.3
Sulfur	0.83	0.73	0.68	0.76
Coke yields, % of dry coal				
Total	71.7	72.2	73.3	72.8
Furnace (+1 in.)	68.7	68.7	69.9	69.4
Nut (1 x ½ in.)	0.9	1.0	1.0	1.2
Breeze (−½ in.)	2.1	2.5	2.4	2.2
Coke screen test, % of coke				
Total +4 in.	4.1	1.8	2.8	2.8
Total +3 in.	31.6	29.2	29.7	25.2
Total +2 in.	79.3	78.2	77.1	75.4
Total +1 in.	95.8	95.2	95.4	95.3
Av. size, in.	2.61	2.54	2.55	2.48
Tumbler test				
Stability (+1 in.)	55.9	55.4	55.0	55.3
Hardness (+¼ in.)	69.2	68.9	67.9	69.6
Shatter test				
% of +2 in.	64.0	68.2	65.3	64.8
% of +1½ in.	88.8	87.8	88.9	87.0
Apparent gravity	0.824	0.825	0.842	0.838
Gas				
Cu. ft./lb. dry coal	6.50	6.42	6.14	6.15
B.t.u.	486	496	545	541
B.t.u. in gas/lb. coal	3159	3184	3346	3327

and satisfactory checks are obtained on other physical tests. It is noted on all experimental runs that the apparent gravity of the coke made in the pilot oven is about 0.045 less than that made in commercial ovens. This figure can be used as a correction constant.

COOPERATION WITH KOPPERS COMPANY, INC.

At the time the pilot oven was being built in our laboratory, it was learned that Koppers Company, Inc., was considering the use of Illinois high-volatile coal for the production of blast furnace coke at its plant in Granite City, Illinois. The Granite City plant consists of one battery of 49 Koppers Underjet type coke ovens of 17-inch average width and 17 tons coal capacity, by-product recovery equipment for tar, light oils, ammonium sulfate and gas, and two blast furnaces, one of 17 feet 9 inches hearth diameter and 86 feet overall height, and the other of 19 feet 6 inches hearth diameter and 92 feet overall height.

The coke oven battery at the Koppers Company plant, which was built by the Defense Plant Corporation, had been operating since it was started in March, 1943, on an all-eastern coal blend of 70 percent high-volatile Hernshaw seam coal and 30 percent low-volatile Pocahontas No. 3 seam coal. A very satisfactory coke was made and used as blast furnace fuel. However, as there is a freight differential of $2.12 per ton between West Virginia and Illinois coals delivered to the Koppers plant, a research program involving the use of

Table 2.—Comparison between Coking Results in Commercial Ovens and Pilot Oven on Same Coal Blend

	Commercial Ovens 57 days average	Pilot Oven Run No. 102
Coke analysis %		
Volatile matter	1.5	1.0
Fixed carbon	87.4	87.8
Ash	11.1	11.2
Sulfur	0.77	0.69
Coke yields, % of coal		
Total	65.0	65.0
Furnace (+1 in.)	58.1	62.2
Nut (1 x ½ in.)	3.4	0.7
Breeze (−½ in.)	3.5	2.1
Coke screen test, % of Coke		
Total +4 in.	8.4	6.4
Total +3 in.	35.8	48.4
Total +2 in.	78.3	87.2
Tumbler test		
Stability (+1 in.)	49.3	49.0
Hardness (+¼ in.)	67.9	66.8
Shatter test		
% of +2 in.	66.0	63.6
% of +1½ in.	94.9	96.4
Apparent gravity	0.848	0.802

Illinois coal was justified. Realizing that this was an opportunity for mutual assistance, the Illinois State Geological Survey and the Koppers Company have cooperated in this program.

Pilot Plant Oven and Laboratory Cooperation

Our cooperation with Koppers Company was started immediately after completing construction of the pilot oven. The operation of this oven was standardized by first coking the all-eastern coal blend being used at the Koppers Company plant, and comparing experimental with commercial results. Proper control of flue temperatures was obtained on the second experimental run, and coking results checked plant operation closely. The operating procedure developed in these tests has been continued with only minor changes.

Following the test runs on all-eastern coal, coking tests were made on blends of Illinois No. 6 seam coal and Pocahontas coal. In the first Illinois coal studies, the percentages of high- and low-volatile coals were varied, and Illinois coals from different mines were tested. Petroleum coke was tried as a substitute for low-volatile coal. The coking temperature was also varied and the effect on the coke structure was noted.

The first plant test in the Koppers ovens on an Illinois coal blend was made after twenty-one experimental runs had been made in the pilot oven. It was noted that physical properties of the coke made in the full-scale ovens again duplicated the properties of experimental coke made from the same coal blend, thereby indicating that the pilot oven coking results could be used as a dependable guide in predicting commercial oven practice.

During the entire period of our cooperation with Koppers Company, the pilot oven has been used in exploring the coking properties of coals from the different Illinois mines, in determining the effect of variations in the proportions of high- and low-volatile coals, in establishing proper carbonizing temperatures and rates of coking when using Illinois coal blends, and in determining the effect of coal density, coal pulverization, surface moisture, and inert material on the physical properties of coke.

The plastic properties of coals have been studied in our laboratories, and the findings applied to the proper blending of coals to produce the physical properties desired in blast furnace coke at the Koppers plant. This has involved a study of eastern coals as well as those from Illinois. These studies have been evaluated, and experimental data have been made available to the Koppers Company.

Early Plant Tests

In the first plant test made by Koppers Company on Illinois coal, referred to in the preceding section, five full-scale ovens were charged with a blend of approximately 60 percent Illinois No. 6 seam coal and 40 percent Pocahontas. The regular coking time of 16.3 hours was maintained at normal oven flue temperatures. The coke produced was tough and blocky and gave satisfactory shatter and tumbler tests.

At this time it was found that petroleum coke fines could be purchased in Wood River, Illinois, about ten miles from Granite City. It was thought that this fuel might be substituted for Pocahontas coal in the Illinois-Pocahontas blend and result in a further savings in cost and transportation. Experimental runs were made in the pilot oven on Illinois coal-petroleum coke blends. These were followed by full-scale oven tests at Granite City. The coke produced was found to have low resistance to breakage and to result in more than the normal amount of fines. These results, together with the nonuniform composition of the petroleum coke, convinced Koppers Company that such a blend would not be satisfactory.

Experimental pilot oven tests had shown that Illinois No. 5 seam coal from Saline County, which is the highest rank coal mined commercially in Illinois, has exceptionally good coking properties. This coal when blended with No. 3 Pocahontas produced low breeze, and the furnace coke was strong and somewhat smaller in size than that made from No. 6 seam coal. Excellent shatter and tumbler tests were obtained. Koppers Company tested a blend of 65 percent No. 5 seam Illinois coal and 35 percent Pocahontas in the oven battery. The coke produced had excellent physical properties and a pleasing appearance. However, previous commitments on this coal prevented further plant tests of longer duration in which the coke could have been evaluated as blast furnace fuel.

Full Oven Battery Tests by Koppers Company

The experience gained in the early plant tests at Granite City, and in the pilot oven tests in our laboratories, enabled Koppers Company to place the entire Granite City coke oven battery on a blend of 60 percent Illinois No. 6 seam coal and 40 percent Pocahontas coal on April 25, 1944. Just before the change to Illinois coal, the larger blast furnace was shut down and it was necessary to lengthen the coking time to approximately 24 hours. As Illinois coal has been shown to coke better at faster coking rates, considerable experimental manipulation of oven heats was required to determine best operating procedure to produce a maximum yield of furnace coke having the physical properties required for blast furnace fuel. It was found that with this long coking period, a rapid coking rate followed by a soaking period in which the coke temperature reaches 1900° F. or higher produces a good structure coke.

Illinois coals of 1½ inches x ¾ inch and 2 inches x ⅜ inch sizes have been used exclusively by Koppers Company. Finer coal sizes than ⅜ inch have been avoided because fusain tends to concentrate in the finer sizes, and as the tendency for weathering is greatly increased by the large surface area of the fine size coal.

Koppers Company continued to test Illinois-Pocahontas coal blends, increasing the amount of Illinois coal from time to time from 60 to 65, to 70, and to 75 percent, with corresponding decreases in Pocahontas coal. These blends produced large, blocky coke tending to have irregular surfaces and pebbly seams. The coke was tough, having exceptionally high shatter and tumbler stability. More coke fines were produced than when all-eastern coal was used. Blast furnace results indicated that the coke supported the burden well. There was, however, a decrease in furnace tonnage, accompanied by other indications pointing to a too-open stock column, a condition which might have been improved by a reduction in the size of the coke to the furnace. Unavoidable changes in ores used were made throughout the tests which reduced the accuracy of any direct comparisons in tonnages and coke rates.

In October 1944, Koppers Company began charging a coal blend containing 75 percent Illinois No. 6 seam coal, 15 percent eastern high-volatile coal, and 10 percent Pocahontas. The blend was later changed to 65 percent Illinois, 25 percent eastern high-volatile, and 10 percent Pocahontas. This blend, and others similar to it, have continued to be used. Addition of eastern high-volatile coal resulted in reduction of the coke size, elimination of pebbly seams, and reduction in the amount of coke fines. The oven battery has operated smoothly on these blends. Blast furnace operation has improved, and iron tonnage increased.

Effects of Illinois Coal

The problems involved in the use of Illinois coal at the Koppers Company Granite City plant have not all been solved. The effects of using Illinois coal in the production of metallurgical coke during this testing program may be summed up, however, as follows.

OVEN OPERATION

The coke oven battery at the Koppers plant has operated smoothly on Illinois coal blends during the entire testing period. Less trouble due to heavy tar and carbon deposits has been experienced than when all-eastern coal was used. This may be due in part to the longer coking time. It has not been necessary to leave ovens empty for decarbonization. The coke has pushed easily with no increase in power for pushing. Coke shrinks from the oven walls and there have been no stickers. Approximately the same tonnage of coal is charged per oven as when all-eastern coal was used. The heat for underfiring has increased about 30 percent due, in part, to the longer coking time and higher final coke temperature, and probably in part to the nature and higher moisture content of the Illinois coal. No comparison has been made between underfiring Illinois coal and eastern coal under the same operating conditions.

COKE PROPERTIES

When Illinois No. 6 seam coal from the mines furnishing coal to the Koppers plant was blended with Pocahontas coal of 17 percent volatile matter, a large, blocky coke of high stability was produced. The coke had irregular surfaces, contained pebbly seams, and produced a greater than normal yield of fines. Reducing the Pocahontas coal from 40 percent to 25 percent had little effect on these properties. Addition of 15 to 25 percent of eastern high-volatile coal with more fluid plastic properties improved the coke structure, eliminated the pebbly seams, and decreased the coke fines.

Coke of uniform chemical composition, containing about 0.75 percent sulfur, has been produced consistently from the washed Illinois coals used at this plant.

The yield of furnace coke has been decreased about 1 percent for each 10 percent of Illinois No. 6 seam washed coal which replaced the eastern Hernshaw seam coal in the blend. When the percentage of Pocahontas coal was also decreased, as in the later tests at the Granite City plant, the coke yield was naturally reduced further in accordance with the fixed carbon content of the coal blend.

BY-PRODUCTS

The total by-product yields from the carbonization of Illinois coal are somewhat less than from the best high-volatile eastern coals for the same ratio of high- and low-volatile coal in the blends. The tests at the Koppers Company plant show the following trends, part of which may be due to the different conditions under which the Illinois coal has been coked.

a) *Gas*—Total yield in therms is not appreciably different from Koppers' former experience with the all-eastern coal blend. The B.t.u. value of the gas is reduced, however, from 5 to 10 percent, depending on the coal blend being used.

b) *Tar*—Yield is reduced about 1 gallon per ton. Tar gravity is also lower.

c) *Ammonium Sulfate*—Yield is increased 20 to 30 percent.

d) *Light Oils*—Little change in yield. Present yields are greater than before Illinois coal tests were started due, in part at least, to improved plant operation.

COAL STORAGE

To avoid any tendency toward weathering, the Koppers Company has not stocked Illinois coal. The proximity of this plant to the mines, a distance of only 80 miles, has assured a dependable daily supply of coal. Our pilot plant data indicate that the Illinois coal being used at this plant could be stocked without detrimental effect on the coking properties for a thirty day period, and perhaps much longer, but no controlled plant tests on weathered coal have been made.

BLAST FURNACE OPERATION

A complete correlation of blast furnace practice with the various coal blends cannot be made for reasons previously stated. In general, it appears that the production of iron per day is lower and the pounds of coke per ton of iron are higher than would be expected from a direct comparison of the eastern and the Illinois cokes. This condition is due in part to the more open stock and higher top temperature resulting from the larger size of the Illinois coke. The latter condition might be corrected by the installation of adequate crushing facilities.

ECONOMICS AND TRANSPORTATION

No figures on the relative economics of the use of eastern high-volatile and Illinois coals are included in this report other than the fact that there is a freight differential to Granite City of $2.12 per ton.

In June, 1945, at the conclusion of W. P. B. sponsorship of this project, the Koppers plant at Granite City was consuming Illinois coal mined within 80 miles of the plant at a rate of approximately 600 tons per day. Indications are that the rate of consumption will continue at about this level until it is again possible to operate two blast furnaces simultaneously. When this occurs, the consumption of Illinois coal will increase. From the start of the Illinois coal tests in April 1944, until the termination of our W.P.B. contract on June 30, 1945, Koppers Company carbonized 228,-107 tons of Illinois coal, representing a transportation saving of 2,326,700 car miles not including return of the empty cars to the mines.

COOPERATION WITH INLAND STEEL COMPANY

Early in April 1944, we were invited to consult with officials of the Inland Steel Company in East Chicago, Indiana, on the possible use of our pilot oven in connection with their research program. Inland Steel carbonizes about 8,000 tons of coal daily, 4,700 tons in four Koppers oven batteries at the main plant, and 3,300 tons in two new batteries of Koppers Underjet type ovens in the plant built in 1943 by the Defense Plant Corporation. About 70 percent of the total coal used is high-volatile bituminous, that used in the main plant being supplied from Inland's captive mine in the No. 3 Elkhorn seam of eastern Kentucky, and that used in the D.P.C. plant being allocated by the government from miscellaneous eastern Kentucky and West Virginia mines.

Inland Steel Company holds extensive coal reserves in the low-sulfur area of southern Illinois. No coal has been mined from this holding, but other areas near this property have been mined extensively in the No. 6 seam, and drill tests indicate that the Inland Steel reserves are similar to those coals. It was thus of mutual advantage to Inland Steel Company and to ourselves to determine the coking characteristics of blends of this Illinois coal with the coals normally used in the Inland Steel plant for production of blast furnace coke.

Early Pilot Plant Oven Tests

In order to check the ability of our experimental oven to give results comparable to commercial coking practice, a sample of the coal blend being used at the Inland Steel plant was coked in this oven under conditions approaching the operating practice in the Inland plant. Experimental results checked average plant results remarkably well. Other coal blends used at both Inland plants were carbonized in the experimental oven, and results checked closely with commercial practice, thereby indicating that the pilot oven could be used as a guide for large-scale coking experiments on commercial ovens.

Cooperative Research Program

In June 1944, the officials of the Inland Steel Company requested the loan of Mr. Harold W. Jackman (Chemical Engineer in charge of our pilot oven operation) for a period of three months to direct their research program and to correlate it with experimental work of the Illinois State Geological Survey at Urbana. Believing that this arrangement would be of value to the progress of this project, the Survey complied with the request and Mr. Jackman worked with the Inland Steel Company for the period of July 1 to October 1, 1944. The cooperative work between the two organizations was carried out largely under this arrangement.

SCOPE OF RESEARCH

The research program as planned by Inland Steel Company at this time contemplated a general study of coal expansion and carbonization properties, and a critical examination of Beckley seam low-volatile coal from an area in Raleigh County, West Virginia, to determine its coking and expansion properties when blended with Inland's eastern Kentucky Elkhorn seam coal. This program was expanded to include tests on these coals in blends with Illinois No. 6 seam coal similar to that in Inland's reserve in Jefferson County, Illinois.

TESTING PROCEDURE

The following procedure was used in the Inland Steel Company coal testing program.

1. Expansion pressure tests were made (by Inland Steel Company) on coal blends in a movable-wall Koppers type test oven. This test gives an indication of the pressure that is developed on the oven walls during carbonization.
2. Coal blends under consideration were carbonized in the pilot oven in Urbana to determine their coking properties.
3. Full-scale oven tests were then made on each coal blend which warranted further investigation. Each blend being tested was charged to four ovens on three successive days and carbonized under normal plant operating conditions. The coke was sampled and tested on each day for its physical and chemical properties.
4. As a final check on coke properties and oven operation, and as an indication of blast furnace performance when using the test cokes as fuel, certain coal blends were charged to one entire coke oven battery of 73 ovens at the D.P.C. plant for periods of three weeks each, and the test cokes were used exclusively on one blast furnace where their performances were studied and compared.
5. Following the above research program, series of coal drying tests were made in cooperation with the Link-Belt Company of Chicago, the objective being to remove

the surface moisture from wet washed coals without injury to their coking properties. Coking and expansion pressure tests were made on blends of these coals before and after drying.

Results

COAL EXPANSION PRESSURE TESTS

No attempt is made in this report to describe the Koppers movable-wall test oven in detail or to elaborate on the many coal expansion tests made during this investigation. Reference to these tests is made, however, because of the importance of coal expansion data in coke oven practice, and because of the information obtained on the expansion properties of Illinois coal blends.

The Koppers Company was one of the first to realize the damaging effect of expanding coal on by-product coke ovens. Based on the experience gained from actual oven failures, Koppers has concluded that the maximum wall pressure which can safely be developed during the carbonization of any coal is 2 pounds per square inch. To measure this wall pressure, Koppers has developed the movable-wall oven which was used in these tests.

Generally speaking, high-volatile coals contract and low-volatile coals expand during carbonization. Low-volatile coals from different seams, and even from different sections of the same seam, have different expansion characteristics. By avoiding the use of highly expanding coals, and by using experimental blends to determine the expansion pressure developed, it is possible to avoid blends which may exert damaging pressures on the oven walls.

In addition to the inherent expansion properties of the coals used, there are other factors which strongly influence the pressure developed in an oven during the coking period. The most important of these is the bulk density of the coal as charged, which is influenced by coal moisture and pulverization. Ash and petrographic composition also have a bearing on the pressure developed. The effects of these factors were studied at this time.

From the standpoint of our research, two important conclusions were reached from the study of expansion pressure.

1. The Beckley coal under consideration was found to produce higher expansion pressures when blended with Inland's Elkhorn coal than the Pocahontas normally used at the Inland plant.
2. The expansion pressure of a Beckley-Elkhorn blend can be reduced materially by including a relatively small proportion of certain No. 6 seam Illinois coals in the blend. For example, a blend of 70 percent Elkhorn, 30 percent Beckley developed an expansion pressure of 4.21 pounds per square inch. Substituting 25 percent of a No. 6 seam coal for an equal amount of Elkhorn reduced the expansion pressure to 2.58 pounds per square inch.

This property of decreasing the expansion pressure of a highly expanding blend is regarded as important. In this way, low-volatile coals not now in general use for carbonization because of their expansion properties might be made usable in the coking industry by the inclusion of certain Illinois coals in the blend.

PILOT OVEN TESTS AT URBANA

The tests in the pilot plant at Urbana were made to determine the coking properties of many coal blends of interest to this cooperative research. In all, 35 pilot plant runs were made in connection with the Inland Steel cooperative program.

Of special value to the general knowledge of carbonization were the runs made to determine the effect of such factors as coal density, moisture, pulverization, and mine preparation on the properties of the coke. The trends noted here will be described in more detail in that section of this report entitled "Trends in Pilot Oven Tests."

One point of interest brought to our attention by these tests was the use of Pocahontas coal of 22 percent volatile matter to improve the plastic properties of coal blends containing a large percentage of Illinois No. 6 seam coal. This medium-volatile Pocahontas coal is much more fluid when in the plastic condition than is the regular Pocahontas coal of 17 percent volatile matter. The Illinois No. 6 seam coal used in these tests has a low fluidity, and its coking properties are improved by addition of the more highly fluid Pocahontas coal.

A series of coking tests was made on Beckley-Elkhorn coal blends in which the Beckley coal was increased by increments of five percent from 15 percent to 30 percent of the total blend. This series showed an improvement in coke properties consistent with the increase in Beckley coal.

To show the effect of substituting 25 percent Illinois No. 6 coal for a portion of the Elkhorn coal in blends of Elkhorn and low-volatile, three sets of comparative tests were made both with and without No. 6 coal from the Orient No. 1 mine. Results indicated consistently that the No. 6 coal blends produced a slightly blockier coke with very little change in stability, but with a slight increase in size and shatter index, and a lower apparent gravity. Physical tests indicate that coke made from blends containing this amount of No. 6 coal would be satisfactory as blast furnace fuel.

FULL-SCALE OVEN TESTS

In addition to tests in the pilot ovens, Inland Steel tested nine coal blends under plant operating conditions in full-scale Koppers ovens at the D.P.C. plant. Ten to twelve ovens were charged with each coal blend tested. Of interest to this project is the comparison in properties of the coke made from two similar coal blends, the difference being the inclusion of 25 percent of Illinois No. 6 seam coal in one of the blends.

Illinois No. 6 coal from the Orient No. 1 mine in Franklin County was chosen as being representative of Inland's Illinois reserve. The 2 inches x 3/8 inch size coal was used. Minus 3/8 inch Illinois coal was not used in any of the Inland tests because of concentration of fusain in the fine size of coal. Significant coke properties as shown in table 3 indicate that the Orient coal produced a small increase in the size and strength of the coke, a decrease in apparent gravity, and a slightly rougher and darker coke structure.

THREE-WEEK OVEN AND BLAST FURNACE TESTS

In the final phase of the Inland Steel research program, three-week oven battery tests were made on selected coal blends, consuming about 35,000 tons of coal per test, and the coke was used as blast furnace fuel. Here again two similar coal blends, one of all-eastern coals, and the other containing 25 percent Orient coal, were compared. The coke from the Orient coal blend was

Table 3.—Effect of Addition of Illinois Coal to a Beckley-Elkhorn Coal Blend

	25% Elkhorn Egg 45% Elkhorn Slack 30% Beckley	25% No. 6 Illinois (Orient) 45% Elkhorn Slack 30% Beckley
Furnace coke yield (% of coal charged)	67.3	66.0
Average size (in.)	2.25	2.30
Shatter (+2″)	59.6	61.4
Tumbler		
Stability (+1″)	52.7	54.8
Hardness (+¼″)	69.7	69.3
Apparent gravity	0.899	0.886
True gravity	1.86	1.88
Porosity (%)	51.8	53.0
Appearance	Gray—normal. Smooth surfaces. Blocky—tough.	Slightly darker than normal. Surface somewhat rough. Blocky—tough.

again slightly larger with a higher shatter test, and with tumbler stability very similar to that of the coke made from the all-eastern coal blends. Coke oven operation was satisfactory with both blends.

Operation of the blast furnace was erratic during the first half of the three-week test when coke containing Orient coal was used as fuel. Iron tonnage for the entire period was nearly 4 percent lower than when no Orient coal was used. During the last half of the test period, furnace operation became more uniform and this decrease in tonnage dropped to 1.8 percent. Fuel consumed per ton of iron was high. This likewise improved as the test progressed. It was unfortunate that this test could not be continued longer to evaluate more accurately this coke as blast furnace fuel.

Average efficiencies obtained in the blast furnace during the period in which Orient coal was used indicated that the Illinois coal blend was comparable to the all-eastern blend being used at the D.P.C. plant. Allowing for time in which to adjust blast furnace operation, an advantage should be gained from use of Illinois coal of uniform chemical composition in place of an equal amount of eastern coal from a number of mines in which the chemical composition is variable. Inland Steel, therefore, expressed a desire to place both batteries of the D.P.C. plant on a blend containing 25 percent of Illinois coal for a period of one month. It was found, however, that Illinois coal in that quantity was not then available, and no further tests were made at that time.

COAL DRYING TESTS

In addition to the major cooperative research program described above, we have cooperated in this project with Inland Steel Company and Link-Belt Company of Chicago, Illinois, in coal drying tests on No. 6 seam Illinois coal, Beckley seam coal, and Inland's Kentucky Elkhorn coal.

Mechanical mining is making it more imperative to remove coal impurities at the mines with washing equipment. Anticipating the use of washed coal in the plant, Inland Steel has realized that surface moisture remaining on the coal causes it to freeze in the cars in winter weather and to give trouble in handling. Surface moisture also lowers the bulk density of the coal charge in the ovens and reduces oven capacity.

Link-Belt Company is developing a coal drier in which coal can be heat dried quickly and at a relatively low temperature. It is hoped in this way to remove surface moisture without oxidizing the coal and injuring its coking properties. The coal drying tests described below were made on the pilot size drier located in the Link-Belt plant in Chicago.

Slack coal from the Beckley and Elkhorn seams, and 2 inches x 3/8 inch sized coal from the Orient mine, were drenched with water and surface dried to approximately the moisture content of the coals as mined. Blends of these coals were coked in our pilot coke oven before and after drying. The heat dried coal blends produced cokes of lower tumbler stability than did the blends of the untreated coals. (See Runs 113 to 121 inc., in Appendix A.)

This series of coal drying tests was repeated in the Link-Belt drier, and care was taken to use somewhat lower temperatures than before. Here again lower stabilities were obtained on the cokes made from the heat-dried coals.

Expansion pressure tests made by the Inland Steel Company on coal blends from both of these series of tests showed in every case that heat drying caused a reduction in the pressure exerted on the oven walls by these blends during the coking period.

It was therefore concluded that heat drying these three coals had resulted in some oxidation which manifested itself primarily in reduction of the tumbler stability of the coke, and in reducing the expansion characteristics of the coal blends.

In the tests just described, no attempt was made to determine the effect of heat drying on each individual coal. Subsequently, a third series of drying tests was made and the heat dried coals were substituted one at a time in the coal blends. It was found that the use of heat dried Elkhorn (2 inches x 0) coal caused a reduction in the tumbler stability as in the previous tests. Use of the Beckley (5/8 inch x 0) heat dried coal caused a small increase in coke stability. No effect was noted when Illinois (2 inches x 3/8 inch) heat dried coal was substituted for the undried coal.

Expansion pressure tests on this third series of coals showed that heat drying again caused a reduction in the pressure developed by the blends containing heat dried Elkhorn and Beckley coals. Heat drying Illinois coal caused no change in the expansion characteristics of the coal blend.

This last series of tests leads us to believe that the coal fines, with their large surface area, undergo appreciable oxidation in this type of heat drying. We believe that both the Elkhorn and Beckley fine coals show oxidation. The coking properties of the Elkhorn coal, which is not strongly coking, are somewhat injured by this oxidation of the fines. The Beckley coal, which is much more strongly coking, appears to be one of those which produces more blocky coke when slightly oxidized. The Illinois coal, containing no fines, and thus having much less surface area, was not oxidized appreciably in the drying process. Pertinent data on these coal drying tests are shown in table 4.

We believe that the problem of drying coal without injury to its coking properties is one of great importance to the Illinois coal producers. Illinois has pioneered in coal washing, and the removal of surface moisture is a problem which should be solved if quantities of washed Illinois coals are to be used for coking.

Table 4.—Heat Drying Tests on Link-Belt Drier

	Tumbler stability % + 1 inch.	Expansion pressure lb/sq. in.
Series I		
75% Elkhorn		
25% Beckley		
Coals as mined	55.1	1.60
Drenched and heat dried	52.7	1.35
25% Illinois		
50% Elkhorn		
25% Beckley		
Coals as mined	55.6	1.10
Drenched and heat dried	52.4	1.00
Series II		
75% Elkhorn		
25% Beckley		
Coals as mined	52.1	2.75
Drenched and heat dried	49.7	2.68
25% Illinois		
50% Elkhorn		
25% Beckley		
Coals as mined	53.3	2.46
Drenched and heat dried	50.2	2.35
Series III		
75% Elkhorn		
25% Beckley		
Coals as mined	43.8	2.25
Elkhorn drenched and heat dried	41.0	2.18
Beckley drenched and heat dried	46.8	1.90
25% Illinois		
50% Elkhorn		
25% Beckley		
Coals as mined	47.2	1.82
Illinois drenched and heat dried	47.9	1.81

Remarks

Inland Steel Company has considered this cooperative research program with the Illinois State Geological Survey to be successful. The Beckley seam coal was purchased, thus assuring a supply of low-volatile coal which tests have shown can be blended with eastern Kentucky coal and with the coal similar to that from Inland's reserves in Jefferson County, Illinois.

Although Inland Steel has not been active in testing Illinois coal since this series of tests was completed, it has used Franklin County coal in the plant during periods of coal shortage. The progress of this project has been followed with interest, and the testing program with Illinois coal is not considered to be completed.

During the tests just described, there were approximately 10,000 tons of Illinois coal used in the Inland Steel plant. This coal was mined at a distance of 319 miles from the Chicago area and replaced eastern Kentucky coal mined at 546 miles from this area. Freight on the Illinois coal is $1.14 per ton less than the all-rail haul from eastern Kentucky, and $0.50 less than the combination rail and lake boat rate. Any continued use of Illinois coal at this plant would, of course, be dependent on the economics of the process, and this can only be determined by plant tests of long enough duration to establish operating procedures and determine accurate yields and costs.

GENERAL COKING TESTS

In addition to the pilot oven tests made in direct cooperation with the Koppers Company and with Inland Steel Company, coals from most of the low-sulfur Illinois mines have been tested to evaluate them for use in production of metallurgical coke. As all Illinois coals which have been tested must be blended with other coals to produce metallurgical coke with satisfactory physical properties, a study has also been made of low-volatile coals and of certain eastern high-volatile coals for blending with Illinois coal.

Illinois Coals

FRANKLIN COUNTY

The low-sulfur coals tested in the Franklin County area, including adjoining areas in Jefferson, Perry, and Williamson counties, are from the No. 6 Illinois seam. The washed coals from this area are of uniform chemical composition, with sulfur ranging from 0.7 to 1.2 percent, depending upon the location of the mine.

No. 6 seam coal in the Franklin County area has relatively low fluid characteristics when in the plastic state, and has a tendency to form a rough structure coke when blended with Pocahontas coal of about 17 percent volatile matter. This tendency toward a rough structure can be overcome by replacing this Pocahontas coal with certain more fluid coals of about 22 percent volatile matter, such as the medium-volatile Pocahontas used in a number of our experimental runs, or by addition of a third coal to the Illinois-Pocahontas blend. This third coal may be either a high- or low-volatile coal possessing more fluid plastic characteristics than the Illinois No. 6 seam coal. Rapid coking also improves the coke structure.

Coals from certain mines in the northwestern portion of this area have been shown to have somewhat more fluid plastic properties than other coals mined farther south and east. Pilot plant tests indicate that these more fluid Illinois coals can be blended with Pocahontas of 17 percent volatile matter with production of a desirable coke without the addition of a third more highly fluid coal.

Generally speaking, coke made from a blend of Illinois No. 6 seam coal from Franklin County and Pocahontas coal is rather large and strong. Shatter and tumbler tests indicate that this coke should support satisfactorily the burden in a blast furnace. The coke is lighter and slightly more porous than coke usually made from all-eastern coal. By proper blending, such as is practiced at the Koppers Company plant at Granite City, Illinois, No. 6 seam coal can be used successfully in production of blast furnace fuel.

SALINE COUNTY

No. 5 seam Illinois coal which underlies Saline County, south and east of Franklin County, tends to have the strongest coking properties of any Illinois coal which has been tested. This is the highest rank coal mined commercially in Illinois.

Washed coals obtained from this area contain less moisture than Franklin County No. 6 seam coal, and about 1.5 percent less oxygen on the dry ash-free basis. Sulfur in this coal ranges from 1.7 to 2.1 percent, except for one low-sulfur area where washed coal of 0.75 to 1.0 percent sulfur can be produced.

No. 5 seam coal can be coked successfully in blends with Pocahontas to form a blocky coke high in stability, with a desirable surface structure. It does not appear to be necessary to increase the fluidity of the No. 5 seam-Pocahontas coal blends by the addition of more fluid eastern coals. Pilot plant results and commercial oven tests at the Koppers Granite City plant bear out this statement.

MADISON COUNTY

There is a small low-sulfur coal area in the No. 6 seam in Madison County, near Troy. Coal sampled from this area contained high moisture, high ash, and about 1.5 percent sulfur. No attempt was made to clean this coal. Laboratory tests indicate very weak coking properties, but when 20 percent of this coal from Madison County was blended with Franklin County coal and Pocahontas of 22 percent volatile matter, a very strong coke was produced.

WOODFORD COUNTY

There is also a low-sulfur area in the No. 2 Illinois coal seam in Woodford County in the north-central part of the State. Previous mine samples taken here had analyzed about 1 percent sulfur. The Minonk mine is operating in this area. It is without coal washing facilities, and produces coal of about 13 percent moisture. The samples taken at this mine on the stoker size coal showed 1.5 to 2.0 percent sulfur. Indications are that this sulfur would have been reduced by cleaning. Minonk coal is somewhat more fluid than the Franklin County coals tested, and produces a fairly smooth coke with a low percentage of fines, even when blended with 40 percent of Pocahontas coal. The coke strength is fair, but can be improved by proper blending. This coal might be used in small quantities to improve the fluidity of a coal blend.

INDIANA NO. IV SEAM COAL REPRESENTING DEPOSITS IN ILLINOIS

The Saxton No. 1 mine, located in Vigo County, Indiana, just across the eastern Illinois state line, produces low sulfur, low ash coal with high moisture content. The coal has a low fluidity and produces a sandy appearing, but fairly tough coke. Proper blending should improve the coke structure. This coal is of interest because of its low sulfur content of less than 1 percent, and because it may be representative of the undeveloped No. 4 seam in adjacent areas of eastern Illinois.

Non-Illinois Coals

LOW-VOLATILE COALS

As stated, it is necessary to blend Illinois coals with coal from other areas to produce coke having the desirable characteristics for metallurgical use. Coal commonly used for this purpose in the Chicago and St. Louis areas is from the No. 3 Pocahontas seam in West Virginia, and contains about 17 percent volatile matter. Plastic tests on this Pocahontas coal show it to have a low fluidity.

In normal coal blending procedure, this low-fluid Pocahontas coal is blended with highly fluid eastern high-volatile coal. The blend produces a good coke. Experimental data have led us to the belief, however, that when Illinois coal is used to replace the eastern high-volatile coal, the resulting blend may not have sufficient fluidity to produce the desired coke structure. In line with this belief, it has been found that improved coke structure results from increasing the fluidity of the blend through inclusion of more highly fluid coals, either high- or low-volatile.

It has been found that a Pocahontas coal of about 22 percent volatile matter becomes much more fluid when in the plastic state than do the lower volatile Pocahontas coals. When this more fluid coal is blended with Illinois coal of low fluidity, the blend produces a smooth coke structure with a low percentage of coke fines. Coke stability and size are somewhat reduced. Three-way blends in which Illinois coal is blended with both low- and medium-volatile Pocahontas coals have produced cokes combining high stability with a good appearance and low percentage of coke fines.

The medium-volatile Pocahontas coal mentioned here, and subsequently in this bulletin, is from one West Virginia mine which is not identified by name. It must not be construed that all medium-volatile coals have coking properties similar to this coal. However, two other coals of similar volatile content have been investigated, one being the Buccaneer Carey seam coal mentioned in this bulletin, and the other being from the No. 6 Pocahontas seam. Both of these coals develop high fluidity in the plastic stage. When blended with Illinois coal and coked in the experimental oven, desirable coke structures have resulted which are similar to those resulting from use of the medium-volatile Pocahontas coal first mentioned.

Other low-volatile coals from the Beckley seam of West Virginia have been blended with No. 6 seam Illinois coal. These Beckley coals are also more fluid than the regular Pocahontas and can be blended to advantage with Illinois coal.

HIGH-VOLATILE COALS

Another means of improving the structure of the coke from an Illinois-Pocahontas coal blend is by including a percentage of fluid eastern high-volatile coal. In pilot oven blends run in cooperation with Koppers Company, and in coal blends used at the Koppers Company plant, No. 2 Gas and Hernshaw seam coals from West Virginia have been used for this purpose. Experimental and commercial coking results indicate that addition of either of these coals to an Illinois-Pocahontas coal blend improves the physical properties of the coke.

TRENDS IN PILOT PLANT OVEN TESTS

No attempt is made in this report to discuss in detail all of the 183 experimental coke runs made on the pilot oven during the period of W.P.B. sponsorship. Many of these runs were made at the request of the cooperating industrial companies to aid in their choice of coal blends, and to help determine proper operating procedure. Other runs, as previously stated, were made in our survey of low-sulfur coals of the State, and in our study of coal blending. Detailed data on all pilot oven runs, including oven operating conditions, coal and coke analyses, physical properties and yields of coke, and yields and composition of by-products, are presented in tabular form in Appendix A.

Certain later data supplementing those obtained in the original 183 coking runs have been included at this point in the discussion of coking trends. These data are presented to substantiate trends noted in the early work but which could not be verified until later.

Pilot oven tests have shown definitely that coal from the low-sulfur area of Illinois can be used in blends for the production of coke having physical and chemical properties similar to the cokes now being used in industry for metallurgical purposes. In evaluating the experimental cokes, we have been handicapped by lack of accepted specifications for blast furnace fuel. Cokes have been compared one with another, and with commercial coke, by such standard physical tests as shatter, tumbler, and gravity. It has only been through our cooperative work with industry that certain of these cokes have been evaluated in terms of blast furnace operation.

Experimental runs in the pilot oven have shown the effects on coke properties of oven operating conditions and coal preparation and blending. Trends have been shown which are of value to an understanding of the coking properties of Illinois coal. Discussion of certain of these trends follows.

Effect of Coking Time and Temperature on Coke Properties

In table 5 are shown the results of carbonizing Illinois coal blends at increasing temperatures. It is noted that an increase in the rate of coking is shown to decrease the average size of the coke produced, with a corresponding decrease in shatter index. Coke stability is reduced, and the hardness factor is increased. The breeze (-½-inch coke) decreases as the coking rate is increased, and the coke appearance is improved, judging by color and uniformity of cell structure.

Further studies made on the effect of coking time and temperature, in which coal blends were coked at five different rates corresponding to coking times of 24, 22, 20, 18 and 16½ hours in a 19-inch oven, are shown in table 6. Here trends similar to those noted in table 5 are shown as the coking time is decreased.

Other experimental runs (Nos. 102 and 108) in which the coal was coked at a normally fast rate and then allowed to remain in the oven for a four-hour to six-hour soaking period, during which time the coke temperature gradually increased about 90° F., did not show any decided change in coke quality attributable to the soaking period (compare with runs 103 and 126 respectively in which no soaking periods were employed). It is concluded that it is the rate of coking that is largely responsible for coke quality. It is also concluded that a fast coking rate is desirable when coking such Illinois coal blends in order to produce the best cellular coke structure, and to keep coke breeze at a minimum.

Preparation of Coal

Pulverization—Effect on Coke Properties

Many modern metallurgical coke plants pulverize coal to pass 80 percent through a ⅛-inch screen. Other plants pulverize to only 65 percent minus ⅛-inch size and a few plants are known to carbonize coal passing 90 percent through a ⅛-inch screen in order to improve the quality of the coke.

Table 5.—Effect of Coking Time and Temperature on Coke Properties. (I)

Run No.	Final flue temp. °F.	Coking time Hr.: Min.	Shatter +2″ %	Tumbler: Stability % + 1″	Tumbler: Hardness % + ¼″	Av. size in.	Breeze −½″ % of coal
		Coal Blend: 60% Energy No. 5. (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell					
8	1850	12:15	62.2	50.0	68.2	2.77	4.2
7	1900	11:35	58.4	47.1	69.5	2.74	4.0
14	1950	11:05	50.2	47.8	70.0	2.50	2.7
15	2000	10:23	45.6	47.1	70.8	2.38	2.8
		Coal Blend: 60% Orient No. 1. (1½″ x ¾″ Washed) 40% Pocahontas-Carswell					
25	1750	17:30	83.8	56.2	59.2	3.48	6.0
9	1850	12:03	60.7	52.2	69.1	2.85	3.3

Table 6.—Effect of Coking Time and Temperature on Coke Properties. (II)

Run No.	Final flue temp. °F.	Coking time Hr.: Min.	Shatter +2" %	Tumbler Stability % + 1"	Tumbler Hardness % + ¼"	Av. size in.	Breeze −½" % of coal
		Coal Blend: 75% Orient No. 1. (2" x ⅜" Washed) 25% Pocahontas-Carswell					
262	1760	17:42	83.9	51.7	58.1	3.21	6.1
261	1810	16:13	81.1	51.9	61.7	2.97	5.0
260	1860	14:44	70.9	52.1	63.7	2.58	4.3
259	1910	13:16	67.4	50.3	66.7	2.44	3.7
258	1960	12:15	61.3	49.2	66.9	2.31	4.1
		Coal Blend: 75% Old Ben No. 11. (2" x 1½" Washed) 25% Pocahontas No. 4 Seam					
233	1760	17:42	77.9	45.8	62.7	2.99	3.4
232	1810	16:13	73.1	46.8	64.8	2.79	3.0
231	1860	14:44	67.0	46.2	65.8	2.52	3.0
230	1910	13:16	59.8	44.1	66.1	2.34	2.9
229	1960	12:15	55.2	43.1	67.0	2.21	2.8

Table 7.—Effect of Coal Pulverization on Coke Properties

Run No.	Pulverization −8m %	Shatter +2" %	Tumbler Stability % + 1"	Tumbler Hardness % + ¼"	Av. size in.	Breeze −½" % of coal
	Coal Blend: 25% Orient No. 1. (2" x ⅜" Washed) 45% Wheelwright Slack—30% Glen Rogers					
76	62.7	76.9	51.0	62.1	3.30	1.8
63	78.4	72.7	53.7	65.6	2.95	3.0
77	92.7	66.6	59.1	70.5	2.82	3.2
	Coal Blend: 25% Orient No. 1. (2" x ⅜" Washed) 40% Wheelwright Slack—35% Medium-Volatile Pocahontas					
68	81.1	63.0	48.3	68.2	2.92	2.1
57	91.5	66.1	54.7	67.5	2.72	2.2

Table 7 shows the effects of pulverization on two coal blends when carbonized in the experimental oven. Increasing the degree of pulverization produces the following changes in coke quality.

(1) Reduction in average coke size.

(2) Increase in coke stability.

Fine pulverization of the Glen Rogers blend is shown also to decrease the shatter index and increase the amount of coke fines.

MOISTURE—EFFECT ON COKE PROPERTIES

Moisture is considered under the heading of "Coal Preparation" because of the effect of preparation methods on the moisture content of coal as delivered. Wet washing processes add surface moisture to the prepared coal. Shaker screens and coal driers remove moisture. A number of coke plants are adding moisture to the coal before pulverization as an effective means of reducing bulk density in the coke ovens, thereby reducing the expansion pressure developed by the coal during carbonization.

The fact that surface moisture does affect bulk density has been evident throughout this entire testing program. It has been necessary to air dry washed coals partially before charging to the experimental oven

Table 8.—Effect of Moisture on Coke Properties
Coal Blend: 25% Wheelwright Egg
50% Wheelwright Slack
25% Glen Rogers

Run No.	Coal moisture %	Bulk density lb./cu. ft.	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
				Stability % + 1″	Hardness % + ¼″			
83	2.4	54.6	63.5	53.1	68.2	2.93	2.2	0.878
62	3.2	51.1	69.0	53.3	68.2	2.94	2.5	0.855
84	5.8	47.7	73.1	53.1	65.6	3.36	2.1	0.805

in order to obtain the desired bulk density of about 50 pounds per cu. ft.

Table 8 shows results of a series of tests in which the coal moisture is increased from 2.4 to 3.2 and 5.8 percent. The bulk density of the coal charge in the oven is shown to drop from 54.6 to 51.1 and 47.7 pounds per cu. ft. This decrease in bulk density results in a corresponding decrease in the apparent gravity of the coke. Coke size is increased. The shatter index also increases, probably due to the larger coke, and tumbler stability remains constant.

COAL CLEANING—EFFECT ON COKE PROPERTIES

No general statement can be made relative to the effect of coal ash on coke properties. When ash is reduced in a coal cleaning process, the ratio of the petrographic constituents in the coal may be changed, along with removal of high ash coal and free impurities such as pyrite and slate particles.

It is known that free non-coal impurities shatter into fine particles when coal is pulverized, and that these particles may form points of weakness in the coke structure which cause cracks and shattering. Removal of such impurities before crushing will eliminate this condition. Tests made on coal from the Jefferson No. 20 mine, with and without removal of free impurities, illustrate this fact. Raw coal from this mine contained visible pieces of free non-coal impurities. It is shown in Table 9 that removal of these impurities from the coal by flotation at 1.5 gravity produced a much stronger coke with higher shatter index and increased tumbler stability and hardness. Coke fines were reduced. Visual examination of coke made from the raw coal showed that small particles of free impurities formed nuclei about which radiated many cracks in the coke structure.

Table 9.—Effect of Removal of Non-Coal Impurities
Coal Blend: 80% Jefferson No. 20. (1½″ x ¾″)
20% Pocahontas-Carswell

Run No.	Condition of Jefferson coal	Coal ash %	Shatter + 2″ %	Tumbler		Av. size in.	Nut + breeze − 1″ % of coal
				Stability % + 1″	Hardness % + ¼″		
173	Raw	8.1	67.6	43.5	61.4	2.63	3.9
178	Float at 1.5 gr.	6.9	71.8	53.2	65.1	2.58	3.2

Weathering of Illinois Coals

When Illinois coal from the No. 6 seam is stocked for an extended period of time after mining it is known to weather with a gradual loss of its coking properties. This is true especially with the fine coal sizes where large surface areas are exposed to oxidation. Consequently, it has not been considered advisable by certain operators to stock Illinois coal, even temporarily, when it is to be used for production of coke.

Preliminary coking tests made on blends containing Illinois No. 6 seam 1½ x ¾-inch coal, in which the Illinois coal was stocked for approximately three-month and six-month periods in a roofed but otherwise open bin, indicated that storage of this coal did not seriously impair the coking properties of the blends in which it was used. (See table 10.)

Following these preliminary tests, other series of weathering tests have been made at regular intervals on Illinois coals which were stocked in the open in conical piles of from two to four tons. The coals were exposed in this way to maximum weathering conditions during the storage period. Certain of these tests are still in progress. Data are shown in tables 11 and 12.

Plant storage.—Illinois coal, largely of the 6 x 3 inch and 3 x 2 inch sizes from a number of mines, was stocked in a ridge-shaped pile approximately 150 feet long and 25 feet high on a concrete pad at a midwest coke plant. This coal was sampled and tested by us one, two, and six months after stocking. The first two samples were taken from the top of the pile where the coal had been exposed directly to the air for the entire period. The six-month sample was taken from near the bottom of the pile as the coal was exposed when being removed from storage. Data in table 13 show that six months storage had not resulted in sufficient weathering to be noticeable when the coal was used as 25 percent of the total blend. It was noted also that the coal in the pile still showed the original bright surfaces, and that there was no noticeable size degradation. At no time had there been any evidence of heating.

Consideration of all of the weathering test data obtained to this date on No. 6 seam Illinois coals indicates that where washed, prepared sizes of Illinois coal, exclusive of fines, are to be used as not more than 25 percent of the total coal blend, storage of from three to six months is allowable. Likewise, where as much as 80 percent of this Illinois coal is to be blended with a fluid medium-volatile coal such as is shown in table 11, six months storage has no detrimental effects on the physical properties of the coke.

Blending of weathered No. 6 seam Illinois coal with Carswell-Pocahontas of low fluidity apparently gives a blend with borderline plastic characteristics. In table 12, Series I and II, the Orient coal blends

Table 10.—Effect of Weathering Illinois Coal. (I)

Run No.	Age of Ill. coal since mining No. days	Shatter + 2″ %	Tumbler		Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″		
Coal Blend: 25% Orient No. 1. (1½″ x ¾″ Washed) 45% Wheelright Slack 30% Glen Rogers						
63	Fresh	72.7	53.7	65.6	3.0	0.842
104	83	74.4	49.3	63.2	2.0	0.830
Coal Blend: 80% Orient No. 1. (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas						
94	Fresh	58.2	47.4	67.6	1.8	0.813
141	186	57.5	47.8	68.0	2.7	0.802

produced very good coke after 30 days in storage. The 2 x ⅜-inch size continued to produce good coke after 60 days, and showed only minor deterioration after 90 days weathering. The 3 x 2 inch size, on the other hand, showed considerable weathering effect in 60 days, and still more in 90 days.

It can be assumed from these data that Orient coal can be safely stocked for a period of 30 days and blended with Carswell-Pocahontas using as much as 80 per-cent Orient in the blend. Stocking this coal in a pile of commercial size where only the surface is exposed directly to the weather has been shown to reduce the effect of weathering and should minimize the oxidation shown in our laboratory tests. No evidence of heating in storage has been found.

No. 5 seam Illinois coal is shown in table 12, Series III, to withstand three months' weathering with only a small effect on its coking properties. As this is a higher rank coal than that from the No. 6 seam, it is to be expected that its weathering characteristics would be superior to those of the No. 6 seam coal.

In all these tests, it is shown that weathering is first evidenced by an increase in breeze

Table 11.—Effect of Weathering Illinois Coal. (II)
Coal Blend: 80% Orient No. 1. (2″ x ⅜″ Washed)
20% Medium-Volatile Pocahontas

Run No.	Age of Illinois coal since mining No. days	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
195	13	61.8	48.7	66.6	2.24	3.5	0.808
212	72	63.1	47.9	65.8	2.35	2.8	0.785
225	132	61.5	46.0	66.2	2.34	3.0	0.798
239	198	66.2	48.2	66.4	2.33	3.1	0.779
256	258	69.3	42.8	62.3	2.46	4.2	0.785

Table 12.—Effect of Weathering Illinois Coal. (III)

Run No.	Age of Illinois coal since mining No. days	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
Series I—Coal Blend: 80% Orient No. 1. (2″ x ⅜″ Washed) 20% Pocahontas-Carswell							
246	31	63.3	49.4	67.2	2.43	3.0	0.809
255	62	71.8	47.1	66.5	2.42	3.5	0.774
263	94	63.5	48.4	64.8	2.51	4.2	0.756
270	122	65.4	42.5	59.8	2.49	6.1	0.823
279	153	69.2	37.0	51.5	2.37	9.5	0.806
Series II—Coal Blend: 80% Orient No. 1. (3″ x 2″ Washed) 20% Pocahontas-Carswell							
249	31	62.7	51.4	67.2	2.48	3.1	0.792
257	59	63.3	46.5	63.9	2.45	4.4	0.811
265	91	65.1	44.8	59.6	2.39	6.2	0.818
273	122	68.3	38.9	53.0	2.37	9.8	0.834
282	154	64.9	29.4	39.9	1.89	22.4	0.835
Series III—Coal Blend: 80% Harco No. 47. (2″ x 1″ Washed) (No. 5 seam Illinois Coal) 20% Pocahontas-Carswell							
250	32	66.5	55.5	67.9	2.33	2.3	0.822
266	90	69.1	55.1	66.7	2.39	3.5	0.838
283	153	69.6	45.0	59.0	2.47	7.1	0.865
307	244	63.6	40.1	52.4	2.32	10.5	0.841

Table 13.—Weathering of Illinois Coal Stocked in Plant Storage Pile
Coal Blend: 25% Illinois No. 6 Seam
25% Eastern Kentucky
50% Pocahontas No. 4 Seam

Run No.	Time in storage, months	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
220	1	64.0	31.3	64.0	2.55	3.0	0.887
226	2	62.2	28.3	62.7	2.63	3.1	0.889
254	6	62.9	34.5	65.4	2.63	3.1	0.892

and a lowered hardness factor. Coke size usually increases slightly after the first one or two months and then remains constant. The shatter test is not greatly affected by weathering, and the tumbler stability factor decreases very slowly, and has never been shown in these tests to drop below 42. Likewise, the hardness factor has never dropped to less than 58.4. Judging from these physical tests, it would not appear that the maximum weathering shown here would greatly affect the use of these cokes as blast furnace fuel.

Effects of Blending Pocahontas Coals of Different Characteristics with Illinois Coal

It has been shown, as previously stated, that Medium-Volatile Pocahontas coal of 22 percent volatile matter, which has a high fluidity when in the plastic state, is effective in reducing coke breeze and rough coke appearance when blended with No. 6 seam Illinois coal. Comparisons are made in table 14 between blends of Illinois coal with (1) Pocahontas coal of 17 percent volatile

Table 14.—Effect of Blending Different Pocahontas Coals with Illinois Coal

Run No.	Coal blend	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
152	80% Zeigler 20% Pocahontas-Carswell	60.0	49.2	66.5	2.43	2.8	0.795
153	80% Zeigler 20% Medium-Volatile Pocahontas	53.9	48.7	68.3	2.31	2.3	0.788
148	80% Zeigler 10% Pocahontas-Carswell 10% Medium-Volatile Pocahontas	59.7	49.4	67.1	2.35	2.5	0.803
149	70% Zeigler 15% Pocahontas-Carswell 15% Medium-Volatile Pocahontas	57.7	50.7	68.3	2.31	2.2	0.828
150	60% Zeigler 20% Pocahontas-Carswell 20% Medium-Volatile Pocahontas	63.2	52.7	67.3	2.42	2.2	0.846

matter, (2) Medium-Volatile Pocahontas coal, and (3) combinations of these two blending coals.

Comparisons shown in table 14 between blends of Illinois coal with (1) Pocahontas of 17 percent volatile matter, and with (2) Medium-Volatile Pocahontas coal indicate that blending the medium-volatile coal produces coke with lower shatter index and tumbler stability but with increased hardness. The coke size is reduced by the medium-volatile coal, and less breeze is produced. Coke gravity is normally higher; in this respect Run 153 is not typical.

It is further noted in this table that a stronger, heavier coke can be made by combining equal quantities of Carswell-Pocahontas and Medium-Volatile Pocahontas coals in blends with 80, 70 or 60 percent of Illinois coal, and that the breeze produced remains small. It is this property of Medium-Volatile Pocahontas coal which indicates its value for blending with coals of low fluidity.

Effect of Increasing the Percentage of Low-Volatile Coal in Illinois Coal Blends

Table 15 shows the effect of increasing the amount of lower volatile coals in Illinois coal blends.

Table 15.—Effect of Increasing the Percentage of Lower Volatile Coals in Illinois Coal Blends

Run No.	Coal blend	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
	Series I—Orient—Pocahontas-Carswell Blends						
140	90% Orient 10% Pocahontas-Carswell	49.8	37.4	67.4	2.20	2.6	0.774
130	85% Orient 15% Pocahontas-Carswell	62.3	46.3	64.9	2.53	3.1	0.788
131	75% Orient 25% Pocahontas-Carswell	66.5	54.8	67.2	2.47	2.8	0.798
3	70% Zeigler 30% Pocahontas-Carswell	57.2	49.5	65.0	2.76	4.4	0.798
4	60% Zeigler 40% Pocahontas-Carswell	59.7	51.4	65.9	2.69	4.7	0.811
5	50% Zeigler 50% Pocahontas-Carswell	63.2	52.7	70.9	2.78	3.9	0.827
	Series II—Orient—Medium-Volatile-Pocahontas Blends						
96	90% Orient 10% Medium-Volatile Pocahontas	50.9	39.7	69.6	2.52	2.0	0.792
138	85% Orient 15% Medium-Volatile Pocahontas	54.3	45.6	68.4	[a] 2.23	2.3	0.798
94	80% Orient 20% Medium-Volatile Pocahontas	58.2	47.4	67.6	2.66	1.8	0.813

[a]Size not comparable with other two runs.

Table 16.—Effect of Using Petroleum Coke as a Substitute for Pocahontas Coal

Run No.	Coal blend	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
18	90% Orient 10% Petroleum Coke	37.0	26.6	65.2	2.40	2.1	0.775
20	85% Orient 15% Petroleum Coke	46.8	39.3	66.8	2.32	3.2	0.794
21	80% Orient 20% Petroleum Coke	48.2	39.5	61.3	2.45	3.5	0.789

In Series I of this table where Carswell-Pocahontas is increased from 10 to 25 percent and from 30 to 50 percent, it is seen that increasing the low-volatile coal tends to increase the coke strength. The apparent gravity of the coke also increases consistently as the percentage of Pocahontas coal is increased.

In Series II where Medium-Volatile Pocahontas is blended with Orient coal, the coke strength again increases as the medium-volatile coal is increased from 10 to 20 percent. No runs were made in which a larger percentage of medium-volatile coal was used. The coke breeze remains low. Apparent gravity increases as the amount of the lower volatile coal is increased. The gravities are consistently higher than those of the corresponding cokes of Series I in which the lower volatile coal used was from the Carswell mine.

Effect of Using Petroleum Coke as a Substitute for Pocahontas Coal

The petroleum coke used in these experimental runs contained about 13 percent volatile matter and formed a very weak button in the standard volatile-matter determination. Table 16 shows the quality of the coke produced when petroleum coke was blended with Orient coal and coked in the experimental oven.

Petroleum coke is seen to cause the formation of a soft coke with poor shatter and tumbler tests. As the amount of petroleum coke used in the blend is increased to 20 percent, the hardness factor drops and the amount of coke breeze increases. These same trends were noticed in plant oven tests made by Koppers Company at Granite City, Illinois.

Comparison of No. 6 Seam Coals from Different Illinois Mines

Coals from the low-sulfur area of the No. 6 seam vary somewhat in their plastic properties. Of those subjected to test in this program, the ones from the northwest part of the area give evidence of somewhat higher fluidity than the others and produce less breeze when carbonized in blends with Pocahontas (see table 17). Lower breeze is also

Table 17.—Comparison of No. 6 Seam Coals

Run No.	Illinois coal used	Breeze − ½″ % of coal
	Coal Blend: 80% Illinois No. 6 seam coal 20% Pocahontas–Carswell	
152	Zeigler No. 1 and 2	2.8
165	Old Ben No. 14	2.6
182	Majestic	2.4
178	Jefferson No. 20 (Float at 1.50 gr.)	2.3
154	Old Ben No. 11	2.2
	Coal Blend: 60% Illinois No. 6 seam coal 40% Pocahontas–Carswell	
4	Zeigler No. 1 and 2	4.7
8	Energy No. 5	4.2
9	Orient No. 1	3.3
166	Old Ben No. 14	3.3
183	Majestic	3.0
174	Jefferson No. 20 (Raw)	2.9
164	Old Ben No. 11	2.6

Table 18.—Comparison of No. 5 Seam Coals

Run No.	Illinois coal used	Breeze − ½″ % of coal
	Coal Blend: 80% Illinois No. 5 seam coal, 20% Pocahontas–Carswell	
44	Sahara No. 16	2.4
180	Harco No. 47	2.0
176	Buckhorn	1.9
	Coal Blend: 60% Illinois No. 5 seam coal, 40% Pocahontas–Carswell	
49	Sahara No. 16	3.5
181	Harco No. 47	2.1
177	Buckhorn	2.1

accompanied by an improved appearance of the coke. It is not to be inferred that the coals which produce higher breeze are of inferior quality, as by proper blending they may be made to produce equally satisfactory cokes.

Comparison of No. 5 Seam Coals From Different Illinois Mines

Coals have been tested from four No. 5 seam mines; three in Saline County and one, the Buckhorn mine, in Williamson County. Coal from this last mine proved to be high in sulfur.

No. 5 seam coal when blended with Pocahontas has consistently produced a strong coke with desirable physical properties. Coke with smooth surface structure and a small amount of breeze is produced. Here again differences in coal plasticity are found to exist; coals from Harco No. 47 and Buckhorn mines are the most fluid. The breeze produced from carbonizing Illinois No. 5 seam-Pocahontas coal blends is shown in table 18. This table does not list the Sahara No. 4 and No. 5 mine coals which are combined at the tipple and have also been tested but not in the same blends as shown in the table. These coals also produced low breeze when carbonized with Pocahontas coal (see Run No. 54).

Blends Containing Both No. 5 and No. 6 Seam Coals

Having shown in pilot oven tests that No. 5 seam coal tends to be more strongly coking than that from No. 6 seam, it was desired to find the effect of addition of a percentage of No. 5 seam coal to blends containing No. 6 seam and Pocahontas coals. Two comparisons are shown in table 19 between similar blends with and without the addition of No. 5 seam coal.

Table 19.—Effect of Adding No. 5 Seam Coal to a Blend of No. 6 Seam Coal and Pocahontas Coal

Run No.	Coal used	Shatter + 2″ %	Tumbler		Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″		
140	90% Orient (No. 6 Seam) 10% Pocahontas-Carswell	49.8	37.4	67.4	2.6	0.774
106	50% Orient (No 6 Seam) 40% Sahara No. 16 (No. 5 Seam) 10% Pocahontas-Carswell	60.5	45.5	65.1	2.7	0.773
130	85% Orient (No. 6 Seam) 15% Pocahontas-Carswell	62.3	46.3	64.9	3.1	0.788
109	60% Orient (No. 6 Seam) 25% Sahara No. 16 (No. 5 Seam) 15% Pocahontas-Carswell	61.9	53.3	68.7	2.4	0.794

It is seen that where coal from the Sahara No. 16 mine is added to blends of Orient and Pocahontas coals, the quality of the coke is improved. Not only is the strength increased, but the general appearance of the coke structure is better.

Addition of Eastern High-Volatile Coal to the Blend

In the description of the cooperative work with Koppers Company at Granite City, Illinois, it was stated that Koppers Company had reduced the size and breeze content of the plant coke made from Illinois coal blends by reduction in the Pocahontas coal and addition of from 15 to 25 percent of eastern high-volatile coal of high fluidity. Pilot plant results shown in table 20 indicate the effect of this eastern high-volatile coal on the quality of the coke produced. A comparison is made of coal blends containing 10 percent of Pocahontas, with and without eastern high-volatile coal. A further comparison is made of coal blends containing 65 percent Orient coal where the amount of eastern high-volatile coal is reduced and the Pocahontas is increased.

Examination of Runs 140 and 122 show that when 25 percent of Midvale eastern high-volatile coal is added to the blend containing 10 percent Pocahontas, the coke strength and size are both increased, the breeze is decreased, and the coke is heavier. The coke made without Midvale tends to be pebbly, and when Midvale is added the pebbly structure disappears entirely.

The second comparison, where Midvale is decreased and Pocahontas increased, indicates that the coke becomes more resistant to breakage, and somewhat larger. Breeze is not increased until Midvale is cut to 15 percent. In this last blend, the fluidity is low, and a tendency toward pebblyness is noted in the coke.

Koppers' Company has carbonized these three blends in the plant at Granite City, and the same trends have been noticed in the commercial coke. Higher carbonizing temperatures were used in the plant at this time than those used on the pilot oven, and the tendency to produce stronger coke as Midvale was reduced was more pronounced than in the pilot oven. The plant coke also increased in size as the amount of Midvale was reduced. It was not possible to obtain actual yields of coke breeze during the plant tests with 17½ and 15 percent Midvale in the blends, but visual observation indicated that coke breeze increased. The coke had occasional pebbly streaks when only 15 percent Midvale was included.

Table 20.—Addition of Eastern High-Volatile Coal to the Blend

Run No.	Coal used	Shatter + 2″ %	Tumbler		Av. size in.	Breeze − ½″ % of coal	App. gr.
			Stability % + 1″	Hardness % + ¼″			
140	90% Orient 10% Pocahontas	49.8	37.4	67.4	2.20	2.6	0.774
122	65% Orient 25% Midvale 10% Pocahontas	63.4	47.9	65.1	2.63	2.1	0.815
122	65% Orient 25% Midvale 10% Pocahontas	63.4	47.9	65.1	2.63	2.1	0.815
167	65% Orient 17½% Midvale 17½% Pocahontas	70.4	46.6	63.8	2.65	2.0	0.824
170	65% Orient 15% Midvale 20% Pocahontas	71.4	50 0	63.3	2.73	2.6	0.811

Table 21.—Comparison of Ash Fusion Temperatures of Eastern and Illinois Coal Blends

Run No.	Coal blend	Ash softening temp. °F.
	Comparing eastern high-volatile with Illinois coal	
2	70% Wharton (West Virginia)—30% Pocahontas	2120
3	70% Zeigler—30% Pocahontas	2156
37	70% Energy—30% Pocahontas	2240
42	70% Sahara 16—30% Pocahontas	2261
41	70% Sahara 16 (Raw)—30% Pocahontas	2308
54	70% Sahara 4 and 5—30% Pocahontas	2090
	Decreasing eastern—Increasing Illinois coal	
2	70% Wharton—30% Pocahontas	2120
16	30% Wharton—50% Energy—20% Pocahontas	2192
37	70% Energy—30% Pocahontas	2240
24	45% Wheelwright Slack—20% Wheelwright Egg—35% Pocahontas	2154
53	45% Wheelwright Slack—20% Orient—35% Pocahontas	2341
89	40% Wheelwright Slack—25% Orient—35% Pocahontas	2320
90	25% Wheelwright Slack—40% Orient—35% Pocahontas	2333

Effect of Illinois Coal on Ash Fusion

Ash fusion determinations were made on all cokes produced in the experimental oven. Fusion data were obtained on only a few of the individual coals used, but a comparison of the fusion data on cokes from the various coal blends indicates the effect of Illinois coal on the ash fusion of the blends.

In table 21 is shown a comparison of ash fusion data on similar blends of Wharton (West Virginia) and Illinois coals with Carswell-Pocahontas. The effect of replacing increasing percentages of Wheelwright (eastern Kentucky) with Illinois coal is also shown. Examination of this table shows that all Illinois coal blends listed, with one exception, have higher ash fusion temperatures than do the corresponding blends of all-eastern coals.

Table 22 contains further ash fusion data on cokes from similar blends of various Illinois coals. It is noted that blends containing No. 6 seam coals all produce cokes having ash fusion temperatures in approximately the same range. No. 5 seam coals, with the exception of Sahara No. 16, produce cokes having the lowest ash fusion temperatures of any of those tested. No. 16 Sahara coal, on the other hand, when blended with Pocahontas as shown produces cokes having exceptionally high ash fusions.

SPECIAL TESTS

From the preceding discussion of coking results in the pilot plant oven, it is obvious that studies of coal plasticity have played an important part in planning the experimental program and in interpreting the results obtained. Other special laboratory tests made in conjunction with the pilot plant studies have also contributed to the interpretation of experimental results, and their application to industrial situations. A discussion of these special tests follows.

Plasticity Study

Plastic properties of many of the individual coals and blends carbonized were studied. For this purpose, the Gieseler plastometer was used. The equipment was similar to the modified form of the Gieseler plastometer described by Brewer.[13] In order to obtain somewhat greater sensitivity in the instrument, use was made of a smaller pulley on the dial than on the stirring head of the plastometer. The dial pulley was 1¼ inches in diameter and the stirring head pulley was 1¾ inches in

TABLE 22.—ASH FUSION OF COKES FROM BLENDS OF VARIOUS ILLINOIS COALS

Run No.	Coal blend	Ash softening temp. °F.
	No. 6 seam coals	
29	100% Zeigler	2358
28	80% Zeigler—20% Pocahontas	2141
3	70% Zeigler—30% Pocahontas	2156
4	60% Zeigler—40% Pocahontas	2160
5	50% Zeigler—50% Pocahontas	2146
140	90% Orient 1—10% Pocahontas	2309
124	85% Orient 1—15%Pocahontas	2232
131	75% Orient 1—25% Pocahontas	2224
9	60% Orient 1—40% Pocahontas	2140
33	60% Orient 1—40% Pocahontas	2237
173	80% Jefferson No. 20—20% Pocahontas	2158
174	60% Jefferson No. 20—40% Pocahontas	2212
36	70% Energy No. 5—30% Pocahontas	2188
37	70% Energy No. 5—30% Pocahontas	2240
7	60% Energy No. 5—40% Pocahontas	2131
15	60% Energy No. 5—40% Pocahontas	2135
154	80% Old Ben No. 11—20% Pocahontas	2207
164	60% Old Ben No. 11—40% Pocahontas	2183
165	80% Old Ben No. 14—20% Pocahontas	2272
166	60% Old Ben No. 14—40% Pocahontas	2241
	No. 5 seam coals	
193	100% Harco	2124
180	80% Harco—20% Pocahontas	2070
181	60% Harco—40% Pocahontas	2095
176	80% Buckhorn—20% Pocahontas	2063
177	60% Buckhorn—40% Pocahontas	2148
54	70% Sahara 4 and 5—30% Pocahontas	2090
93	25% Sahara 4 and 5—65% Orient—10% Pocahontas	2171
92	15% Sahara 4 and 5—75% Orient—10% Pocahontas	2202
48	90% Sahara 16—10% Pocahontas	2446
127	85% Sahara 16—15% Pocahontas	2390
44	80% Sahara 16—20% Pocahontas	2353
42	70% Sahara 16—30% Pocahontas	2261
41	70% Sahara 16 (Raw)—30% Pocahontas	2308
59	65% Sahara 16—35% Pocahontas	2323
49	60% Sahara 16—40% Pocahontas	2299
80	40% Sahara 16—60% Orient	2242

diameter. This differs from the Russell-Soth modification in which the two pulleys are the same size, being 1⅞ inches in diameter.[14] By using different sized pulleys, the maximum fluidity readings obtained are somewhat higher than with the Russell-Soth modification. However, this difference does not appear to be in direct ratio to the sizes of the pulleys of the two instruments.

Table 23.—Gieseler Plasticity Data for Individual Coals

Description	County	No. samples	Softening temp. °C.	Fusion temp. °C.	Max. fluidity temp. °C.	Solidification temp. °C.	Max. fluidity dial Div./Min.
Illinois Coals							
Orient No. 1 .... No. 6 seam (1½″ x ¾″ Washed)	Franklin	1	378	...	409	445	4 4
Orient No. 1 .... No. 6 seam (2″ x ⅜″ Washed)	Franklin	3	372 av.	407 av.	422 av.	448 av.	11.1 av.
Orient No. 2 .... No. 6 seam (2″ x ⅜″ Washed)	Franklin	1	387	401	417	444	18.4
Old Ben No. 11 .... No. 6 seam (2″ x 2½″ Washed)	Franklin	1	371	405	418	442	13.3
Old Ben No. 14 .... No. 6 seam (3″ x 2″ Washed)	Franklin	1	358	403	419	439	12.1
Zeigler No. 1 and 2.... No. 6 seam (1½″ x ¾″ Washed)	Franklin	1	361	403	413	438	8.8
Jefferson No. 20 .... No. 6 seam (1½″ x ¾″ Raw)	Jefferson	1	...	402	420	449	43.5
Sahara No. 4 and 5.... No. 5 seam (3″ x 1½″ Washed)	Saline	1	367	404	422	453	23.4
Sahara No. 16 .... No. 5 seam (6″ x 28 mesh Washed)	Saline	1	382	419	430	459	20.5
Sahara No. 16 No. 5 seam (3″ x 2″ Washed)	Saline	1	375	411	423	453	7.5
Buckhorn .... No. 5 seam (1½″ x ¾″ Washed)	Williamson ...	1	363	390	414	456	345
Harco No. 47 .... No. 5 seam (3″ x 2″ Washed)	Saline	1	360	397	426	455	52
Other Coals							
Pocahontas-Carswell ... No. 3 seam	McDowell–West Virginia	3	437 av.	467 av.	475 av.	492 av.	13.8 av.
Pocahontas-Inland Steel No. 3 seam	McDowell-West Virginia	1	419	456	465	499	14.7
Glen Rogers .... Beckley seam	Wyoming-West Virginia	2	411 av.	441 av.	466 av.	498 av.	81 av.
Eccles .... Beckley seam	Raleigh-West Virginia	1	420	455	472	502	62

Table 23.—(Concluded)

Description	County	No. samples	Softening temp. °C.	Fusion temp. °C.	Max. fluidity temp. °C.	Solidification temp. °C.	Max. fluidity dial Div./Min.
Medium-Volatile....... No. 3 seam	McDowell-West Virginia	1	382	414	450	483	1224
Buccaneer............ Carey seam (1¼″ x ¾″)	Buchanan-Virginia	1	385	415	455	497	1840
Wheelwright Slack Elkhorn No. 3 seam	Floyd-Kentucky	2	384 av.	415 av.	434 av.	462 av.	97.5 av.
Wheelwright Egg Elkhorn No. 3 seam	Floyd-Kentucky	1	382	407	432	466	590
Amherst Eagle Eagle seam	Logan-West Virginia	1	371	401	437	479	8000
Wharton.............. Hernshaw seam	Boone-West Virginia	1	354	388	427	471	>15000
Midvale No. 2 Gas seam	Fayette-West Virginia	1	357	400	439	484	>15000

The Gieseler plastometer gives the following information:

Softening Temperature—temperature (°C.) at which movement is 0.5 dial divisions per minute.
Fusion Temperature—temperature (°C.) at which movement reaches 5.0 dial divisions per minute.
Maximum Fluidity Temperature—temperature (°C.) of maximum rate of dial movement.
Solidification Temperature—temperature (°C) at which dial movement stops.
Maximum Fluidity—maximum rate of dial movement in dial divisions per minute.

It should be stated that duplication of results in our Gieseler plastometer is not sufficiently precise to warrant more than a qualitative interpretation.

Gieseler plasticity data for certain individual coals used in the work of this project are tabulated in table 23. Unsuccessful attempts were made to secure such data for several other coals studied. In general, the Illinois coals tested, especially those from the No. 6 seam, show low fluidity. Pocahontas No. 3 coals are in general also of low fluidity. The Medium-Volatile Pocahontas has a much higher fluidity, whereas the high-volatile eastern coals such as Wharton, Amherst Eagle and Midvale are also quite fluid.

In this work it has been found impossible to estimate fluidities of coal blends from known fluidities of the individual coals making up the blends. In table 24 comparison is made of determined and calculated Gieseler data for several coal blends studied. Calculated values appearing in this table are weighted average values arrived at from known data for individual coals and known percent composition of the blends. It is seen readily that determined and calculated critical temperature values are not greatly different, but that determined and calculated maximum fluidities differ widely.

The importance of plasticity data, as described above, for this work lies in the possibility of its use in choosing proper coal blends and predicting the properties of coke to be made therefrom.

Table 25 has been compiled by choosing six ranges of maximum fluidity of coal blends carbonized, and averaging characteristics of cokes made from coal blends having fluidities within each range. The number of cases falling within each range as well as maximum and average deviations are shown. Unfortunately, insufficient data are available for a reliable correlation. The number of cases in each group is too small

Table 24.—Comparison of Determined and Calculated Gieseler Data for Coal Blends

Run No.	Blend	Softening temp. °C.		Fusion temp. °C.		Max. fluidity temp. °C.		Solidification temp. °C.		Max. fluidity Dial Div./Min.	
		Detd.	Calc.	Detd.	Calc.	Detd.	Calc.	Detd.	Calc.	Detd.	Calc.
67	25% Wheelwright Egg 45% Wheelwright Slack 30% Glen Rogers	390	362	414	421	433	443	468	474	67	215
69	35% Wheelwright Egg 40% Wheelwright Slack 25% Medium-Volatile Pocahontas	381	383	406	412	433	437	467	469	300	551
87	25% Orient No. 1 (1½" x ¾") 50% Wheelwright Slack 25% Medium-Volatile Pocahontas	381	382	411	...	430	432	467	463	70	356
94	80% Orient No. 1 (1½" x ¾") 20% Medium-Volatile Pocahontas	...	379	407	...	413	417	445	453	7.3	248
124	85% Orient No. 1 (2" x ⅜") 15% Pocahontas-Carswell	369	382	406	416	416	430	447	455	6.0	11.0
125	85% Orient No. 1 (2" x ⅜") 15% Eccles	374	379	412	414	419	430	447	456	5.7	104
127	85% Sahara No. 16 (3" x 2") 15% Pocahontas-Carswell	373	384	417	419	428	431	453	459	9.7	8.5
129	85% Sahara No. 16 (3" x 2") 15% Medium-Volatile Pocahontas	381	376	417	411	437	427	461	458	21	190

148	80% Ziegler No. 1 and 2 10% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	377	371	420	411	425	423	454	448	5.2	131
154	80% Old Ben No. 11 20% Pocahontas-Carswell	381	384	405	417	415	429	448	452	8.1	13.4
155	80% Old Ben No. 11 20% Buccaneer	372	373	397	407	425	425	454	453	30.8	379
166	60% Old Ben No. 14 40% Pocahontas-Carswell	384	390	...	429	425	441	450	460	2.9	12.8
173	80% Jefferson No. 20 20% Pocahontas-Carswell	365	...	399	415	419	431	452	458	22.8	37.6
176	80% Buckhorn 20% Pocahontas-Carswell	362	378	395	405	419	426	455	463	109	379
73	25% Amherst Eagle. 45% Wheelwright Slack 30% Glen Rogers	381	389	408	419	434	444	470	477	325	2068

Table 25.—Correlation of Coal Blend Fluidities and Coke Characteristics

Coke properties	Fluidity Range: 0–9.9, 37 Tests, Mean value	Deviation Max.	Deviation Av.	10–19.9, 5 Tests, Mean value	Deviation Max.	Deviation Av.	20–49.9, 10 Tests, Mean value	Deviation Max.	Deviation Av.	50–99.9, 3 Tests, Mean value	Deviation Max.	Deviation Av.	100–199.9, 5 Tests, Mean value	Deviation Max.	Deviation Av.	200–299.9, 2 Tests, Mean value	Deviation Av.
Shatter + 2"	63.2	13.4	4.6	65.5	6.3	4.5	67.7	7.4	3.5	65.5	4.2	2.8	67.3	6.3	4.1	64.6	2.8
Shatter + 1½"	86.5	7.3	2.1	86.7	3.1	1.9	87.5	3.4	1.7	88.0	0.9	0.6	88.3	2.7	1.5	85.7	1.2
Tumbler + 1"	50.1	12.7	2.8	49.6	4.6	3.0	48.9	6.9	3.4	47.8	12.0	8.0	52.5	5.8	2.6	47.7	4.1
Tumbler + ¼"	66.3	7.3	1.5	66.7	2.2	1.4	64.8	4.1	2.1	64.5	7.8	5.2	66.6	4.4	2.5	67.7	0.8
Size + 2"	75.1	11.0	4.0	74.2	8.1	4.2	79.9	4.7	2.5	79.7	0.4	0.3	79.0	5.2	3.6	80.3	4.5
Size 2" x ½"	21.1	10.7	3.9	22.4	7.8	4.0	16.7	4.5	2.3	17.0	0.8	0.5	17.9	4.9	3.5	16.9	4.4
Size − ½"	3.7	2.6	0.4	3.4	0.3	0.1	3.4	0.8	0.2	3.3	0.4	0.2	3.1	0.3	0.1	2.9	0.2
Av. size	2.48	.56	.12	2.46	.23	.15	2.60	.22	.11	2.63	.03	.02	2.60	.17	.11	2.70	.19
Breeze (−½") % of coal	2.5	1.5	0.3	2.3	0.1	0:0	2.3	0.6	0.2	2.2	0.2	0.1	2.2	0.3	0.1	2.0	0.1
App. gr.	.809	.037	.016	.811	.026	.014	.819	.048	.015	.814	.044	.029	.843	.021	.009	.846	.003

and maximum deviations are large. Furthermore, no attention has been given to other variables in compiling this table. For these reasons, application of generalizations appearing in these data to individual cases should be made with caution. However, certain trends do appear which would seem to be worthy of further confirmation. The two trends which are most evident in this table are:

1. As the maximum fluidity of the blend increases, the percentage of breeze decreases.
2. As the maximum fluidity of the blend increases, the apparent specific gravity increases.

Carbon and Hydrogen Determinations on Cokes

Carbon and hydrogen determinations were made on most of the cokes produced in the first 95 pilot plant runs using micro methods. Data obtained are tabulated and compared with volatile matter and final coke temperature in table 33 of Appendix A. These analyses were made in order to learn whether such data could be used satisfactorily in determining the end of the coking period. Variations in hydrogen content were found to be too small to permit the use of these data for this purpose, due probably to the fact that, with but few exceptions, carbonizing conditions fell within a limited range. In a few cases where operating temperatures were decidedly different, corresponding changes in the hydrogen content of the coke were shown. These tests were discontinued when it became apparent that no practical results were being obtained.

Ash Analyses

Ash analyses were made on a number of individual coals and coal blends to determine the general characteristics of the ash which would enter into the slag reaction in blast furnace operation. A few coke ash analyses also were made to compare with the ash from the coal blends, and good checks were obtained.

In general, there is about the same ratio between acids and alkalies in the ash from Illinois coals tested as in the ash from the eastern high-volatile coals tested. Ash analyses are tabulated in table 26.

BY-PRODUCTS

Scope of By-Product Tests

The examination of by-products was not complete. Primary emphasis of the project has been on the coke, and although all tars were tested in the laboratory, light oils and aqueous liquors were not collected. An outline of the by-product tests that were made follows.

GAS

The gas was metered and a continuous record of its heating value was obtained from the recording calorimeter. At 30-minute intervals during each run a small sample (usually 0.002 times the preceding half hour's make) was diverted into a 5 cu. ft. gas holder. The resulting composite gas sample was used to determine the heating value of the gas for that run. The locations of meter, calorimeter and gas holder are shown in figure 7, and data on gas yields and heating values are given in table 32, Part F, of Appendix A.

LIGHT OIL

Although the available equipment and personnel did not permit collection and examination of light oil, the composite gas samples from several runs were subjected to the freezing method of estimating light oil.[15] The results were of the order of magnitude of half that obtained in commercial practice, and were not significantly different for different blends of coal, whether all-eastern coals or part Illinois coals. It is thought that two factors may have contributed to these low values: loss of light oil in the gas purification train and low top temperature in the oven. It was not possible to investigate this phase of the problem in more detail.

TABLE 26.—ASH ANALYSES

Lab. No.	Run No.	Description	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	SO_3 %	Loss on ignition %	Alkalies by diff. %
		Illinois Coals								
C-3470		Orient No. 1 (1½" x ¾" Washed)	54.49	26.12	7.77	1.11	3.71	2.45	1.57	2.78
C-3778		Orient No. 1 (2" x ⅜" Washed)	50.88	24.75	10.78	1.06	4.20	4.06	3.05	1.22
C-3515		Sahara No. 16 (6" x 28 mesh Washed)	48.76	29.23	11.28	1.21	3.66	2.08	1.44	2.34
C-3775		Madison County (3" x ½" Raw)	49.10	23.01	10.97	1.01	6.12	5.85	2.51	1.43
		Indiana Coal								
C-3724		Saxton (2" x 1¼" Raw)	50.04	36.24	3.86	1.03	2.65	0.73	1.04	4.41
		Eastern High-Vol. Coals								
C-3533		Wheelwright Egg	31.58	28.21	21.38	1.88	7.14	5.93	2.20	1.68
C-3585		Amherst Eagle	52.02	31.48	6.28	1.00	3.12	2.54	2.11	1.45
C-3886		Midvale	46.59	28.97	14.45	1.06	3.28	1.71	0.83	1.11
		Low- and Medium-Vol. Coals								
C-3513		Pocahontas-Carswell	41.19	26.24	10.99	1.56	9.20	7.21	1.58	2.03
C-3498		Medium-Volatile Pocahontas	42.71	22.05	11.54	2.63	9.57	8.81	2.66	0.03
C-3524		Glen Rogers (Raw)	42.50	32.65	14.70	1.30	2.89	2.44	1.21	2.31
C-3532		Glen Rogers (Washed)	46.64	34.77	8.20	1.12	3.33	2.81	1.36	1.77
C-3833		Eccles (Washed)	50.03	34.49	6.87	0.97	2.28	2.07	1.24	2.05

		Coal Blends and Cokes								
C-3514	59	65% Sahara No. 16 (6" x 28 mesh) 35% Pocahontas-Carswell	46.00	28.05	11.00	1.31	5.41	4.73	1.77	1.73
C-3521		Coke from Run No. 59	46.62	27.87	12.39	1.34	5.28	3.03	1.85	1.63
C-3584	73	45% Wheelwright Slack 25% Amherst Eagle 30% Glen Rogers (Washed)	45.30	31.15	10.21	1.42	4.01	3.61	3.07	1.23
C-3826	86	65% Saxton (2" x 1¼") 35% Pocahontas-Carswell	46.96	33.22	5.88	1.06	5.27	2.36	1.53	3.72
C-3832	110	25% Orient No. 2 (2" x ⅜") 18% Wheelwright Egg 32% Wheelwright Slack 25% Eccles	47.23	28.99	13.11	1.49	3.13	1.91	1.18	2.96
C-3837		Coke from Run No. 110	47.12	28.14	13.87	1.31	3.08	2.07	1.84	2.57
C-3892	122	65% Orient No. 1 (2" x ⅜") 25% Midvale 10% Pocahontas-Carswell	52.07	25.91	9.20	1.19	4.29	3.40	1.43	2.51
C-3897		Coke from Run No. 122	50.78	26.67	11.08	1.28	4.99	1.33	0.89	2.98

TABLE 27.—EFFECT OF CARBONIZING CONDITIONS ON TAR CHARACTERISTICS
Key to Abbreviations is given in Table 30, Appendix A

Run No.	Blend carbonized		Flue temp. limits, °F.	Temp. rise, °F. per hr.	Sp. gr. 60°F.	Percent of dry tar		
	Coals	%				Free Carbon	Tar acids	Naphthalene
25	01 1½" x ¾", PC	60–40	1500–1750	15	1.143	3.9	10.5	4.6
33	01 1½" x ¾", PC	60–40	1600–1850	30	1.156	5.3	8.1	6.5
9	01 1½" x ¾", PC	60–40	1600–1850	50	1.171	4.9	6.6	7.5
108	01 2" x ⅜", MVP	85–15	1600–1860–1970	30, 20	1.153	3.5	9.4	6.2
138	01 2" x ⅜", MVP	85–15	1600–1860	40	1.157	3.1	8.2	6.1
102	01, Wn, PC	75–15–10	1600–1860–1970	30, 20	1.157	3.7	9.2	5.9
95	01, Wn, PC	75–15–10	1600–1860	40	1.159	4.0	8.9	6.0
103	01, Wn, PC	75–15–10	1600–1860	40	1.153	4.0	8.9	6.2
37	E5 1½" x ⅜", PC	70–30	1500–1750	15	1.136	3.1	11.4	4.1
36	E5 1½" x ⅜", PC	70–30	1600–1850	30	1.151	4.8	9.3	6.2
88	We, Ws, PI	20–45–35	1600–1850	30	1.150	3.3	6.3	6.8
24	We, Ws, PI	20–45–35	1600–1850	30	1.162	6.2	6.1	6.5
23	We, Ws, PI	20–45–35	1600–1850	50	1.170	7.8	5.1	7.4
8	E5, PC	60–40	1600–1850	50	1.16	5.0	6.7	7.3
7	E5, PC	60–40	1650–1900	50	1.16	5.5	6.2	8.1
14	E5, PC	60–40	1650–1950	50	1.16	4.5	5.7	8.1
15	E5, PC	60–40	1650–2000	64	1.16	5.0	5.4	8.9
122	01, Md, PC	65–25–10	1600–1860	40	1.156	3.2	8.2	6.1
	Koppers Plant Tar				1.194	6.1	3.1	9.5

TAR

The tar samples from the tar separator (fig. 7) were measured by volume and taken to the laboratory for moisture, free carbon, and specific gravity determinations. Subsequently, the dried tar was distilled to 350° C. in a 1-liter, short-necked distilling flask analogous to the flask used in standard tar distillation procedures[16] and the distillate extracted and the extracts distilled for the determination of tar acids, bases, neutrals, and naphthalene. Phenol, *o-*, *m-*, and *p*-cresols were determined where tar acid fractions were of sufficient size, and in a number of other cases the tar acids from similar carbonization runs were combined and the phenolic compounds were determined on the combined samples.

For the examination of these tars, modifications of standard and published procedures were developed to suit the needs of the problem and the size of samples available. For example, it is known that simple extraction with aqueous alkali and acid does not give a clean-cut separation of the weak acids (phenols), weak bases, and the neutrals,[17] and for this reason the somewhat involved extraction procedure was used. Inasmuch as the methods used have not been described elsewhere, they are given in considerable detail and with supplementary notes in Appendix B.

Tabulated results of composition of tars tested are given in tables 34 and 35 of Appendix A.

Discussion of By-Product Tests

An attempt has been made to ascertain whether changes in carbonizing conditions and composition of coal blends have caused any significant changes in tar properties. The following paragraphs with tabulated data indicate that certain trends are distinguishable. It might be well to point out that the tar studies are subject to some error, due to the fact that each tar may have been contaminated by a small amount of tar which remained in the collecting system from the previous run. It is believed, however, that such error was not great enough to affect the direction of trends herein noted.

EFFECT OF CARBONIZING CONDITIONS ON TAR CHARACTERISTICS

The trends observed in this phase of the investigation are in line with those usually noted in commercial coke oven operation. Table 27 presents data which support the following general conclusions: with increasing severity of carbonizing conditions, one may expect an increase in tar specific gravity and in naphthalene content, and a decrease in tar acids; the trend in "free carbon" may be upward, although the data are not conclusive. The last two entries in this table compare the pilot oven tar with commercial tar (Koppers Company) for the same coal blend, and indicate that the tar in the commercial oven was subjected to considerably more drastic cracking conditions.

EFFECT OF VARYING THE PROPORTIONS OF HIGH- AND LOW-VOLATILE COALS

The runs made on various blends of all-eastern coals were insufficient in number and of too low a range of blend composition to warrant drawing conclusions. A number of comparisons are possible in cases where the percentage of Illinois high-volatile coal was changed while operating conditions remained constant, and these are presented in table 28.

Tar yields and data are less reliable for the early runs than later when more experience had been gained. An operating difficulty encountered on Run 125 affected tar results on that and several subsequent runs; these are excluded from comparisons.

In general, it will be noted that specific gravity and naphthalene content show no significant trend in variation as the percentage of high-volatile coal in the blend is decreased, but total tar yield and percentage of acids in the tar decrease.

The last group in the table comprises runs made on blends containing only Illinois high-volatile coals.

TABLE 28.—EFFECT ON TAR CHARACTERISTICS OF VARYING THE PROPORTIONS OF HIGH- AND LOW-VOLATILE COALS
Key to Abbreviations is given in Table 30, Appendix A

Run No.	Blend carbonized		Flue temp. limits °F.	Rate of rise °F.	Sp. gr.	Tar acids	Naphthalene	Tar yield gal./T coal charged
	Coals	%						
29	Z, PC	100–0	1600–1850	50	1.151	11.8	5.0	7.6
28	Z, PC	80–20	1600–1850	50	1.147	9.0	6.1	6.8
3	Z, PC	70–30	1600–1850	50	1.176	5.5	8.0	5.4
4	Z, PC	60–40	1600–1850	50	1.166	5.8	7.7	5.6
5	Z, PC	50–50	1600–1850	50	1.168	5.7	8.1	5.3
178	J, PC	80–20	1600–1900	40	1.151	9.8	6.1	8.0
173	J, PC	80–20	1600–1900	40	1.151	10.0	5.8	8.0
174	J, PC	60–40	1600–1900	40	1.155	7.6	6.9	6.0
165	OB14, PC	80–20	1570–1860	40	1.148	9.9	6.4	8.5
166	OB14, PC	60–40	1560–1860	40	1.149	9.7	6.2	7.9
176	Bh, PC	80–20	1600–1900	40	1.158	8.9	6.2	8.8
177	Bh, PC	60–40	1600–1900	40	1.153	8.2	6.5	6.8
154	OB11, PC	80–20	1570–1860	40	1.156	9.3	6.1	7.4
164	OB11, PC	60–40	1570–1860	40	1.153	7.6	6.9	6.5
180	H, PC	80–20	1650–1900	40	1.159	8.6	6.4	7.6
181	H, PC	60–40	1650–1900	40	1.156	7.8	6.4	5.9
182	M, PC	80–20	1650–1900	40	1.154	8.5	6.9	6.7
183	M, PC	60–40	1650–1900	40	1.158	6.5	7.6	6.1
159	Mn, PC	80–20	1560–1850	40	1.154	9.1	5.8	9.2
163	Mn, PC	60–40	1560–1850	40	1.156	7.5	6.6	7.1
66	S516, PC	80–20	1600–1850	30	1.157	5.8	6.8	7.4
65	S516, PC	65–35	1600–1850	30	1.157	4.5	6.9	6.9
48	S16 3″ x 1″, PC	90–10	1600–1850	30	1.143	9.9	5.0	9.1
44	S16 3″ x 1″, PC	80–20	1600–1850	30	1.145	9.1	5.7	6.2
42	S16 3″ x 1″, PC	70–30	1600–1850	30	1.143	8.9	5.7	5.7
49	S16 3″ x 1″, PC	60–40	1600–1850	30	1.145	9.2	6.2	5.9
47	S16 6″ x 1″, PC	90–10	1600–1850	30	1.138	9.5	5.6	6.6
41	S16 6″ x 1″, PC	70–30	1600–1850	30	1.144	8.4	6.3	5.8
60	S16 6″ x 28m, PC	80–20	1600–1850	30	1.148	6.9	5.6	6.8
59	S16 6″ x 28m, PC	65–35	1600–1850	30	1.150	5.6	6.6	6.4
140	O1, PC	90–10	1600–1860	40	1.153	9.7	6.2	8.8
130	O1, PC	85–15	1600–1860	40	1.153	8.7	6.2	7.0
124	O1, PC	85–15	1600–1860	40	1.159	7.7	6.6	6.8
131	O1, PC	75–25	1600–1860	40	1.157	8.3	6.8	7.6
148	Z, MVP, PC	80–10–10	1600–1860	40	1.157	9.2	5.5	6.7
151	Z, MVP, PC	60–20–20	1600–1860	40	1.161	6.8	6.3	8.2
143	O1, MVP, PC	80–10–10	1600–1860	40	1.154	9.0	6.1	7.9
144	O1, MVP, PC	70–15–15	1600–1860	40	1.156	8.8	6.4	7.9
147	O1, MVP, PC	60–20–20	1600–1860	40	1.163	7.6	6.1	6.8
80	O1, S16	80–20	1600–1850	30	1.155	10.0	5.5	8.9
81	O1, S16	70–30	1600–1850	30	1.165	11.4	5.3	9.2
82	O1, S16	60–40	1600–1850	30	1.162	12.1	5.0	8.7

TABLE 29.—EFFECT ON TAR CHARACTERISTICS OF SUBSTITUTION OF ILLINOIS HIGH-VOLATILE FOR EASTERN HIGH-VOLATILE COAL
Key to Abbreviations is given in Table 30, Appendix A

Run No.	Blend carbonized		Flue temp. limits °F.	Rate of rise, °F.	Sp. gr. 60° F.	Tar acids	Naphthalene	Tar yield gal./T coal charged
	Coals	%						
103	O1, Wn, PC	75–15–10	1600–1860	40	1.153	8.9	6.2	8.0
95	O1, Wn, PC	75–15–10	1600–1860	40	1.159	8.9	6.0	8.1
140	O1, PC	90–10	1600–1860	40	1.153	9.7	6.2	8.8
52	O1, Ws, PI	20–50–30	1600–1850	30	1.148	8.3	6.4	8.5
51	O1, Ws, PI	40–30–30	1600–1850	30	1.148	8.3	6.5	8.0
122	O1, Md, PC	65–25–10	1600–1860	40	1.156	8.2	6.1	8.3
140	O1, PC	90–10	1600–1860	40	1.153	9.7	6.2	8.8
139	O1, KWA, PC	65–25–10	1600–1860	40	1.155	9.2	6.2	9.6
93	O1, S5, PC	65–25–10	1600–1860	40	1.159	9.3	6.0	8.1
123	O1, Md, PC	70–15–15	1600–1860	40	1.158	8.3	6.3	7.6
134	O1, Md, PC	70–15–15	1600–1860	40	1.155	8.3	6.0	7.5
130	O1, PC	85–15	1600–1860	40	1.153	8.7	6.2	7.0(?)
124	O1, PC	85–15	1600–1860	40	1.159	7.7	6.6	6.8
111	O1, S5, PC	70–15–15	1600–1860	40	1.150	10.1	6.2	7.7
(a)	Ws, GR	70–30	1600–1850	30	1.159	5.6	6.3	8.1
(b)	O1, Ws, GR	25–45–30	1600–1850	30	1.155	7.2	6.4	8.2
(c)	Ws, Ec	75–25	1600–1850	30	1.155	7.0	6.1	9.6
(d)	O2, Ws, Ec	25–50–25	1600–1850	30	1.154	7.1	6.1	8.5

(a) Average values of 4 runs: 61, 70, 72, 79
(b) Average values of 5 runs: 63, 76, 77, 85, 104
(c) Average values of 4 runs: 118, 119, 120, 121
(d) Average values of 5 runs: 113, 114, 115, 116, 117

SUBSTITUTION OF ILLINOIS HIGH-VOLATILE FOR EASTERN HIGH-VOLATILE COALS

In view of the fact that the high-volatile coals of Illinois are of higher oxygen content, an increase in the percentage of these coals in blends carbonized might be expected to result in an increase in tar acids. This trend could be noted in the preceding table. However, the substitution of Illinois coal for a part of the eastern high-volatile coal in blends otherwise alike in preparation and coking conditions did not result in very marked tar acid increases. Table 29 gives results of various runs, grouped for ready comparison. It will be noted that the substitution of Illinois for eastern high-volatile coals is from 15 to 25 percent of the coal blend; more conclusive evidence as to the effects of this substitution could be gained by comparisons of blends involving higher percentage changes.

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APPENDIX A

Complete Tabular Data on Experimental Coking Runs Made Through June 30, 1945

This section presents in tabular form the complete data on coal analyses and testing, on coke oven operation, coke tests and analyses, and on tar investigations.

The tests are listed in chronological order.

In certain of these tables, abbreviations are used for the names of coals. These abbreviations, together with information on the source of the coals, are listed in table 30. Table 36 is an index to carbonization run numbers, and is arranged alphabetically by coals used. It is cross-indexed.

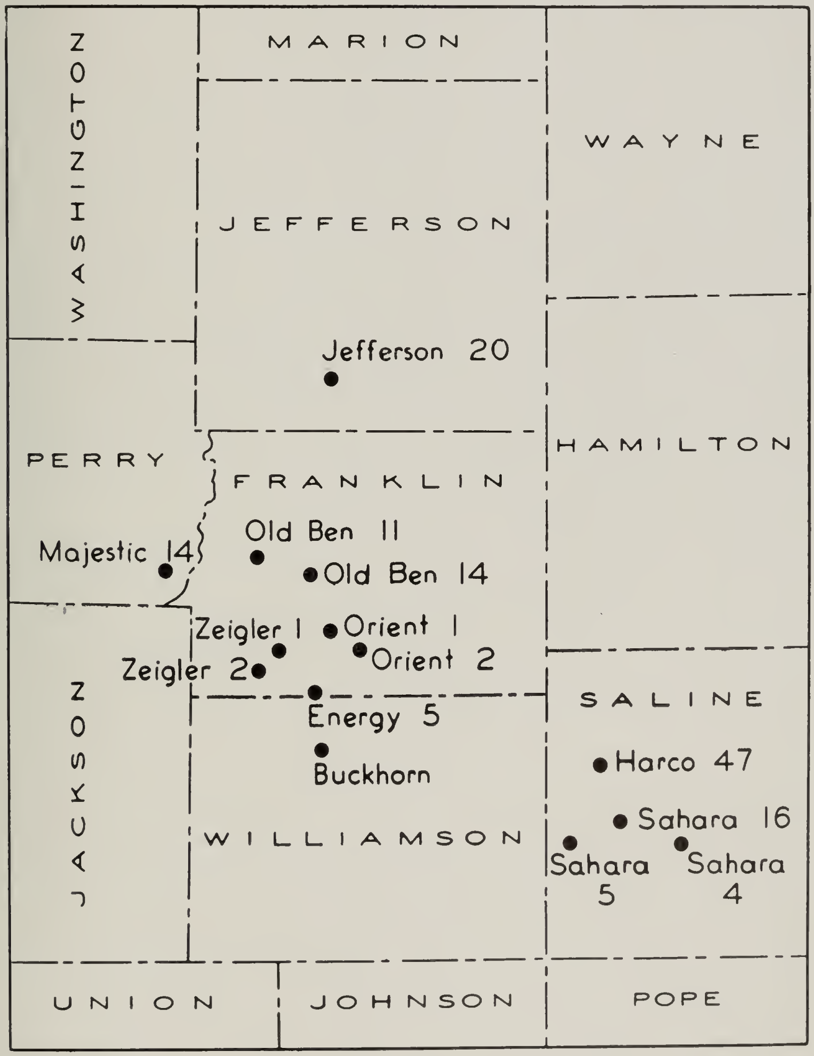

Fig. 9.—Low-sulfur coal area of southern Illinois showing locations of mines sampled.

Table 30.—Names and Sources of Coals Tested with Abbreviations Used

Coal Designation	Abbreviation	Seam	State	County
Amherst Eagle	AE	Eagle	W. Va.	Logan
Buccaneer	Bc	Cary	Va.	Buchanan
Buckhorn	Bh	5	Ill.	Williamson
Corban	C	....	Eastern	....
Eccles	Ec	Beckley	W. Va.	Raleigh
Energy No. 5	E5	6	Ill.	Franklin
Glen Rogers	GR	Beckley	W. Va.	Wyoming
Harco No. 47	H	5	Ill.	Saline
Jefferson No. 20	J	6	Ill.	Jefferson
Kentucky White Ash	KWA	Adair	Ky.	Daviess
Madison County	MC	6	Ill.	Madison
Majestic No. 14	M	6	Ill.	Perry
Medium-Volatile Pocahontas	MVP	Pocahontas 3	W. Va.	McDowell
Midvale	Md	No. 2 Gas	W. Va.	Fayette
Minonk	Mn	2	Ill.	Woodford
Old Ben No. 11	OB11	6	Ill.	Franklin
Old Ben No. 14	OB14	6	Ill.	Franklin
Orient No. 1	O1	6	Ill.	Franklin
Orient No. 2	O2	6	Ill.	Franklin
Petroleum Coke	PetC	....	....	....
Pocahontas-Carswell	PC	Pocahontas 3	W. Va.	McDowell
Pocahontas-Inland Steel	PI	Pocahontas 3	W. Va.	McDowell
Pocahontas-Inland, D.P.C.	PDP	....	....	....
Sahara No. 5 (and No. 4 + No. 5)	S5	5	Ill.	Saline
Sahara No. 16	S16	5	Ill.	Saline
Sahara No. 5 + No. 16	S516	5	Ill.	Saline
Saxton	Sx	IV	Ind.	Vigo
Wharton	Wn	Hernshaw	W. Va.	Boone
Wheelwright (egg)	We	Elkhorn 3	Ky.	Floyd
Wheelwright (slack)	Ws	Elkhorn 3	Ky.	Floyd
Zeigler No. 1 + No. 2	Z	6	Ill.	Franklin

Table 31.—Analyses of Coals and Coal Blends
Part A. Coals—Proximate Analyses
(On the "as received" basis)

Lab. No.	Coal	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
C-3585	Amherst Eagle	3.0	30.8	59.9	6.3	0.71	13962	8.0
C-4032	Buccaneer (1¼″ x ¾″)	0.9	21.3	66.3	11.5	1.51	13676	8.5
C-4151	Buckhorn (1½″ x ¾″ Washed)	5.9	35.3	48.9	9.9	3.15	12343	4.0
C-3381	Corban (Raw)	4.2	33.3	53.7	8.8	1.24	12963	4.0
C-3967	Corban (Raw)	4.2	32.6	55.7	7.5	0.84	13374	6.0
C-3833	Eccles (⅝″ x 0 Washed)	0.9	17.3	75.1	6.7	0.80	14516	9.0
C-3845	Eccles (⅝″ x 0 Washed)	1.2	17.2	72.9	8.7	0.98	14067	8.5
C-3862	Eccles (⅝″ x 0 Washed. Heat Dried.)	0.9	17.9	73.7	7.5	0.96	14316	9.0
C-3027	Energy No. 5 (3″ x 2″ Raw)	7.6	34.2	48.5	9.7	0.63	11969	4.5
C-3040	Energy No. 5 (1½″ x ⅜″ Washed)	8.7	32.7	50.9	7.7	0.73	12144	4.5
C-3086	Energy No. 5 (1½″ x ⅜″ Washed)	10.5	31.2	51.2	7.1	0.67	11960	5.0
C-3279	Energy No. 5 (1½″ x ⅜″ Raw)	8.5	32.4	51.1	8.0	0.81	12163	5.0
C-3524	Glen Rogers (Mine Run—Raw)	0.9	18.8	70.1	10.2	0.98	13824	9.0
C-3532	Glen Rogers (Mine Run—Washed)	4.1	18.8	69.7	7.4	0.73	13784	9.0
C-3569	Glen Rogers (Float—1.5 gr.)	1.1	19.1	74.3	5.5	0.73	14620	9.0
C-3579	Glen Rogers (Float—1.4 gr.)	1.6	19.6	74.9	3.9	0.56	14872	9.5
C-3624	Glen Rogers (Mine Run—Raw Course Grind)	1.2	16.7	70.0	12.1	0.55	13437	7.5
C-3632	Glen Rogers (Mine Run—Washed)	2.9	17.7	70.9	8.5	0.75	13812	7.5
C-3704	Glen Rogers (Mine Run—Washed)	2.4	18.1	71.1	8.4	0.72	13900	9.0
C-3782	Glen Rogers (Mine Run—Washed)	4.4	17.6	69.7	8.3	0.72	13661	8.5
C-4175	Harco No. 47 (3″ x 2″ Washed)	6.8	32.2	53.8	7.2	1.83	12701	5.5
C-4139	Jefferson No. 20 (1½″ x ¾″ Raw)	8.7	30.8	51.8	8.7	1.16	11979	5.5
C-4158	Jefferson No. 20 (1½″ x ¾″ Float at 1.5 gr.)	9.0	32.7	51.2	7.1	1.15	12272	4.5
C-3986	Kentucky White Ash (Brazil Lower Block—Raw)	11.4	34.7	50.9	3.0	0.62	12510	2.5
C-3775	Madison County (3″ x 1½″ Raw)	15.5	29.1	43.9	11.5	1.26	10334	3.0
C-4182	Majestic No. 14 (3″ x 1½″ Washed)	8.6	33.7	49.7	8.0	1.27	11956	4.0
C-3498	Medium-Volatile Pocahontas (Slack—Raw)	2.1	22.2	69.5	6.2	0.62	14518	9.0
C-3562	Medium-Volatile Pocahontas (Slack—Raw)	1.0	22.7	69.3	7.0	0.56	14506	9.0
C-3825	Medium-Volatile Pocahontas (Slack—Raw)	2.3	21.9	69.7	6.1	0.56	14492	9.0
C-3913	Medium-Volatile Pocahontas (Slack—Raw)	2.5	21.7	69.0	6.8	0.54	14265	9.0

TABLE 31.—PART A.—(Continued)

Lab. No.	Coal	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
C-3980	Medium-Volatile Pocahontas (Slack—Raw)	3.8	21.8	67.3	7.1	0.54	14014	9.0
C-4109	Medium-Volatile Pocahontas (Slack—Raw)	1.7	23.3	69.3	5.7	0.63	14541	9.0
C-3886	Midvale	2.1	34.9	57.6	5.4	0.75	14250	7.5
C-4094	Midvale	2.1	33.1	56.2	8.6	0.83	13513	7.0
C-4051	Minonk (4″ x 2½″ Hand Picked. Crushed and Screened to 1″ x ⅜″)	13.4	32.8	46.8	7.0	1.38	11653	5 5
C-4079	Minonk (Same size as C-4051)	12.1	33.0	47.4	7.5	1.79	11767	5.5
C-4038	Old Ben No. 11 (2″ x 1½″ Washed)	8.2	32.9	51.5	7.4	1.03	12088	6.0
C-4052	Old Ben No. 11 (2″ x 1½″ Washed)	7.6	33.5	51.2	7.7	0.95	12176	5.5
C-4081	Old Ben No. 11 (2″ x 1½″ Washed)	8.4	33.1	51.3	7.2	1.10	12185	5.5
C-4086	Old Ben No. 14 (3″ x 2″ Washed)	8.6	32.4	51.7	7.3	0.98	12153	5.0
C-4116	Old Ben No. 14 (3″ x 2″ Washed)	8.1	33.4	50.7	7.8	1.11	12147	4.5
C-3045	Orient No. 1 (1½″ x ¾″ Washed)	9.8	32.1	50.9	7.2	0.80	12067	5.0
C-3061	Orient No. 1 (2″ x 1½″ Washed)	9.3	33.1	50.4	7.2	0.73	12162	5.0
C-3067	Orient No. 1 (6″ x 3″ Washed)	8.0	33.0	51.3	7.7	0.88	12276	4.5
C-3123	Orient No. 1 (⅜″ x 0 Air Cleaned)	8.8	31.4	50.6	9.2	0.92	11892	5.5
C-3129	Orient No. 1 (1½″ x ¾″ Washed)	8.6	32.3	52.4	6.7	0.98	12310	5.0
C-3154	Orient No. 1 (1½″ x ¾″ Washed)	9.0	32.5	52.1	6.4	0.84	12309	4.5
C-3195	Orient No. 1 (1½″ x ¾″ Washed)	9.1	31.9	51.7	7.3	0.65	12186	5.0
C-3313	Orient No. 1 (1½″ x ¾″ Washed)	8.1	33.2	52.1	6.6	0.80	12286	3.5
C-3441	Orient No. 1 (1½″ x ¾″ Washed)	9.4	31.7	51.3	7.6	0.78	12084	4.5
C-3470	Orient No. 1 (1½″ x ¾″ Washed)	8.3	32.7	51.7	7.3	0.80	12260	5.0
C-3535	Orient No. 1 (1½″ x ¾″ Washed)	8.5	32.5	51.6	7.4	0.81	12202	4.5
C-3561	Orient No. 1 (1½″ x ¾″ Washed)	8.9	32.6	51.2	7.3	0.78	12152	4.5
C-3625	Orient No. 1 (1½″ x ¾″ Washed)	8.1	32.5	52.0	7.4	0.80	12265	5.0
C-3640	Orient No. 1 (1½″ x ¾″ Washed)	9.1	31.2	51.8	7.9	0.65	12047	5.5
C-3730	Orient No. 1 (1½″ x ¾″ Washed)	8.9	31.6	52.6	6.9	0.76	12225	4.5
C-3750	Orient No. 1 (1½″ x ¾″ Washed)	8.7	31.4	51.9	8.0	0.75	12054	5.5
C-3791	Orient No. 1 (2″ x ⅜″ Washed)	9.7	31.3	51.3	7.7	0.79	12101	5.0
C-3887	Orient No. 1 (2″ x ⅜″ Washed)	7.7	32.6	51.9	7.8	0.70	12377	5.0
C-3931	Orient No. 1 (2″ x ⅜″ Washed)	8.3	31.7	52.6	7.4	0.73	12252	5.0
C-3979	Orient No. 1 (2″ x ⅜″ Washed)	8.1	32.3	52.4	7.2	0.84	12366	5.5

TABLE 31.—PART A.—(Continued)

Lab. No.	Coal	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
C-3990	Orient No. 1 (1½″ x ¾″ Washed Weathered 6 months)	7.6	31.9	52.7	7.8	0.80	12315	4.0
C-3997	Orient No. 1 (2″ x ⅜″ Washed)	8.9	32.5	51.4	7.2	0.91	12202	5.0
C-4007	Orient No. 1 (2″ x ⅜″ Washed)	8.1	32.9	51.5	7.5	0.81	12263	5.5
C-4095	Orient No. 1 (2″ x ⅜″ Washed)	8.9	31.7	51.8	7.6	0.64	11970	5.0
C-4169	Orient No. 1 (2″ x ⅜″ Washed)	8.6	31.4	52.8	7.2	0.79	12234	4.5
C-3778	Orient No. 2 (2″ x ⅜″ Washed)	8.6	32.6	52.6	6.2	1.07	12424	3.0
C-3846	Orient No. 2 (2″ x ⅜″ Washed)	7.0	31.9	53.5	7.6	1.12	12432	5.0
C-3863	Orient No. 2 (2″ x ⅜″ Washed. Heat Dried)	6.6	32.5	53.6	7.3	0.92	12559	4.0
C-3131	Petroleum Coke (−¼″ Screenings)	4.9	12.9	82.0	0.2	2.53	14994	1.0
C-3155	Petroleum Coke (−¼″ Screenings)	4.4	12.9	82.5	0.2	2.44	15008	1.0
C-2937	Pocahontas-Carswell	2.9	17.7	73.2	6.2	0.67	.....	...
C-3513	Pocahontas-Carswell	2.0	16.5	75.5	6.0	0.66	14494	9.0
C-3543	Pocahontas-Carswell	2.6	16.2	74.4	6.8	0.72	14294	...
C-3725	Pocahontas-Carswell	1.9	16.5	75.9	5.7	0.62	14587	9.0
C-3893	Pocahontas-Carswell	2.9	17.2	74.2	5.7	0.61	14349	9.0
C-4008	Pocahontas-Carswell	2.8	16.4	74.4	6.4	0.65	14251	9.0
C-4093	Pocahontas-Carswell	2.0	17.5	74.1	6.4	0.61	14338	9.0
C-4150	Pocahontas-Carswell	1.7	16.8	74.3	7.2	0.72	14345	8.5
C-3966	Pocahontas-Inland DPC	4.2	17.5	69.4	8.9	0.73	13471	7.0
C-3440	Pocahontas-Inland Steel	3.0	17.1	71.6	8.3	0.59	13972	9.0
C-3448	Pocahontas-Inland Steel	4.4	17.2	69.5	8.9	0.60	13633	9.0
C-3740	Pocahontas-Inland Steel	4.0	16.2	71.9	7.9	0.55	13863	9.0
C-3943	Pocahontas-Inland Steel	4.0	17.1	70.4	8.5	0.55	13758	9.0
C-3400	Sahara No. 4 and 5 (3″ x 1½″ Washed)	7.1	33.6	52.1	7.2	1.69	12617	5.5
C-3459	Sahara No. 4 and 5 (3″ x 1½″ Washed)	5.8	34.0	52.0	8.2	2.01	12669	6.0
C-3752	Sahara No. 5 (3″ x 2″ Washed)	6.2	32.7	52.4	8.7	2.49	12497	5.5
C-3314	Sahara No. 16 (6″ x 1″ Hand Picked)	7.7	31.8	54.1	6.4	0.63	12622	4.5
C-3324	Sahara No. 16 (3″ x 1″ Washed)	7.4	31.2	55.5	5.9	0.69	12781	4.5
C-3399	Sahara No. 16 (3″ x 1″ Washed)	7.9	32.1	53.8	6.2	0.82	12658	5.5
C-3515	Sahara No. 16 (6″ x 28 mesh Washed)	7.5	31.9	54.2	6.4	0.93	12719	5.0
C-3641	Sahara No. 16 (6″ x 1½″ Raw)	5.5	30.6	54.1	9.8	1.07	12397	5.0
C-3805	Sahara No. 16 (3″ x 1½″ Washed)	8.4	30.3	54.7	6.6	0.74	12562	5.5
C-3914	Sahara No. 16 (3″ x 2″ Washed)	8.3	30.1	52.8	8.8	0.78	12215	5.0
C-3542	75% Sahara No. 16 25% Sahara No. 5 (6″ x 28 mesh Washed)	8.6	31.5	52.6	7.3	1.30	12365	5.5
C-3724	Saxton (2″ x 1¼″ Raw)	14.4	30.9	47.9	6.8	0.55	11505	4.0
C-4065	Saxton (2″ x 1¼″ Raw)	13.5	31.9	48.1	6.5	0.62	11601	5.5

Table 31.—Part A.—(Concluded)

Lab. No.	Coal	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
C-2936	Wharton	2.0	35.1	56.4	6.5	0.88	.....	...
C-3790	Wharton	3.3	32.8	57.8	6.1	0.84	13952	6.0
C-3508	Wheelwright Egg (4″ x 2″ Raw)	4.1	35.6	57.7	2.6	0.67	14165	5.5
C-3533	Wheelwright Egg (4″ x 2″ Raw)	3.0	36.3	58.3	2.4	0.73	14327	5.0
C-3554	Wheelwright Egg (4″ x 2″ Raw)	4.4	34.8	57.3	3.5	0.84	13927	5.0
C-3573	Wheelwright Egg (4″ x 2″ Raw)	3.5	34.8	58.5	3.2	0.78	13904	5.0
C-3631	Wheelwright Egg (4″ x 2″ Raw)	4.7	34.8	57.0	3.5	0.81	13919	6.0
C-3706	Wheelwright Egg (4″ x 2″ Raw)	4.3	34.1	58.8	2.8	0.81	14109	6.0
C-3777	Wheelwright Egg (4″ x 2″ Raw)	4.4	34.8	57.9	2.9	0.71	14099	5.0
C-3941	Wheelwright Egg (4″ x 2″ Raw)	3.4	36.3	57.5	2.8	0.79	14248	5.5
C-3439	Wheelwright Slack (2″ x 0 Raw)	5.8	32.0	56.5	5.7	0.86	13306	5.0
C-3450	Wheelwright Slack (2″ x 0 Raw)	4.5	33.5	55.1	6.9	0.96	13356	5.0
C-3497	Wheelwright Slack (2″ x 0 Raw)	4.7	33.3	55.4	6.6	0.88	13376	5.0
C-3523	Wheelwright Slack (2″ x 0 Raw)	5.4	31.8	55.8	7.0	0.81	13126	4.5
C-3555	Wheelwright Slack (2″ x 0 Raw)	4.3	32.5	55.5	7.7	0.92	13192	4.5
C-3565	Wheelwright Slack (2″ x 0 Raw)	5.8	31.3	55.7	7.2	0.94	13096	5.0
C-3577	Wheelwright Slack (2″ x 0 Raw)	6.5	31.2	55.5	6.8	0.82	13042	5.0
C-3623	Wheelwright Slack (2″ x 0 Raw)	3.6	33.8	57.6	5.0	0.79	13805	5.0
C-3636	Wheelwright Slack (2″ x 0 Raw)	6.3	31.9	55.3	6.5	0.82	13132	4.5
C-3705	Wheelwright Slack (2″ x 0 Raw)	4.2	31.6	57 2	7.0	0.94	13382	5.5
C-3711	Wheelwright Slack (2″ x 0 Raw)	3.4	32.9	56.5	7.2	0.90	13454	5.5
C-3739	Wheelwright Slack (2″ x 0 Raw)	5.2	32.7	56.4	5.7	0.79	13487	6.0
C-3776	Wheelwright Slack (2″ x 0 Raw)	5.1	31.2	56.8	6.9	0.80	13298	5.0
C-3802	Wheelwright Slack (2″ x 0 Raw)	4.7	32.4	56.5	6.4	0.94	13416	4.5
C-3847	Wheelwright Slack (2″ x 0 Raw)	3.1	33.0	60.0	3.9	0.85	14060	5.0
C-3861	Wheelwright Slack (2″ x 0 Raw. Heat Dried)	2.7	34.3	59.9	3.1	0.71	14307	5.0
C-3943	Wheelwright Slack (2″ x 0 Raw)	3.2	36.2	56.8	3.9	0.82	14094	5.0
C-3012	Zeigler No. 1 and 2 (3″ x 2″ Washed)	9.6	32.5	50.1	7.8	0.79	12078	3.5
C-3230	Zeigler No. 1 and 2 (3″ x 2″ Washed)	8.7	31.5	53.0	6.8	0.73	12256	4.5
C-4016	Zeigler No. 1 and 2 (1½″ x ¾″ Washed)	8.3	31.9	52.5	7.3	0.97	12207	5.0
C-4026	Zeigler No. 1 and 2 (1½″ x ¾″ Washed)	8.1	32.0	53.0	6.9	0.82	12304	5.0

TABLE 31.—ANALYSES OF COALS AND COAL BLENDS
PART B. COALS—ULTIMATE ANALYSES
(On the "moisture and ash free" basis)

Lab. No.	Coal	Hydrogen %	Carbon %	Nitrogen %	Oxygen %	Sulfur %
C-3585	Amherst Eagle	5.62	86.47	1.58	5.55	0.78
C-4032	Buccaneer (1¼″ x ¾″)	5.39	87.30	1.43	4.15	1.73
C-4151	Buckhorn (1½″ x ¾″ Washed)	5.98	79.29	1.73	9.26	3.74
C-3833	Eccles (⅝″ x 0 Washed)	4.92	90.58	1.63	2.01	0.86
C-3532	Glen Rogers (Mine Run—Raw)	4.89	89.17	1.60	3.24	1.10
C-3532	Glen Rogers (Mine Run—Washed)	4.76	89.70	1.64	3.07	0.83
C-4175	Harco No. 47 (3″ x 2″ Washed)	5.80	81.42	2.05	8.60	2.13
C-4139	Jefferson No. 20 (1½″ x ¾″ Raw)	5.57	81.84	1.89	9.30	1.40
C-3986	Kentucky White Ash (Brazil Lower Block—Raw)	5.96	80.77	1.71	10.84	0.72
C-3775	Madison County (3″ x 1½″ Raw)	5.48	80.40	1.59	10.81	1.72
C-4182	Majestic No. 14 (3″ x 2″ Washed)	6.01	79.40	1.83	11.24	1.52
C-3498	Medium-Volatile Pocahontas (Slack—Raw)	5.27	89.86	1.31	2.88	0.68
C-3886	Midvale	5.91	85.74	1.66	5.88	0.81
C-4051	Minonk (4″ x 2½″ Hand Picked, Crushed and Screened to 1″ x ⅜″)	5.97	80.92	1.49	9.89	1.73
C-4086	Old Ben No. 14 (3″ x 2″ Washed)	5.68	81.43	1.78	9.95	1.16
C-3441	Orient No. 1 (1½″ x ¾″ Washed)	5.63	81.92	1.79	9.72	0.94
C-3778	Orient No. 2 (2″ x ⅜″ Washed)	5.52	81.87	1.86	9.50	1.25
C-3440	Pocahontas-Inland Steel	4.86	90.64	1.21	2.63	0.66
C-3513	Pocahontas-Carswell	4.74	90.87	1.40	2.27	0.72
C-3400	Sahara No. 4 and 5 (3″ x 1½″ Washed)	5.51	82.24	1.96	8.32	1.97
C-3399	Sahara No. 16 (3″ x 1″ Washed)	5.50	82.95	2.00	8.59	0.96
C-3515	Sahara No. 16 (6″ x 28 mesh Washed)	5.61	82.72	1.99	8.60	1.08
C-3724	Saxton (2″ x 1¼″ Raw)	5.65	81.40	1.84	10.41	0.70
C-3533	Wheelwright Egg (4″ x 2″ Raw)	5.70	85.02	1.64	6.87	0.77
C-3439	Wheelwright Slack	5.66	84.74	1.56	7.07	0.97
C-4016	Zeigler No. 1 and 2 (1½″ x ¾″ Washed)	5.71	81.12	1.82	10.20	1.15

Table 31.—Analyses of Coals and Coal Blends
Part C. Coal Blends—Proximate Analyses
(On the "as received" basis)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
1 and 2	70% Wharton 30% Pocahontas-Carswell	2.6	30.3	60.7	6.4	0.97	14063	6.0
3	70% Zeigler No. 1 and 2 (3″ x 2″ Washed) 30% Pocahontas-Carswell	7.7	27.5	57.3	7.5	0.88	12566	3.0
4	60% Zeigler No. 1 and 2 (3″ x 2″ Washed) 40% Pocahontas-Carswell	6.7	26.0	60.7	6.6	0.77	13011	2.5
5	50% Zeigler No. 1 and 2 (3″ x 2″ Washed) 50% Pocahontas-Carswell	5.7	24.1	63.7	6.5	0.74	13319	3.0
6	60% Energy No. 5 (3″ x 2″ Raw) 40% Pocahontas-Carswell	5.3	26.3	60.7	7.7	0.64	13109	3.0
7	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	5.8	26.6	60.9	6.7	0.70	13150	2.5
8	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	4.7	....	....	...	....	.....	...
9	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	6.3	25.7	62.0	6.0	0.69	13220	3.5
10	60% Orient No. 1 (2″ x 1½″ Washed) 40% Pocahontas-Carswell	6.4	26.3	60.4	6.9	0.70	13046	3.5
11	60% Orient No. 1 (6″ x 3″ Washed) 40% Pocahontas-Carswell	6.6	27.2	59.2	7.0	0.76	13010	3.0
12	55% Orient No. 1 (1½″ x ¾″ Washed) 45% Pocahontas-Carswell	7.0	25.5	60.0	7.5	0.74	12899	3.0
13	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	7.8	24.8	60.7	6.7	0.64	12830	3.0
14	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	5.5	26.0	61.8	6.7	0.65	13214	3.0
15	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	6.1	....	....	...	....	.....	...
16	50% Energy No. 5 (1½″ x ⅜″ Washed) 30% Wharton 20% Pocahontas-Carswell	5.4	28.3	60.4	5.9	0.78	13405	5.0
17	60% Orient No. 1 (⅜″ x 0 Air Cleaned) 40% Pocahontas-Carswell	6.2	25.4	60.4	8.0	0.83	12871	3.0

TABLE 31.—PART C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
18	90% Orient No. 1 (1½″ x ¾″ Washed) 10% Petroleum Coke	8.0	30.4	55.5	6.1	1.14	12567	4.5
19	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	8.4	27.9	57.9	5.8	1.23	12651	3.5
20	85% Orient No. 1 (1½″ x ¾″ Washed) 15% Petroleum Coke	7.7	30.0	56.2	6.1	1.10	12701	4.0
21	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	7.9	28.2	58.6	5.3	1.13	12853	3.5
22	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	8.2	27.7	58.4	5.7	1.12	12772	3.0
23	20% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	3.8	28.5	62.0	5.7	0.71	13927	6.0
24	20% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	2.5	28.4	63.9	5.2	0.64	14148	6.0
25	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	6.0	25.9	61.6	6.5	0.72	13120	3.0
26	60% Orient No. 1 (1½″ x ¾″ Washed) 20% Wharton 20% Petroleum Coke	5.7	29.1	59.3	5.9	1.13	13198	3.5
27	60% Orient No. 1 (1½″ x ¾″ Washed) 20% Pocahontas-Carswell 20% Petroleum Coke	6.0	25.5	62.9	5.6	1.11	13249	2.0
28	80% Zeigler No. 1 and 2 (3″ x 2″ Washed) 20% Pocahontas-Carswell	7.5	28.8	57.0	6.7	0.70	12657	4.0
29	100% Zeigler No. 1 and 2 (3″ x 2″ Washed)	9.0	31.1	53.0	6.9	0.55	12188	3.0
30	20% Wheelwright Egg 50% Wheelwright Slack 30% Pocahontas-Inland Steel	2.7	29.5	61.7	6.1	0.80	13904	5.0
31	20% Wheelwright Egg 50% Wheelwright Slack 30% Pocahontas-Inland Steel	3.0	....	....	...	....	.....	...
32	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell (⅛ of 1% oil added)	7.1	26.4	59.6	6.9	0.80	12933	2.5
33	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell (No oil added)	5.5	25.6	62.2	6.7	0.70	13138	3.0

TABLE 31.—PART C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
34	75% Corban 25% Pocahontas-Inland DPC	3.5	28.1	60.3	8.1	0.76	13388	4.0
35	75% Corban 25% Pocahontas-Inland DPC	3.8	....	....	...	....	.....	...
36	70% Energy No. 5 (1½″ x ⅜″ Raw) 30% Pocahontas-Carswell	6.6	27.7	58.1	7.6	0.76	12757	3.5
37	70% Energy No. 5 (1½″ x ⅜″ Raw) 30% Pocahontas-Carswell	7.0	26.6	58.5	7.9	0.78	12586	3.0
38	75% Corban 25% Pocahontas-Inland DPC	3.9	31.0	58.4	6.7	0.84	13513	4.5
39	75% Corban 25% Pocahontas-Inland DPC	2.8	....	....	...	....	.....	...
40	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	5.9	27.9	60.4	5.8	1.15	13012	2.0
41	70% Sahara No. 16 (6″ x 1″ Raw, Hand Picked) 30% Pocahontas-Carswell	5.8	27.2	60.9	6.1	0.63	13204	3.5
42	70% Sahara No. 16 (3″ x 1″ Washed) 30% Pocahontas-Carswell	5.0	27.4	62.0	5.6	0.72	13369	3.5
43	80% Sahara No. 16 (3″ x 1″ Washed) 20% Petroleum Coke	6.1	27.6	61.2	5.1	1.07	13292	3.0
44	80% Sahara No. 16 (3″ x 1″ Washed) 20% Pocahontas-Carswell	6.2	28.5	59.4	5.9	0.86	13113	4.5
45	80% Corban 20% Pocahontas-Inland DPC	3.2	29.9	58.7	8.2	1.08	13376	3.0
46	80% Corban 20% Pocahontas-Inland DPC (Blend reground)	2.9	30.5	58.1	8.5	1.06	13337	3.5
47	90% Sahara No. 16 (6″ x 1″ Raw, Hand Picked) 10% Pocahontas-Carswell	6.0	30.4	57.1	6.5	0.78	12837	3.5
48	90% Sahara No. 16 (3″ x 1″ Washed) 10% Pocahontas-Carswell	6.8	30.1	57.1	6.0	0.78	12915	3.5
49	60% Sahara No. 16 (3″ x 1″ Washed) 40% Pocahontas-Carswell	5.4	26.1	62.7	5.8	0.74	13419	3.5
50	40% Orient No. 1 (1½″ x ¾″ Washed) 25% Wheelwright Slack 35% Pocahontas-Inland Steel	5.2	27.5	59.6	7.7	0.78	13109	3.0
51	40% Orient No. 1 (1½″ x ¾″ Washed) 30% Wheelwright Slack 30% Pocahontas-Inland Steel	4.8	28.3	59.5	7.4	0.81	13209	3.5

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
52	20% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 30% Pocahontas-Inland Steel	4.1	28.9	60.1	6.9	0.85	13454	4.0
53	20% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 35% Pocahontas-Inland Steel	4.3	27.9	60.4	7.4	0.80	13450	3.5
54	70% Sahara No. 4 and 5 (3″ x 1½″ Washed) 30% Pocahontas-Carswell	4.4	29.5	58.6	7.5	1.67	13229	4.5
55	25% Sahara No. 4 and 5 (3″ x 1½″ Washed) 40% Orient No. 1 (1½″ x ¾″ Washed) 35% Pocahontas-Inland Steel	5.7	27.8	58.6	7.9	1.01	12890	4.5
56	25% Sahara No. 4 and 5 (3″ x 1½″ Washed) 40% Wheelwright Slack 35% Pocahontas-Inland Steel	3.9	27.7	60.9	7.5	1.10	13497	5.0
57	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	4.4	29.5	59.5	6.6	0.77	13510	6.0
58	25% Wheelwright Egg 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	3.0	29.8	62.0	5.2	0.66	14093	7.0
59	65% Sahara No. 16 (6″ x 28 mesh, Washed) 35% Pocahontas-Carswell	5.6	26.0	62.0	6.4	0.84	13265	3.0
60	80% Sahara No. 16 (6″ x 28 mesh, Washed) 20% Pocahontas-Carswell	6.0	28.9	58.5	6.6	0.88	13042	4.0
61	70% Wheelwright Slack 30% Glen Rogers (Raw)	2.9	28.5	60.9	7.7	0.86	13589	5.0
62	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	3.2	29.9	60.7	6.2	0.85	13744	5.0
63	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	5.0	27.9	60.1	7.0	0.78	13275	3.5
64	25% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 25% Glen Rogers (Washed)	5.2	28.9	59.9	6.0	0.80	13377	4.0

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
65	65% Sahara 25% No. 5 (6″ x 28 mesh, Washed) 75% No. 16 (6″ x 28 mesh, Washed) 35% Pocahontas-Carswell	6.2	26.0	60.6	7.2	1.04	13018	3.5
66	80% Sahara 25% No. 5 (6″ x 28 mesh, Washed) 75% No. 16 (6″ x 28 mesh, Washed) 20% Pocahontas-Carswell	7.3	28.0	57.1	7.6	1.21	12675	4.5
67	25% Wheelwright Egg 45% Wheelwright Slack 30% Glen Rogers (Washed)	3.8	29.0	60.4	6.8	0.83	13584	5.5
68	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	4.1	29.5	59.3	7.1	0.79	13466	6.0
69	35% Wheelwright Egg 40% Wheelwright Slack 25% Medium-Volatile Pocahontas	3.5	31.4	59.1	6.0	0.82	13811	6.5
70	70% Wheelwright Slack 30% Glen Rogers (1.5 float)	3.8	27.7	62.2	6.3	0.91	13725	5.5
71	25% Wheelwright Egg 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	3.2	30.0	60.6	6.2	0.73	13877	6.5
72	70% Wheelwright Slack 30% Glen Rogers (1.4 float)	4.4	27.2	62.9	5.5	0.78	13781	6.0
73	25% Amherst Eagle 45% Wheelwright Slack 30% Glen Rogers (Washed)	3.5	28.4	61.7	6.4	0.74	13757	6.5
74	25% Wheelwright Egg 55% Wheelwright Slack 20% Glen Rogers (Washed)	3.5	30.1	60.5	5.9	0.81	13728	5.0
75	25% Wheelwright Egg 60% Wheelwright Slack 15% Glen Rogers (Washed)	3.6	30.3	60.1	6.0	0.82	13703	5.5
76	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack (Coarse Grind) 30% Glen Rogers (Washed)	3.9	28.7	60.2	7.2	0.78	13439	5.0

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
77	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack (Fine Grind) 30% Glen Rogers (Washed)	4.4	27.6	60.4	7.6	0.80	13328	3.5
78	70% Wheelwright Egg 30% Glen Rogers (Washed)	3.1	30.5	61.8	4.6	0.75	14095	5.0
79	70% Wheelwright Slack 30% Glen Rogers (Washed)	3.3	29.3	60.9	6.5	0.77	13703	5.0
80	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Sahara No. 16 (6″ x 1½″ Raw)	8.3	31.8	51.0	8.9	0.77	12071	5.5
81	70% Orient No. 1 (1½″ x ¾″ Washed) 30% Sahara No. 16 (6″ x 1½″ Raw)	8.2	31.3	52.7	7.8	0.87	12244	4.5
82	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Sahara No. 16 (6″ x 1½″ Raw)	8.3	31.1	52.8	7.8	0.76	12226	4.5
83	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	2.4	29.2	62.3	6.1	0.81	13942	6.0
84	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	5.8	29.1	58.9	6.2	0.79	13471	6.0
85	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	4.4	27.2	60.7	7.7	0.75	13342	3.5
86	65% Saxton (2″ x 1¼″ Raw) 35% Pocahontas-Carswell	9.3	26.2	58.7	5.8	0.56	12774	3.0
87	25% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 25% Medium-Volatile Pocahontas	4.4	29.9	58.2	7.5	0.77	13300	6.0
88	20% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	3.2	26.2	63.2	7.4	0.75	13767	4.0
89	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Pocahontas-Inland Steel	5.0	26.6	61.3	7.1	0.69	13367	4.0

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
90	40% Orient No. 1 (1½″ x ¾″ Washed) 25% Wheelwright Slack 35% Pocahontas-Inland Steel	6.9	27.2	58.7	7.2	0.76	13013	4.5
91	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	3.5	27.1	63.4	6.0	0.76	13913	6.0
92	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Sahara No. 5 (3″ x 2″ Washed) 10% Pocahontas-Carswell	7.7	29.9	54.7	7.7	0.97	12469	6.0
93	65% Orient No. 1 (1½″ x ¾″ Washed) 25% Sahara No. 5 (3″ x 2″ Washed) 10% Pocahontas-Carswell	7.4	30.7	54.5	7.4	1.25	12599	5.0
94	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	7.8	30.5	53.8	7.9	0.83	12449	5.5
95	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Wharton 10% Pocahontas-Carswell	7.5	29.5	55.0	8.0	0.70	12499	4.5
96	90% Orient No. 1 (1½″ x ¾″ Washed) 10% Medium-Volatile Pocahontas	8.0	30.4	53.9	7.7	0.82	12344	5.0
97	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Sahara No. 5 (3″ x 2″ Washed) 10% Medium-Volatile Pocahontas	7.8	31.8	52.5	7.9	1.03	12278	5.0
98	25% Orient No. 2 (2″ x ⅜″ Washed) 13% Wheelwright Egg 27% Wheelwright Slack 35% Pocahontas-Inland Steel	4.5	27.7	61.8	6.0	0.87	13630	4.0
99	25% Orient No. 2 (2″ x ⅜″ Washed) 18% Wheelwright Egg 32% Wheelwright Slack 25% Glen Rogers (Washed)	4.0	29.4	60.0	6.6	0.89	13539	5.0
100	25% Orient No. 2 (2″ x ⅜″ Washed) 13% Wheelwright Egg 27% Wheelwright Slack 35% Medium-Volatile Pocahontas	4.0	28.8	60.7	6.5	0.74	13633	6.0

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
101	60% Orient No. 1 (1½" x ¾" Washed) 20% Madison County (Raw) 20% Medium-Volatile Pocahontas	8.7	29.9	54.1	7.3	0.79	12253	5.5
102	75% Orient No. 1 (2" x ⅜" Washed) 15% Wharton 10% Pocahontas-Carswell	6.8	30.0	56.1	7.1	0.79	12751	5.0
103	75% Orient No. 1 (2" x ⅜" Washed) 15% Wharton 10% Pocahontas-Carswell	6.4	30.1	56.4	7.1	0.82	12835	5.0
104	25% Orient No. 1 (1½" x ¾" Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	5.0	28.2	59.8	7.0	0.85	13319	4.5
105	65% Orient No. 1 (2" x ⅜" Washed) 25% Sahara No. 16 (3" x 1½" Washed) 10% Pocahontas-Carswell	7.0	30.0	55.5	7.5	0.82	12616	4.5
106	50% Orient No. 1 (2" x ⅜" Washed) 40% Sahara No. 16 (3" x 1½" Washed) 10% Pocahontas-Carswell	7.9	30.2	54.8	7.1	0.84	12538	4.5
107	40% Orient No. 1 (2" x ⅜" Washed) 40% Sahara No. 16 (3" x 1½" Washed) 20% Pocahontas-Carswell	6.0	29.8	56.9	7.3	0.80	12845	4.5
108	85% Orient No. 1 (2" x ⅜" Washed) 15% Medium-Volatile Pocahontas	6.7	30.3	55.4	7.6	0.75	12684	5.0
109	60% Orient No. 1 (2" x ⅜" Washed) 25% Sahara No. 16 (3" x 1½" Washed) 15% Pocahontas-Carswell	6.1	29.6	56.9	7.4	0.78	12891	3.0
110	25% Orient No. 2 (⅝" x ⅜" Washed) 18% Wheelwright Egg 32% Wheelwright Slack 25% Eccles (2" x 0 Washed)	4.0	30.3	59.8	5.9	0.91	13692	4.0
111	70% Orient No. 1 (2" x ⅜" Washed) 15% Sahara No. 16 (3" x 1½" Washed) 15% Pocahontas-Carswell	5.5	30.5	56.5	7.5	0.88	12848	4.5

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
112	25% Wheelwright Egg 50% Wheelwright Slack 25% Eccles (⅝″ x 0 Washed)	3.3	29.7	61.3	5.7	[a]0.85	13922	5.0
113[b]	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	3.7	29.6	61.2	5.5	0.85	13744	4.5
114[b]	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	3.4	29.2	62.0	5.4	0.90	13797	5.5
115[c]	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	3.2	30.1	61.4	5.3	0.76	13827	4.5
116[b]	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	3.2	29.9	61.9	5.0	0.87	13835	5.0
117[c]	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	3.8	31.9	59.3	5.0	0.78	13663	5.0
118[b]	75% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	2.2	29.9	63.7	4.2	0.88	14251	6.0
119[b]	75% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	1.9	29.9	63.7	4.5	0.97	14289	6.0
120[c]	75% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	2.2	31.7	62.4	3.7	0.77	14326	5.5
121[c]	75% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	2.0	31.4	61.9	4.7	0.80	14253	6.0
122	65% Orient No. 1 (2″ x ⅜″ Washed) 25% Midvale 10% Pocahontas-Carswell	5.6	31.4	56.1	6.9	0.71	13016	5.0

[a]Value calculated from sulfur values of ingredient coals. [b]As received from mines. [c]Heat dried coals.

TABLE 31.—PART C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
123	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Midvale 15% Pocahontas-Carswell	6.4	28.8	57.2	7.6	0.76	12820	4.5
124	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Pocahontas-Carswell	6.9	29.8	55.8	7.5	0.73	12551	3.0
125	85% Orient No. 1 (2″ x ⅜″ Washed). 15% Eccles (⅝″ x 0 Washed)	7.7	31.0	54.0	7.3	0.75	12472	4.5
126	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas	7.0	30.8	54.3	7.9	0.78	12539	4.5
127	85% Sahara No. 16 (3″ x 2″ Washed) 15% Pocahontas-Carswell	5.6	28.5	58.0	7.9	0.81	12864	3.5
128	85% Sahara No. 16 (3″ x 2″ Washed) 15% Eccles (⅝″ x 0 Washed)	6.0	28.5	57.7	7.8	0.94	12759	5.0
129	85% Sahara No. 16 (3″ x 2″ Washed) 15% Medium-Volatile Pocahontas	6.1	29.7	56.2	8.0	0.74	12749	6.0
130	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Pocahontas-Carswell	7.3	29.3	55.9	7.5	0.71	12538	3.0
131	75% Orient No. 1 (2″ x ⅜″ Washed) 25% Pocahontas-Carswell	6.9	27.6	59.1	6.4	0.72	12894	3.5
132	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	3.2	30.3	61.4	5.1	0.72	14013	6.0
133	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	3.9	....	....	...	....	.....	...
134	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Midvale 15% Pocahontas-Carswell	6.4	30.1	56.2	7.3	0.83	12771	4.0
135	25% Orient No. 1 (2″ x ⅜″ Washed) 50% Corban 25% Pocahontas-Inland DPC	4.6	28.5	59.2	7.7	0.82	13088	4.5
136	75% Corban 25% Pocahontas-Inland DPC	4.2	28.3	60.2	7.3	0.82	13479	5.0
137	25% Orient 1 (2″ x ⅜″ Washed) 50% Corban 25% Pocahontas-Inland DPC	5.2	28.4	59.1	7.3	0.79	13139	3.5

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
138	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas	7.4	30.5	55.0	7.1	0.78	12651	5.5
139	65% Orient No. 1 (2″ x ⅜″ Washed) 25% Kentucky White Ash (Brazil Lower Block) 10% Pocahontas-Carswell	8.1	30.7	55.2	6.0	0.74	12763	4.5
140	90% Orient No. 1 (2″ x ⅜″ Washed) 10% Pocahontas-Carswell	7.2	30.6	55.2	7.0	0.84	12669	4.0
141	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	6.7	30.5	55.4	7.4	0.76	12690	4.5
142	75% Kentucky White Ash (Brazil Lower Block) 25% Medium-Volatile Pocahontas	8.5	31.8	55.0	4.7	0.58	12872	2.0
143	80% Orient No. 1 (2″ x ⅜″ Washed) 10% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	7.8	30.6	54.7	6.9	0.85	12643	5.5
144	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	6.6	28.8	57.3	7.3	0.80	12786	5.0
145	70% Orient No. 1 (2″ x ⅜″ Washed) 10% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	6.2	28.9	58.0	6.9	0.83	12899	4.0
146	70% Orient No. 1 (2″ x ⅜″ Washed) 20% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	7.0	29.0	56.6	7.4	0.76	12735	5.5
147	60% Orient No. 1 (2″ x ⅜″ Washed) 20% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	5.7	26.5	60.9	6.9	0.75	13195	5.0
148	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 10% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	6.8	29.3	56.9	7.0	0.91	12714	5.5
149	70% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	6.2	27.6	59.1	7.1	0.79	12966	5.5

Table 31.—Part C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
150	70% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	6.3	28.1	58.1	7.5	0.81	12853	5.0
151	60% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	5.6	27.7	60.4	6.3	0.76	13219	5.0
152	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Pocahontas-Carswell	6.5	28.2	58.4	6.9	0.80	12772	3.5
153	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	6.7	28.9	57.2	7.2	0.86	12753	6.0
154	80% Old Ben No. 11 (2″ x 1½″ Washed) 20% Pocahontas-Carswell	7.2	29.3	56.4	7.1	0.98	12585	4.5
155	80% Old Ben No. 11 (2″ x ½″ Washed) 20% Buccaneer	6.3	30.3	54.9	8.5	1.20	12524	5.5
156	80% Old Ben No. 11 (2″ x 1½″ Washed) 10% Buccaneer 10% Pocahontas-Carswell	6.7	30.4	55.3	7.6	1.02	12594	4.0
157	70% Old Ben No. 11 (2″ x 1½″ Washed) 15% Buccaneer 15% Pocahontas-Carswell	6.4	28.9	56.9	7.8	1.04	12783	4.0
158	80% Old Ben No. 11 (2″ x 1½″ Washed) 20% Medium-Volatile Pocahontas	6.8	29.9	55.7	7.6	0.89	12642	6.0
159	80% Minonk (4″ x 2½″ hand picked, crushed and screened to 1″ x ⅜″) 20% Pocahontas-Carswell	11.0	29.9	52.4	6.7	1.34	12178	4.5
160	80% Minonk (4″ x 2½″ hand picked, crushed and screened to 1″ x ⅜″) 20% Medium-Volatile Pocahontas	11.1	31.4	50.6	6.9	1.40	12136	6.5
161	70% Minonk (4″ x 2½″ hand picked, crushed and screened to 1″ x ⅜″) 10% Medium-Volatile Pocahontas 5% Buccaneer 15% Pocahontas-Carswell	10.2	29.0	53.8	7.0	1.33	12575	5.5

TABLE 31.—PART C.—(Continued)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
162	80% Saxton (2″ x 1¼″ Raw) 20% Pocahontas-Carswell	11.3	29.1	53.3	6.3	0.65	12122	4.0
163	60% Minonk (4″ x 2½″ hand picked, crushed and screened to 1″ x ⅜″) 40% Pocahontas-Carswell	8.4	26.7	58.2	6.7	1.33	12798	4.0
164	60% Old Ben No. 11 (2″ x 1½″ Washed) 40% Pocahontas-Carswell	6.0	27.2	59.9	6.9	1.00	13001	3.0
165	80% Old Ben No. 14 (3″ x 2″ Washed) 20% Pocahontas-Carswell	7.3	29.9	55.6	7.2	0.92	12514	5.0
166	60% Old Ben No. 14 (3″ x 2″ Washed) 40% Pocahontas-Carswell	6.1	26.3	60.8	6.8	0.82	13015	3.5
167	65% Orient No. 1 (2″ x ⅜″ Washed) 17.5% Midvale 17.5% Pocahontas-Carswell	6.4	30.0	56.5	7.1	0.68	12804	4.0
168	65% Orient No. 1 (2″ x ⅜″ Washed) 17.5% Midvale 17.5% Pocahontas-Carswell	6.3	....	....	...	....	.....	...
169	80% Saxton (2″ x 1¼″ Raw) 20% Medium-Volatile Pocahontas	9.4	30.7	53.1	6.8	0.68	12250	5.5
170	65% Orient No. 1 (2″ x ⅜″ Washed) 15% Midvale 20% Pocahontas-Carswell	7.0	28.5	57.3	7.2	0.79	12758	3.0
171	70% Old Ben No. 14 (3″ x 2″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	6.5	29.2	57.1	7.2	0.97	12823	5.5
172	80% Old Ben No. 14 (3″ x 2″ Washed) 20% Medium-Volatile Pocahontas	6.8	30.6	54.5	8.1	0.96	12575	6.0
173	80% Jefferson No. 20 (1½″ x ¾″ Raw) 20% Pocahontas-Carswell	7.3	28.9	55.7	8.1	1.14	12509	5.5
174	60% Jefferson No. 20 (1½″ x ¾″ Raw) 40% Pocahontas-Carswell	6.1	26.1	59.3	8.5	0.96	12803	3.5
175	70% Jefferson No. 20 (1½″ x ¾″ Raw) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	6.6	28.5	57.5	7.4	1.26	12879	6.0

Table 31.—Part C.—(Concluded)

Run No.	Coal blend	Moisture %	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	F.S.I.
176	80% Buckhorn (1½″ x ¾″ Washed) 20% Pocahontas-Carswell	4.7	31.6	54.5	9.2	2.65	12821	5.5
177	60% Buckhorn (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	4.4	28.2	59.3	8.1	2.17	13190	4.5
178	80% Jefferson No. 20 (1½″ x ¾″, Float at 1.50 gr.) 20% Pocahontas-Carswell	7.1	29.3	56.7	6.9	1.10	12663	5.5
179	40% Jefferson No. 20 (1½″ x ¾″, Float at 1.50 gr.) 40% Orient No. 1 (2″ x ⅜″ Washed) 20% Pocahontas-Carswell	7.3	29.2	56.3	7.2	0.85	12618	3.5
180	80% Harco No. 47 (3″ x 2″ Washed) 20% Pocahontas-Carswell	6.0	28.7	58.4	6.9	1.61	13139	6.0
181	60% Harco No. 47 (3″ x 2″ Washed) 40% Pocahontas-Carswell	4.5	26.9	61.8	6.7	1.39	13345	5.0
182	80% Majestic No. 14 (3″ x 1½″ Washed) 20% Pocahontas-Carswell	7.2	30.7	54.3	7.8	1.15	12468	2.5
183	60% Majestic No. 14 (3″ x 1½″ Washed) 40% Pocahontas-Carswell	6.1	27.0	59.5	7.4	0.97	12945	2.5

Table 31.—Analyses of Coals and Coal Blends

Part D. Identification of Coals in Blends by Laboratory Number

(See page 84)

The numbers appearing in this table are Illinois State Geological Survey numbers, assigned serially to all coals analyzed. This tabulation is presented so that the reader may find analyses of individual coals used in making blends. For example, the analysis of the coal blend (C-3444) used in run no. 50 is found in table 31, Part C; to find analyses of the individual coals, one would look in Part A (or Part B for ultimate analyses) and find C-3441 under "Orient No. 1," C-3440 under "Pocahontas-Inland Steel," and C-3439 under "Wheelwright Slack."

The significance of the abbreviations is given in table 30.

Table 31.—Analyses of Coals and Coal Blends (See page 83)
Part D. Identification of Coals in Blends by Laboratory Number

Run No.	Lab. No. of blend	Lab. Nos. of individual coals
1	C-3002	Koppers Blend
2	C-3006	Koppers Blend
3	C-3013	Z C-3012, PC not analyzed
4	C-3020	Z C-3012, PC not analyzed
5	C-3019	Z C-3012, PC not analyzed
6	C-3028	E5 C-3027, PC not analyzed
7	C-3036	E5 C-3040, PC not analyzed
8	C-3041	E5 C-3040, PC not analyzed
9	C-3046	O1 C-3045, PC not analyzed
10	C-3062	O1 C-3061, PC not analyzed
11	C-3068	O1 C-3067, PC not analyzed
12	C-3078	Blend from Koppers
13	C-3087	E5 C-3086, PC not analyzed
14	C-3098	E5 C-3086, PC not analyzed
15	C-3100	E5 C-3086, PC not analyzed
16	C-3111	E5 C-3086, PC not analyzed, Wn not analyzed
17	C-3124	O1 C-3123, PC not analyzed
18	C-3130	O1 C-3129, PetC C-3131
19	C-3137	O1 C-3129, PetC C-3131
20	C-3150	O1 C-3129, PetC C-3131
21	C-3156	O1 C-3154, PetC C-3155
22	C-3170	Koppers Blend
23	C-3187	Inland Steel Blend
24	C-3191	Inland Steel Blend
25	C-3196	O1 C-3195, PC not analyzed
26	C-3209	O1 C-3195, Wn not analyzed, PetC C-3155
27	C-3210	O1 C-3195, PC not analyzed, PetC C-3155
28	C-3231	Z C-3230, PC not analyzed
29	C-3236	Z C-3230
30	C-3241	Inland Steel Blend
31	C-3250	Inland Steel Blend
32	C-3253	O1 C-3195 (?), PC not analyzed
33	C-3256	O1 C-3195 (?), PC not analyzed
34	C-3263	Inland Steel Blend
35	C-3266	Inland Steel Blend
36	C-3280	E5 C-3279, PC not analyzed
37	C-3281	E5 C-3279, PC not analyzed
38	C-3289	Inland Steel Blend
39	C-3296	Inland Steel Blend
40	C-3312	O1 C-3313, PetC C-3155 (?)
41	C-3315	S16 C-3314, PC not analyzed
42	C-3325	S16 C-3324, PC not analyzed
43	C-3343	S16 C-3324, PetC C-3155 (?)
44	C-3344	S16 C-3324, PC not analyzed
45	C-3384	C C-3381, PDP not analyzed
46	C-3385	C C-3381, PDP not analyzed
47	C-3395	S16 C-3314, PC not analyzed
48	C-3403	S16 C-3399, PC not analyzed
49	C-3413	S16 C-3399, PC not analyzed
50	C-3444	O1 C-3441, PI C-3440, Ws C-3439
51	C-3447	O1 C-3441, PI C-3440, Ws C-3439
52	C-3449	O1 C-3441, PI C-3448, Ws C-3450
53	C-3453	O1 C-3441, PI C-3448, Ws C-3450
54	C-3458	S5 C-3459, PC not analyzed
55	C-3471	O1 C-3470, S5 C-3459, PI C-3448
56	C-3475	Ws C-3450, S5 C-3459, PI C-3448
57	C-3499	O1 C-3470, MVP C-3498, Ws C-3497
58	C-3509	We C-3508, MVP C-3498, Ws C-3497
59	C-3514	S16 C-3515, PC C-3513
60	C-3518	S16 C-3515, PC C-3513
61	C-3525	Ws C-3523, GR C-3524
62	C-3531	GR C-3532, Ws C-3523, We C-3533
63	C-3534	GR C-3532, Ws C-3523, O1 C-3535
64	C-3539	GR C-3532, Ws C-3523, O1 C-3535
65	C-3544	S516 C-3542, PC C-3543
66	C-3547	S516 C-3542, PC C-3543
67	C-3556	GR C-3532, We C-3554, Ws C-3555
68	C-3560	O1 C-3561, MVP C-3562, Ws C-3555
69	C-3566	We C-3533, MVP C-3562, Ws C-3565
70	C-3570	GR C-3569, Ws C-3565
71	C-3574	We C-3573, MVP C-3562, Ws C-3565
72	C-3578	GR C-3579, Ws C-3565
73	C-3584	GR C-3532, AE C-3585, Ws C-3577
74	C-3618	GR C-3532, We C-3573, Ws C-3577
75	C-3621	GR C-3532, We C-3573, Ws C-3577
76	C-3622	GR C-3624, Ws C-3623, O1 C-3625
77	C-3628	GR C-3532 (?), Ws C-3623 (?), O1 C-3625
78	C-3633	GR C-3632, We C-3631
79	C-3639	GR C-3632, Ws C-3636
80	C-3642	S16 C-3641, O1 C-3640
81	C-3645	S16 C-3641, O1 C-3640
82	C-3701	S16 C-3641, O1 C-3640
83	C-3707	GR C-3704, We C-3706, Ws C-3705
84	C-3718	GR C-3704, We C-3706, Ws C-3711 (?)
85	C-3721	GR C-3704, O1 C-3625, Ws C-3711
86	C-3726	Sx C-3724, PC C-3725
87	C-3729	MVP C-3562, O1 C-3730, Ws C-3711
88	C-3736	PI C-3448, We C-3706, Ws C-3711 (?)
89	C-3741	PI C-3740, O1 C-3730, Ws C-3739
90	C-3744	PI C-3740, O1 C-3730, Ws C-3739
91	C-3747	PI C-3740, We C-3706, Ws C-3739
92	C-3751	O1 C-3750, S5 C-3752, PC C-3725
93	C-3755	O1 C-3750, S5 C-3752, PC C-3725
94	C-3762	O1 C-3750, MVP C-3562
95	C-3765	Koppers Blend
96	C-3768	O1 C-3750, MVP C-3562
97	C-3773	O1 C-3750, S5 C-3752, MVP C-3562
98	C-3779	PI C-3774, O2 C-3778, We C-3777, Ws C-3776
99	C-3785	GR C-3704 (?), O2 C-3778, We C-3777, Ws C-3776

Table 31.—Part D—(Concluded)

Run No.	Lab. No. of blend	Lab. Nos. of individual coals
100	C-3786	MVP C-3562, O2 C-3778, We C-3777, Ws C-3776
101	C-3789	O1 C-3750, MC C-3775, MVP C-3562
102	C-3794	O1 C-3791, Wn C-3790, PC C-3725
103	C-3797	O1 C-3791, Wn C-3790, PC C-3725
104	C-3801	O1 C-3625, Ws C-3802, GR C-3782
105	C-3806	O1 C-3791, S16 C-3805, PC C-3725
106	C-3809	O1 C-3791, S16 C-3805, PC C-3725
107	C-3821	O1 C-3791, S16 C-3805, PC C-3725
108	C-3828	O1 C-3791, MVP C-3825
109	C-3829	O1 C-3791, S16 C-3805, PC C-3725
110	C-3832	O2 C-3778, We C-3777, Ws 3-3802, Ec C-3833
111	C-3836	O1 C-3791, S16 C-3805, PC C-3725
112	C-3839	We C-3777, Ws C-3802, Ec C-3833
113	C-3850	O2 C-3846, Ws C-3847, Ec C-3845
114	C-3851	O2 C-3846, Ws C-3847, Ec C-3845
115	C-3864	O2 C-3863, Ws C-3861, Ec C-3862
116	C-3865	O2 C-3846, Ws C-3847, Ec C-3845
117	C-3868	O2 C-3863, Ws C-3861, Ec C-3862
118	C-3872	Ws C-3847, Ec C-3845
119	C-3876	Ws C-3847, Ec C-3845
120	C-3879	Ws C-3861, Ec C-3862
121	C-3883	Ws C-3861, Ec C-3862
122	C-3892	O1 C-3887, Md C-3886, PC C-3893
123	C-3896	O1 C-3887, Md C-3886, PC C-3893
124	C-3901	O1 C-3887, PC C-3893
125	C-3904	O1 C-3887, Ec C-3845
126	C-3912	O1 C-3887, MVP C-3913
127	C-3915	S16 C-3914, PC C-3893
128	C-3918	S16 C-3914, Ec C-3845
129	C-3924	S16 C-3914, MVP C-3913
130	C-3927	O1 C-3887, PC C-3893
131	C-3930	O1 C-3931, PC C-3893
132	C-3940	We C-3941, Ws C-3942, PI C-3843
133	C-3947	We C-3941, Ws C-3942, PI C-3943
134	C-3952	O1 C-3931, Md C-3886, PC C-3893
135	C-3971	O1 C-3931, C C-3967, PDP C-3966
136	C-3972	CC-3967, PDP C-3966
137	C-3977	O1 C-3931, C C-3967, PDP C-3966
138	C-3978	O1 C-3979, MVP C-3980
139	C-3983	O1 C-3979, KWA C-3986, PC C-3893
140	C-3989	O1 C-3979, PC C-3893
141	C-3991	O1 C-3990, MVP C-3980
142	C-3994	KWA C-3986, MVP C-3980
143	C-3998	O1 C-3997, MVP C-3980, PC C-3893
144	C-4001	O1 C-3997, MVP C-3980, PC C-3893
145	C-4004	O1 C-3997, MVP C-3980, PC C-3893
146	C-4009	O1 C-4007, MVP C-3980, PC C-4008
147	C-4012	O1 C-4007, MVP C-3980, PC C-4008
148	C-4015	Z C-4016, MVP C-3980, PC C-4008
149	C-4019	Z C-4016, MVP C-3980, PC C-4008
150	C-4022	Z C-4026, MVP C-3980, PC C-4008
151	C-4025	Z C-4026, MVP C-3980, PC C-4008
152	C-4029	Z C-4026, PC C-4008
153	C-4033	Z C-4026, MVP C-3980
154	C-4037	OB11 C-4038, PC C-4008
155	C-4041	OB11 C-4038, Bc C-4032
156	C-4044	OB11 C-4038, Bc C-4032, PC C-4008
157	C-4045	OB11 C-4038, Bc C-4032, PC C-4008
158	C-4050	OB11 C-4052, MVP C-3980
159	C-4055	Mn C-4051, PC C-4008
160	C-4058	Mn C-4051, MVP C-3980
161	C-4061	Mn C-4051, Bc C-4032, MVP C-3980, PC C-4008
162	C-4066	Sx C-4065, PC C-4008
163	C-4080	Mn C-4079, PC C-4008
164	C-4082	OB11 C-4081, PC C-4008
165	C-4089	OB14 C-4086, PC C-4008
166	C-4090	OB14 C-4086, PC C-4008
167	C-4096	O1 C-4095, Md C-4094, PC C-4093
168	C-4107	O1 C-4095, Md C-4094, PC C-4093
169	C-4110	Sx C-4065, MVP C-4109
170	C-4113	O1 C-4095, Md C-4094, PC C-4093
171	C-4117	OB14 C-4116, MVP C-4109, PC C-4093
172	C-4123	OB14 C-4116, MVP C-4109
173	C-4138	J C-4139, PC C-4093
174	C-4142	J C-4139, PC C-4093
175	C-4149	J C-4139, MVP C-4109, PC C-4093
176	C-4152	Bh C-4151, PC C-4150
177	C-4155	Bh C-4151, PC C-4150
178	C-4159	J C-4158, PC C-4150
179	C-4170	O1 C-4169, J C-4158, PC C-4150
180	C-4176	H C-4175, PC C-4150
181	C-4181	H C-4175, PC C-4150
182	C-4183	M C-4182, PC C-4150
183	C-4186	M C-4182, PC C-4150

Table 32.—Coke Oven Operation and Results
Part A. Oven Charge and Operation
(Oven Width 14 in.)

Run No.	Date of test 1944	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
1	Jan. 17	70% Wharton 30% Pocahontas-Carswell	49.0	84.9	52.9	2000	1970	9	...
2	Jan. 21	70% Wharton 30% Pocahontas-Carswell	49.2	84.9	52.9	1850	1824	12	355
3	Jan. 28	70% Zeigler No. 1 and 2 (3″ x 2″ Washed) 30% Pocahontas-Carswell	45.0	87.1	54.2	1850	1825	11′ 45″	360
4	Feb. 1	60% Zeigler No. 1 and 2 (3″ x 2″ Washed) 40% Pocahontas-Carswell	46.7	85.9	51.0	1850	1817	13	378
5	Feb. 4	50% Zeigler No. 1 and 2 (3″ x 2″ Washed) 50% Pocahontas-Carswell	47.2	85.1	49.2	1850	1828	13	380
6	Feb. 14	60% Energy No. 5 (3″ x 2″ Raw) 40% Pocahontas-Carswell	50.3	85.6	49.7	1850	1800	12′ 50″	377
7	Feb. 22	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	49.1	81.2	45.4	1900	1796	11′ 35″	354
8	Feb. 25	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	50.0	86.8	52.2	1850	1791	12′ 15″	370
9	Feb. 29	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	49.5	87.4	54.1	1850	1790	12′ 3″	369
10	Mar. 3	60% Orient No. 1 (2″ x 1½″ Washed) 40% Pocahontas-Carswell	46.7	81.7	44.2	1850	1805	11′ 45″	357
11	Mar. 7	60% Orient No. 1 (6″ x 3″ Washed) 40% Pocahontas-Carswell	47.4	88.0	53.3	1850	1795	11′ 45″	356
12	Mar. 10	55% Orient No. 1 (1½″ x ¾″ Washed) 45% Pocahontas-Carswell	47.5	83.9	47.8	1850	1802	11′ 53″	362
13	Mar. 16	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	44.8	88.8	49.7	1850	1797	11′ 20″	346
14	Mar. 21	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	51.6	86.6	50.3	1950	1857	11′ 5″	377
15	Mar. 23	60% Energy No. 5 (1½″ x ⅜″ Washed) 40% Pocahontas-Carswell	50.3	86.1	50.5	2000	1896	10′ 23″	389

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1944	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
16	Mar. 28	50% Energy No. 5 (1½″ x ⅜″ Washed) 30% Wharton 20% Pocahontas-Carswell	49.6	89.2	54.0	1850	1776	11′ 30″	351
17	Mar. 31	60% Orient No. 1 (⅜″ x 0 Air Cleaned) 40% Pocahontas-Carswell	48.1	90.4	57.1	1850	1779	11′ 35″	359
18	Apr. 4	90% Orient No. 1 (1½″ x ¾″ Washed) 10% Petroleum Coke	48.8	82.3	42.3	1850	1790	11′ 10″	342
19	Apr. 7	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	46.7	79.6	41.0	1850	1772	10′ 35″	329
20	Apr. 11	85% Orient No. 1 (1½″ x ¾″ Washed) 15% Petroleum Coke	50.0	93.7	59.1	1850	1778	11′ 25″	345
21	Apr. 14	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	49.5	93.4	59.4	1850	1786	11′ 10″	341
22	Apr. 18	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	52.2	67.1	37.8	1850	1804	11′ 43″	358
23	Apr. 21	20% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	48.5	77.6	43.8	1850	1799	11′ 45″	347
24	Apr. 25	20% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	52.3	82.3	51.6	1850	1787	13′ 10″	364
25	Apr. 28	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	51.1	86.8	52.6	1750	1694	17′ 30″	401
26	May 2	60% Orient No. 1 (1½″ x ¾″ Washed) 20% Wharton 20% Petroleum Coke	50.0	85.2	51.2	1850	1787	12′ 20″	360
27	May 5	60% Orient No. 1 (1½″ x ¾″ Washed) 20% Pocahontas-Carswell 20% Petroleum Coke	50.8	87.8	53.6	1850	1794	12′ 34″	364
28	May 10	80% Zeigler No. 1 and 2 (3″ x 2″ Washed) 20% Pocahontas-Carswell	50.8	89.3	54.0	1850	1784	12′ 30″	369
29	May 12	100% Zeigler No. 1 and 2 (3″ x 2″ Washed)	50.0	80.2	40.9	1850	1777	12′ 48″	375
30	May 16	20% Wheelwright Egg 50% Wheelwright Slack 30% Pocahontas-Inland Steel	51.7	76.4	44.5	1850	1794	12′ 35″	354

Table 32.—Part A.—(Continued)

Run No.	Date of test 1944	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
31	May 19	20% Wheelwright Egg 50% Wheelwright Slack 30% Pocahontas-Inland Steel	52.2	71.2	39.4	1850	1778	12′ 45″	350
32	May 23	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell (⅛ of 1% oil added)	49.7	86.6	51.4	1850	1782	12′ 50″	369
33	May 26	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Pocahontas-Carswell (No oil added)	47.0	85.8	48.9	1850	1780	12′ 30″	357
34	May 31	75% Corban 25% Pocahontas-Inland DPC	52.7	68.4	39.6	1850	1787	13′ 4″	366
35	June 2	75% Corban 25% Pocahontas-Inland DPC	52.0	61.6	35.6	1850	1772	13′ 30″	374
36	June 6	70% Energy No. 5 (1½″ x ⅜″ Raw) 30% Pocahontas-Carswell	51.0	85.4	49.8	1850	1768	13′ 10″	377
37	June 9	70% Energy No. 5 (1½″ x ⅜″ Raw) 30% Pocahontas-Carswell	49.6	88.1	53.2	1750	1678	18′ 0″	417
38	June 13	75% Corban 25% Pocahontas-Inland DPC	47.5	81.0	50.8	1850	1771	12′ 50″	360
39	June 16	75% Corban 25% Pocahontas-Inland DPC	53.6	77.9	47.1	1850	1781	13′ 0″	358
40	June 20	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Petroleum Coke	50.8	87.6	45.9	1950	1871	12′ 15″	381
41	June 22	70% Sahara No. 16 (6″ x 1″ Raw, Hand Picked) 30% Pocahontas-Carswell	49.7	86.5	50.5	1850	1783	13′ 23″	364
42	June 24	70% Sahara No. 16 (3″ x 1″ Washed) 30% Pocahontas-Carswell	50.8	86.5	45.7	1850	1797	13′ 25″	367
43	June 27	80% Sahara No. 16 (3″ x 1″ Washed) 20% Petroleum Coke	50.4	86.7	49.3	1950	1875	12′ 15″	369
44	June 29	80% Sahara No. 16 (3″ x 1″ Washed) 20% Pocahontas-Carswell	50.3	87.9	51.8	1850	1798	13′ 15″	369
45	July 5	80% Corban 20% Pocahontas-Inland DPC	52.1	[a]88.4	[a]62.6	1850	1796	13′ 25″	367
46	July 7	80% Corban 20% Pocahontas-Inland DPC (Blend reground)	53.1	81.1	51.7	1850	1803	13′ 25″	370

[a]Sizing inaccurate, some large pieces not included in sizing sample.

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1944	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
47	July 11	90% Sahara No. 16 (6″ x 1″ Raw, Hand Picked) 10% Pocahontas-Carswell	49.9	83.8	46.1	1850	1795	13′ 35″	373
48	July 14	90% Sahara No. 16 (3″ x 1″ Washed) 10% Pocahontas-Carswell	50.2	89.7	55.2	1850	1785	13′ 16″	369
49	July 19	60% Sahara No. 16 (3″ x 1″ Washed) 40% Pocahontas-Carswell	50.4	84.3	48.9	1850	1785	13′ 20″	360
50	July 21	40% Orient No. 1 (1½″ x ¾″ Washed) 25% Wheelwright Slack 35% Pocahontas-Inland Steel	50.9	89.1	57.2	1850	1772	12′ 53″	361
51	July 24	40% Orient No. 1 (1½″ x ¾″ Washed) 30% Wheelwright Slack 30% Pocahontas-Inland Steel	50.4	86.8	53.1	1850	1776	13′ 25″	370
52	July 26	20% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 30% Pocahontas-Inland Steel	50.7	90.1	58.3	1850	1782	13′ 23″	363
53	July 28	20% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 35% Pocahontas-Inland Steel	49.6	92.0	61.3	1850	1773	13′ 16″	361
54	July 31	70% Sahara No. 4 and 5 (3″ x 1½″ Washed) 30% Pocahontas-Carswell	51.3	86.5	50.5	1850	1779	13′ 40″	370
55	Aug. 2	25% Sahara No. 4 and 5 (3″ x 1½″ Washed) 40% Orient No. 1 (1½″ x ¾″ Washed) 35% Pocahontas-Inland Steel	51.0	87.1	51.5	1850	1778	13′ 25″	368
56	Aug. 4	25% Sahara No. 4 and 5 (3″ x 1½″ Washed) 40% Wheelwright Slack 35% Pocahontas-Inland Steel	51.4	90.4	59.3	1850	1775	13′ 37″	360
57	Aug. 7	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	50.5	91.5	61.9	1850	1771	13′ 10″	365
58	Aug. 9	25% Wheelwright Egg 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	50.4	91.3	62.5	1850	1772	13′ 7″	353

Table 32.—Part A.—(Continued)

Run No.	Date of test 1944	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
59	Aug. 11	65% Sahara No. 16 (6″ x 28 mesh, Washed) 35% Pocahontas-Carswell	48.7	88.4	61.4	1850	1776	13′ 37″	362
60	Aug. 14	80% Sahara No. 16 (6″ x 28 mesh, Washed) 20% Pocahontas-Carswell	49.7	85.5	50.5	1850	1785	13′ 37″	366
61	Aug. 16	70% Wheelwright Slack 30% Glen Rogers (Raw)	50.5	83.6	49.4	1850	1776	13′ 14″	359
62	Aug. 18	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	51.1	77.6	48.2	1850	1792	13′ 45″	374
63	Aug. 21	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	49.7	78.4	45.8	1850	1771	13′ 47″	377
64	Aug. 23	25% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 25% Glen Rogers (Washed)	49.9	80.6	48.6	1850	1787	13′ 45″	375
65	Aug. 25	65% Sahara 25% No. 5 (6″ x 28 mesh, Washed) 75% No. 16 (6″ x 28 mesh, Washed) 35% Pocahontas-Carswell	48.1	89.1	51.3	1850	1765	13′ 20″	368
66	Aug. 28	80% Sahara 25% No. 5 (6″ x 28 mesh, Washed) 75% No. 16 (6″ x 28 mesh, Washed) 20% Pocahontas-Carswell	47.5	89.1	51.4	1850	1765	13′ 24″	367
67	Aug. 30	25% Wheelwright Egg 45% Wheelwright Slack 30% Glen Rogers (Washed)	50.1	79.3	51.1	1850	1765	13′ 30″	367
68	Sept. 1	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	51.6	81.1	52.8	1850	1769	13′ 55″	377
69	Sept. 6	35% Wheelwright Egg 40% Wheelwright Slack 25% Medium-Volatile Pocahontas	50.8	76.9	47.5	1850	1767	13′ 42″	366
70	Sept. 8	70% Wheelwright Slack 30% Glen Rogers (1.5 float)	51.3	82.2	50.4	1850	1778	14′ 5″	376

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1944	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
71	Sept. 11	25% Wheelwright Egg 40% Wheelwright Slack 35% Medium-Volatile Pocahontas	52.5	76.1	45.3	1850	1776	13′ 50″	378
72	Sept. 13	70% Wheelwright Slack 30% Glen Rogers (1.4 float)	50.3	71.7	41.9	1850	1765	13′ 35″	365
73	Sept. 15	25% Amherst Eagle 45% Wheelwright Slack 30% Glen Rogers (Washed)	50.8	74.8	47.3	1850	1776	13′ 35″	365
74	Sept. 18	25% Wheelwright Egg 55% Wheelwright Slack 20% Glen Rogers (Washed)	50.5	74.3	47.0	1850	1774	13′ 45″	372
75	Sept. 20	25% Wheelwright Egg 60% Wheelwright Slack 15% Glen Rogers (Washed)	50.4	81.4	51.2	1850	1769	13′ 35″	362
76	Sept. 22	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack (Coarse Grind) 30% Glen Rogers (Washed)	50.5	62.7	23.0	1850	1769	14′ 10″	377
77	Sept. 25	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack (Fine Grind) 30% Glen Rogers (Washed)	52.1	92.7	61.6	1850	1780	14′ 0″	374
78	Sept. 27	70% Wheelwright Egg 30% Glen Rogers (Washed)	51.1	78.6	51.1	1850	1778	13′ 45″	364
79	Sept. 29	70% Wheelwright Slack 30% Glen Rogers (Washed)	51.1	83.9	56.7	1850	1774	13 35″	371
80	Oct. 2	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Sahara No. 16 (6″ x 1½″ Raw)	50.3	87.8	55.2	1850	1782	14′ 40″	396
81	Oct. 4	70% Orient No. 1 (1½″ x ¾″ Washed) 30% Sahara No. 16 (6″ x 1½″ Raw)	49.7	79.7	40.6	1850	1758	15′ 5″	401
82	Oct. 6	60% Orient No. 1 (1½″ x ¾″ Washed) 40% Sahara No. 16 (6″ x 1½″ Raw)	49.7	84.6	46.8	1850	1744	15′ 30″	398

Table 32.—Part A.—(Continued)

Run No.	Date of test 1944	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
83	Oct. 9	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	54.6	80.9	53.1	1850	1777	14′ 25″	388
84	Oct. 11	25% Wheelwright Egg 50% Wheelwright Slack 25% Glen Rogers (Washed)	47.7	77.6	43.8	1850	1771	13′ 42″	369
85	Oct. 13	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	51.4	82.2	52.2	1850	1774	14′ 13″	386
86	Oct. 16	65% Saxton (2″ x 1¼″ Raw) 35% Pocahontas-Carswell	49.1	86.8	50.7	1850	1769	13′ 30″	383
87	Oct. 18	25% Orient No. 1 (1½″ x ¾″ Washed) 50% Wheelwright Slack 25% Medium-Volatile Pocahontas	51.3	81.4	49.2	1875	1807	13′ 35″	382
88	Oct. 20	25% Wheelwright Egg 45% Wheelwright Slack 35% Pocahontas-Inland Steel	51.8	77.0	47.2	1850	1813	12′ 50″	367
89	Oct. 23	25% Orient No. 1 (1½″ x ¾″ Washed) 40% Wheelwright Slack 35% Pocahontas-Inland Steel	49.2	80.8	50.1	1850	1794	13′ 7″	369
90	Oct. 25	40% Orient No. 1 (1½″ x ¾″ Washed) 25% Wheelwright Slack 35% Pocahontas-Inland Steel	50.5	76.7	44.3	1850	1801	13′ 15″	370
91	Oct. 27	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	51.2	69.9	42.5	1850	1803	13′ 7″	369
92	Nov. 1	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Sahara No. 5 (3″ x 2″ Washed) 10% Pocahontas-Carswell	50.2	83.7	46.6	1850	1801	13′ 45″	384
93	Nov. 3	65% Orient No. 1 (1½″ x ¾″ Washed) 25% Sahara No. 5 (3″ x 2″ Washed) 10% Pocahontas-Carswell	51.2	75.6	37.9	1860	1807	13′ 15″	387
94	Nov. 6	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	51.1	81.5	43.8	1860	1810	12′ 55″	378

Table 32.—Part A.—(Continued)

Run No.	Date of test 1944	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
95	Nov. 8	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Wharton 10% Pocahontas-Carswell	50.3	74.5	40.3	1860	1803	13′ 25″	399
96	Nov. 10	90% Orient No. 1 (1½″ x ¾″ Washed) 10% Medium-Volatile Pocahontas	50.2	81.5	48.3	1860	1782	13′ 33″	387
97	Nov. 13	75% Orient No. 1 (1½″ x ¾″ Washed) 15% Sahara No. 5 (3″ x 2″ Washed) 10% Medium-Volatile Pocahontas	51.1	82.9	49.4	1860	1780	12′ 45″	375
98	Nov. 15	25% Orient No. 2 (2″ x ⅜″ Washed) 13% Wheelwright Egg 27% Wheelwright Slack 35% Pocahontas-Inland Steel	49 9	76.1	41.5	1860	1783	13′ 5″	366
99	Nov. 17	25% Orient No. 2 (2″ x ⅜″ Washed) 18% Wheelwright Egg 32% Wheelwright Slack 25% Glen Rogers (Washed)	51.0	81.4	50.2	1860	1789	13′ 25″	375
100	Nov. 20	25% Orient No. 2 (2″ x ⅜″ Washed) 13% Wheelwright Egg 27% Wheelwright Slack 35% Medium-Volatile Pocahontas	50.9	80.5	50.0	1860	1783	14′	385
101	Nov. 22	60% Orient No. 1 (1½″ x ¾″ Washed) 20% Madison County (Raw) 20% Medium-Volatile Pocahontas	51.1	85.2	47.1	1900	1810	14′ 53″	421
102	Nov. 27	75% Orient No. 1 (2″ x ⅜″ Washed) 15% Wharton 10% Pocahontas-Carswell	49.0	80.9	48.7	1970	1875	20′	531
103	Nov. 29	75% Orient No. 1 (2″ x ⅜″ Washed) 15% Wharton 10% Pocahontas-Carswell	49.8	82.1	45.3	1860	1787	14′	396
104	Dec. 1	25% Orient No. 1 (1½″ x ¾″ Washed) 45% Wheelwright Slack 30% Glen Rogers (Washed)	51.5	82.0	47.7	1850	1771	13′ 40″	371

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1944 and 1945	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
105	Dec. 4	65% Orient No. 1 (2″ x ⅜″ Washed) 25% Sahara No. 16 (3″ x 1½″ Washed) 10% Pocahontas-Carswell	50.0	84.3	46.5	1970	1864	20′	521
106	Dec. 6	50% Orient No. 1 (2″ x ⅜″ Washed) 40% Sahara No. 16 (3″ x 1½″ Washed) 10% Pocahontas-Carswell	48.4	80.7	41.9	1860	1794	14′	396
107	Dec. 8	40% Orient No. 1 (2″ x ⅜″ Washed) 40% Sahara No. 16 (3″ x 1½″ Washed) 20% Pocahontas-Carswell	50.1	85.7	50.5	1860	1778	14′	387
108	Dec. 11	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas	49.5	85.0	49.8	1970	1879	20′	527
109	Dec. 13	60% Orient No. 1 (2″ x ⅜″ Washed) 25% Sahara No. 16 (3″ x 1½″ Washed) 15% Pocahontas-Carswell	51.0	83.9	47.2	1860	1791	14′	388
110	Dec. 15	25% Orient No. 2 (2″ x ⅜″ Washed) 18% Wheelwright Egg 32% Wheelwright Slack 25% Eccles (⅝″ x 0 Washed)	51.5	77.3	43.3	1850	1778	14′ 20″	378
111	Dec. 18	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Sahara No. 16 (3″ x 1½″ Washed) 15% Pocahontas-Carswell	50.5	84.9	50.8	1860	1795	14′	388
112	Dec. 20	25% Wheelwright Egg 50% Wheelwright Slack 25% Eccles (⅝″ x 0 Washed)	50.7	75.2	42.1	1850	1776	13′ 30″	365
113[b]	1945 Jan. 4	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	50.7	86.6	50.4	1850	1779	14′	379
114[b]	Jan. 8	25% Orient No. 2 (2″ x ⅜″ Washed) 50% Wheelwright Slack (2″ x 0) 25% Eccles (⅝″ x 0)	50.7	87.3	51.6	1850	1800	13′ 40″	368

[b]As received from mines.

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1945	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
115[c]	Jan. 10	25" Orient No. 2 (2" x ⅜" Washed) 50% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	50.2	85.6	49.2	1850	1782	13'	355
116[b]	Jan. 12	25% Orient No. 2 (2" x ¾" Washed) 50% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	51.3	81.9	45.2	1850	1779	14' 20"	380
117[c]	Jan. 15	25% Orient No. 2 (2" x ⅜" Washed) 50% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	50.7	82.6	44.6	1850	1778	14'	378
118[b]	Jan. 17	75% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	51.3	82.9	46.0	1850	1776	14'	373
119[b]	Jan. 19	75% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	50.0	83.7	45.4	1850	1778	14'	373
120[c]	Jan. 22	75% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	50.7	84.8	49.4	1850	1782	14'	375
121[c]	Jan. 24	75% Wheelwright Slack (2" x 0) 25% Eccles (⅝" x 0)	51.1	83.1	45.0	1850	1776	14'	373
122	Jan. 26	65% Orient No. 1 (2" x ⅜" Washed) 25% Midvale 10% Pocahontas-Carswell	50.8	92.3	60.9	1860	1789	14'	403
123	Jan. 29	70% Orient No. 1 (2" x ⅜" Washed) 15% Midvale 15% Pocahontas-Carswell	51.1	84.0	45.6	1860	1783	14'	397
124	Jan. 31	85% Orient No. 1 (2" x ⅜" Washed) 15% Pocahontas-Carswell	50.2	90.0	54.2	1860	1796	14'	398
125	Feb. 2	85% Orient No. 1 (2" x ⅜" Washed) 15% Eccles (⅝" x 0 Washed)	50.7	84.4	44.3	1860	1785	14'	404

[b]As received from mines. [c]Dried coal.

Table 32.—Part A.—(Continued)

Run No.	Date of test 1945	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
126	Feb. 5	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas	50.9	90.4	56.9	1860	1788	14′	406
127	Feb. 7	85% Sahara No. 16 (3″ x 2″ Washed) 15% Pocahontas-Carswell	50.5	86.4	51.0	1860	1767	14′	387
128	Feb. 9	85% Sahara No. 16 (3″ x 2″ Washed) 15% Eccles (⅝″ x 0 Washed)	50.7	84.2	45.9	1860	1816	14′	413
129	Feb. 12	85% Sahara No. 16 (3″ x 2″ Washed) 15% Medium-Volatile Pocahontas	50.7	89.3	53.9	1860	1800	14′	400
130	Feb. 14	85% Orient No. 1 (2″x ⅜″ Washed) 15% Pocahontas-Carswell	50.2	86.4	51.3	1860	1800	14′	401
131	Feb. 16	75% Orient No. 1 (2″ x ⅜″ Washed) 25% Pocahontas-Carswell	50.5	85.9	49.6	1860	1801	14′	406
132	Feb. 19	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	49.3	74.8	39.7	1850	1789	13′ 40″	382
133	Feb. 21	25% Wheelwright Egg 40% Wheelwright Slack 35% Pocahontas-Inland Steel	50.9	76.8	43.0	1850	1793	15′	397
134	Feb. 26	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Midvale 15% Pocahontas-Carswell	50.9	85.4	42.8	1860	1794	14′	407
135	Feb. 28	25% Orient No. 1 (2″ x ⅜″ Washed) 50% Corban 25% Pocahontas-Inland DPC	50.4	84.7	53.5	1850	1789	15′	412
136	Mar. 2	75% Corban 25% Pocahontas-Inland DPC	49.4	75.1	44.2	1850	1792	13′ 35″	377
137	Mar. 5	25% Orient No. 1 (2″ x ⅜″ Washed) 50% Corban 25% Pocahontas-Inland DPC	51.4	83.0	51.1	1850	1794	15′	424
138	Mar. 7	85% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas	50.2	84.9	46.7	1860	1805	14′	403
139	Mar. 9	65% Orient No. 1 (2″ x ⅜″ Washed) 25% Kentucky White Ash (Brazil Lower Block) 10% Pocahontas-Carswell	50.7	84.3	46.0	1860	1798	14′	410

Table 32.—Part A.—(Continued)

Run No.	Date of test 1945	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
140	Mar. 12	90% Orient No. 1 (2″ x ⅜″ Washed) 10% Pocahontas-Carswell	49.9	77.7	41.6	1860	1796	14′	422
141	Mar. 14	80% Orient No. 1 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	51.2	82.4	47.8	1860	1804	14′	411
142	Mar. 16	75% Kentucky White Ash (Brazil Lower Block) 25% Medium-Volatile Pocahontas	48.5	77.1	43.1	1860	1820	14′	413
143	Mar. 19	80% Orient No. 1 (2″ x ⅜″ Washed) 10% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	50.4	77.9	43.3	1860	1801	14′	417
144	Mar. 21	70% Orient No. 1 (2″ x ⅜″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	51.0	78.0	44.7	1860	1799	14′	413
145	Mar. 23	70% Orient No. 1 (2″ x ⅜″ Washed) 10% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	50.6	78.8	44.7	1860	1782	15′	425
146	Mar. 26	70% Orient No. 1 (2″ x ⅜″ Washed) 20% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	50.2	79.5	47.5	1860	1801	15′	426
147	Mar. 28	60% Orient No. 1 (2″ x ⅜″ Washed) 20% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	50.8	81.0	48.8	1860	1818	14′	413
148	Apr. 2	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 10% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	50.9	78.8	45.2	1860	1805	14′	411
149	Apr. 4	70% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	50.9	80.0	47.6	1860	1836	14′	424
150	Apr. 6	70% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas 10% Pocahontas-Carswell	51.5	79.4	46.8	1860	1850	14′	421

Table 32.—Part A.—(Continued)

Run No.	Date of test 1945	Coal blend	Oven Charge: Bulk density lb./cu. ft.	Oven Charge: Sizing (mesh) −8 %	Oven Charge: Sizing (mesh) −20 %	Oven Operation: Final flue temp. °F.	Oven Operation: Final coke temp. °F.	Oven Operation: Coking time hrs.	Oven Operation: Energy consumed kw.-hr.
151	Apr. 9	60% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas 20% Pocahontas-Carswell	50.7	82.0	50.0	1860	1821	14′	401
152	Apr. 11	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Pocahontas-Carswell	50.2	79.6	45.7	1870	1810	14′	405
153	Apr. 13	80% Zeigler No. 1 and 2 (1½″ x ¾″ Washed) 20% Medium-Volatile Pocahontas	50.9	79.3	47.2	1855	1796	14′	395
154	Apr. 16	80% Old Ben No. 11 (2″ x 1½″ Washed) 20% Pocahontas-Carswell	49.4	79.2	44.5	1850	1785	14′	397
155	Apr. 18	80% Old Ben No. 11 (2″ x 1½″ Washed) 20% Buccaneer	51.1	78.4	45.2	1855	1774	14′	409
156	Apr. 20	80% Old Ben No. 11 (2″ x 1½″ Washed) 10% Buccaneer 10% Pocahontas-Carswell	50.6	80.7	47.2	1855	1796	14′	408
157	Apr. 23	70% Old Ben No. 11 (2″ x 1½″ Washed) 15% Buccaneer 15% Pocahontas-Carswell	51.1	81.3	47.6	1860	1800	14′	410
158	Apr. 27	80% Old Ben No. 11 (2″ x 1½″ Washed) 20% Medium-Volatile Pocahontas	51.0	78.5	46.8	1855	1793	14′	406
159	Apr. 30	80% Minonk (4″ x 2½″ Hand Picked, Crushed and Screened to 1″ x ⅜″) 20% Pocahontas-Carswell	49.8	73.7	39.7	1850	1787	14′	416
160	May 2	80% Minonk (4″ x 2½″ Hand Picked, Crushed and Screened to 1″ x ⅜″) 20% Medium-Volatile Pocahontas	49.5	74.4	42.6	1840	1776	14′	410
161	May 4	70% Minonk (4″ x 2½″ Hand Picked, Crushed and Screened to 1″ x ⅜″) 10% Medium-Volatile Pocahontas 5% Buccaneer 15% Pocahontas-Carswell	48.9	80.4	45.7	1865	1789	14′	414

TABLE 32.—PART A.—(CONTINUED)

Run No.	Date of test 1945	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
162	May 7	80% Saxton (2″ x 1¼″ Raw) 20% Pocahontas-Carswell	50.0	76.6	42.6	1865	1796	14′	414
163	May 9	60% Minonk (4″ x 2½″ Hand Picked, Crushed and Screened to 1″ x ⅜″) 40% Pocahontas-Carswell	49.6	79.2	42.6	1865	1798	14′	407
164	May 11	60% Old Ben No. 11 (2″ x 1½″ Washed) 40% Pocahontas-Carswell	50.1	79.6	44.8	1860	1791	14′	402
165	May 14	80% Old Ben No. 14 (3″ x 2″ Washed) 20% Pocahontas-Carswell	50.8	76.4	42.0	1860	1795	14′	403
166	May 16	60% Old Ben No. 14 (3″ x 2″ Washed) 40% Pocahontas-Carswell	50.7	76.9	40.9	1860	1794	14′	407
167	May 18	65% Orient No. 1 (2″ x ⅜″ Washed) 17.5% Midvale 17.5% Pocahontas-Carswell	50.7	79.9	45.8	1855	1778	14′	409
168	May 23	65% Orient No. 1 (2″ x ⅜″ Washed) 17.5% Midvale 17.5% Pocahontas-Carswell	50.4	76.9	42.3	1860	1782	14′	400
169	May 25	80% Saxton (2″ x 1¼″ Raw) 20% Medium-Volatile Pocahontas	Coke burned on wharf.						
170	May 28	65% Orient No. 1 (2″ x ⅜″ Washed) 15% Midvale 20% Pocahontas-Carswell	50.4	77.9	42.9	1860	1782	14′	395
171	June 1	70% Old Ben No. 14 (3″ x 2″ Washed) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	51.1	74.0	40.4	1860	1787	14′	390
172	June 4	80% Old Ben No. 14 (3″ x 2″ Washed) 20% Medium-Volatile Pocahontas	51.1	75.4	42.0	1860	1791	14′	395
173	June 6	80% Jefferson No. 20 (1½″ x ¾″ Raw) 20% Pocahontas-Carswell	50.8	74.9	41.3	1900	1818	14′	405
174	June 8	60% Jefferson No. 20 (1½″ x ¾″ Raw) 40% Pocahontas-Carswell	50.8	76.8	43.2	1900	1827	14′	408

Table 32.—Part A.—(Concluded)

Run No.	Date of test 1945	Coal blend	Oven Charge			Oven Operation			
			Bulk density lb./cu. ft.	Sizing (mesh) −8 %	Sizing (mesh) −20 %	Final flue temp. °F.	Final coke temp. °F.	Coking time hrs.	Energy consumed kw.-hr.
175	June 11	70% Jefferson No. 20 (1½″ x ¾″ Raw) 15% Medium-Volatile Pocahontas 15% Pocahontas-Carswell	51.1	75.9	42.0	1900	1819	14′	405
176	June 13	80% Buckhorn (1½″ x ¾″ Washed) 20% Pocahontas-Carswell	51.1	78.4	44.8	1900	1823	14′	404
177	June 15	60% Buckhorn (1½″ x ¾″ Washed) 40% Pocahontas-Carswell	51.3	75.6	42.1	1900	1832	14′	400
178	June 18	80% Jefferson No. 20 (1½″ x ¾″. Float at 1.50 gr.) 20% Pocahontas-Carswell	50.1	76.4	42.3	1900	1828	14′	405
179	June 20	40% Jefferson No. 20 (1½″ x ¾″. Float at 1.50 gr.) 40% Orient No. 1 (2″ x ⅜″ Washed) 20% Pocahontas-Carswell	49.6	76.4	43.0	1900	1834	14′	400
180	June 22	80% Harco No. 47 (3″ x 2″ Washed) 20% Pocahontas-Carswell	49.3	76.7	42.7	1900	1828	14′	401
181	June 25	60% Harco No. 47 (3″ x 2″ Washed) 40% Pocahontas-Carswell	50.0	77.8	44.2	1900	1832	14′	398
182	June 27	80% Majestic No. 14 (3″ x 1½″ Washed) 20% Pocahontas-Carswell	50.5	78.8	45.5	1900	1852	14′	422
183	June 29	60% Majestic No. 14 (3″ x 1½″ Washed) 40% Pocahontas-Carswell	49.9	79.9	46.5	1900	1850	14′	403

Table 32.—Coke Oven Operation and Results
Part B. Coke Yields[a]
(Percent of coal charged)

Run No.	Total	Furnace + 1″	% of + 2″ in furnace coke	Nut 1″ x ½″	Breeze −½″	Run No.	Total	Furnace + 1″	% of + 2″ in furnace coke	Nut 1″ x ½″	Breeze −½″
1	73.2	69.8	71.7	1.6	1.8	51	70.9	67.0	90.1	0.8	3.1
2	72.5	70.0	85.9	1.0	1.5	52	71.0	67.1	86.4	0.8	3.1
3	67.8	62.8	85.7	0.5	4.4	53	71.0	67.6	90.5	0.7	2.7
4	70.0	64.7	84.5	0.6	4.7	54	69.0	66.4	88.9	0.7	1.9
5	71.6	67.0	82.5	0.6	3.9	55	70.2	66.9	90.3	0.8	2.5
6	69.8	65.1	83.5	0.6	4.1	56	72.6	69.2	85.7	0.8	2.6
7	71.0	66.3	82.0	0.7	4.0	57	69.6	66.8	85.8	0.6	2.2
8	70.5	65.5	81.2	0.8	4.2	58	70.6	67.7	84.5	0.9	2.0
9	70.8	66.8	82.8	0.7	3.3	59	70.6	67.1	88.5	0.7	2.8
10	69.7	65.8	89.5	0.6	3.3	60	68.5	64.6	87.2	1.0	2.9
11	70.3	65.5	84.7	0.5	4.3	61	72.4	68.6	89.3	0.8	3.0
12	71.2	67.0	90.0	0.9	3.3	62	69.8	66.1	84.0	1.2	2.5
13	69.3	63.1	86.4	0.6	5.6	63	70.6	66.6	89.7	1.0	3.0
14	71.5	68.0	73.7	0.8	2.7	64	69.2	65.4	90.0	0.9	2.9
15	70.1	66.3	71.2	1.0	2.8	65	70.5	65.0	88.1	0.8	4.7
16	....	....	86.0	...	...	66	68.0	63.6	89.9	0.9	3.5
17	70.3	64.9	84.0	0.7	4.7	67	71.0	67.4	89.5	1.1	2.5
18	65.2	61.7	72.0	1.4	2.1	68	70.2	67.2	89.6	0.9	2.1
19	66.7	61.1	81.0	1.2	4.4	69	68.9	65.8	86.7	1.2	1.9
20	65.7	61.4	71.6	1.1	3.2	70	71.7	68.5	90.7	0.9	2.3
21	66.0	61.5	77.4	1.0	3.5	71	69.7	66.5	87.6	1.2	2.0
22	67.2	61.7	84.3	1.3	4.2	72	72.9	69.9	92.7	0.8	2.2
23	71.3	68.2	85.2	1.1	2.0	73	72.5	69.5	92.8	0.9	2.1
24	73.5	70.3	89.0	1.0	2.2	74	70.5	67.0	91.1	1.0	2.5
25	70.5	63.9	96.8	0.6	6.0	75	70.2	66.5	90.9	1.2	2.5
26	69.3	66.6	92.9	0.7	2.0	76	70.2	68.6	95.1	0.8	1.8
27	71.9	66.6	89.7	0.8	4.5	77	70.1	66.2	88.4	0.7	3.2
28	67.4	63.3	78.5	0.9	3.2	78	70.7	67.6	87.6	0.8	2.3
29	64.0	58.4	64.7	2.2	3.4	79	72.1	68.3	90.1	0.9	2.9
30	71.5	68.4	91.3	1.0	2.1	80	61.1	57.0	71.7	1.5	2.6
31	71.7	68.2	90.6	1.1	2.4	81	61.9	57.7	74.4	1.9	2.3
32	68.7	62.6	87.0	0.7	5.4	82	64.4	60.0	74.3	1.4	3.0
33	72.3	66.9	87.7	0.7	4.7	83	73.0	69.9	87.5	0.9	2.2
34	71.7	67.2	93.4	1.5	3.0	84	69.8	66.8	93.0	0.9	2.1
35	71.7	67.2	94.3	1.5	3.0	85	70.6	67.2	92.0	0.7	2.7
36	69.2	64.5	91.7	0.9	3.8	86	66.7	61.8	88.5	0.5	4.4
37	69.1	61.4	97.6	0.7	6.9	87	70.4	67.1	90.8	1.1	2.2
38	69.1	65.5	92.2	1.2	2.4	88	72.8	69.3	89.9	1.0	2.5
39	69.9	66.7	90.2	1.2	2.0	89	71.0	67.7	91.1	1.0	2.3
40	69.0	64.5	87.1	1.1	3.4	90	69.0	66.0	89.4	0.7	2.3
41	70.2	66.5	84.5	0.7	3.0	91	72.2	68.5	88.3	1.4	2.3
42	71.6	68.1	80.3	0.9	2.6	92	63.1	60.5	83.3	0.8	1.8
43	69.5	65.9	76.9	1.2	2.4	93	64.8	62.1	85.4	1.0	1.7
44	68.6	65.3	83.6	0.9	2.4	94	64.4	61.9	85.5	0.7	1.8
45	70.1	65.3	93.0	1.1	3.7	95	68.2	64.9	83.8	1.1	2.2
46	70.3	66.2	93.6	1.1	3.0	96	64.1	61.1	78.3	1.0	2.0
47	67.5	63.7	94.3	1.0	2.8	97	64.7	61.8	79.3	0.9	2.0
48	64.6	61.6	83.7	0.7	2.3	98	71.8	68.7	88.3	0.9	2.2
49	72.8	68.8	82.1	0.5	3.5	99	70.0	67.0	85.8	0.9	2.1
50	70.4	66.1	87.0	0.8	3.5	100	68.9	66.4	86.4	0.7	1.8

[a]Starting with Run No. 113 all cokes were dropped a distance of 6 ft. in 50 lb. increments before sizing to simulate commercial handling.

TABLE 32.—PART B.—(CONCLUDED)

Run No.	Total	Furnace + 1″	% of + 2″ in furnace coke	Nut 1″ x ½″	Breeze −½″	Run No.	Total	Furnace + 1″	% of + 2″ in furnace Coke	Nut 1″x½″	Breeze −½″
101	64.7	62.0	84.3	0.7	2.0	146	66.9	63.5	73.1	1.1	2.3
102	65.0	62.2	90.9	0.7	2.1	147	69.2	66.0	73.8	0.9	2.2
103	65.9	63.0	87.4	0.9	2.0	148	66.5	63.0	75.6	1.0	2.5
104	66.3	63.6	91.7	0.7	2.0	149	68.7	65.4	74.2	1.1	2.2
105	65.3	61.5	87.4	1.0	2.8	150	68.0	64.5	72.0	1.2	2.3
106	65.6	61.9	88.9	0.9	2.7	151	69.8	66.5	74.0	1.1	2.2
107	68.9	65.9	88.3	0.7	2.3	152	67.2	63.2	78.1	1.2	2.8
108	65.9	63.0	87.9	1.0	1.9	153	65.1	61.6	74.3	1.2	2.3
109	66.5	63.2	85.0	0.9	2.4	154	66.8	63.5	82.3	1.1	2.2
110	69.0	66.3	88.0	0.8	1.9	155	65.6	62.1	80.4	1.3	2.2
111	67.8	64.2	86.3	0.9	2.7	156	66.1	62.7	81.2	1.1	2.3
112	70.4	67.7	91.3	0.8	1.9	157	68.5	65.2	84.2	1.0	2.3
113	69.1	66.2	82.9	0.9	2.0	158	65.6	62.1	71.7	1.1	2.4
114 [b]	72.5	69.2	83.7	1.0	2.3	159	63.0	59.3	84.7	1.5	2.2
115	69.7	66.6	80.5	0.8	2.3	160	60.8	56.3	75.2	2.1	2.4
116	69.9	66.5	79.3	1.0	2.4	161	64.5	61.1	85.8	1.1	2.3
117	69.7	66.6	83.7	0.8	2.3	162	62.6	58.4	84.3	1.1	3.1
118	71.7	68.4	80.8	1.0	2.3	163	69.6	66.3	88.9	1.1	2.2
119	71.4	68.1	79.0	1.2	2.1	164	70.1	66.5	82.7	1.0	2.6
120	71.5	68.3	78.5	1.1	2.1	165	66.4	62.7	83.4	1.1	2.6
121	71.2	68.0	76.5	1.0	2.2	166	70.7	66.5	82.8	0.9	3.3
122	67.4	64.2	85.9	1.1	2.1	167	67.0	63.6	85.8	1.4	2.0
123	67.1	63.6	82.5	1.2	2.3	168	67.4	64.1	85.6	1.2	2.1
124	66.2	62.5	78.5	1.0	2.7	169	Coke burned on wharf.				
125	65.5	61.9	79.0	1.2	2.4	170	67.4	63.8	87.4	1.0	2.6
126	65.2	61.5	77.3	1.5	2.2	171	68.5	65.3	84.7	1.1	2.1
127	68.3	64.8	79.8	1.1	2.5	172	66.1	62.5	81.5	1.4	2.2
128	67.7	64.4	80.6	0.9	2.4	173	67.5	63.6	85.8	1.6	2.3
129	67.2	63.8	80.9	1.0	2.4	174	70.6	66.7	90.4	1.0	2.9
130	65.9	61.7	84.8	1.1	3.1	175	67.9	64.6	87.9	1.0	2.3
131	67.6	63.8	81.2	1.0	2.8	176	67.7	64.9	88.0	0.9	1.9
132	71.6	68.9	88.2	0.8	1.9	177	71.9	69.0	84.7	0.8	2.1
133	71.1	68.4	90.1	0.9	1.8	178	66.4	63.2	81.5	0.9	2.3
134	66.0	62.6	79.6	1.1	2.3	179	66.4	63.0	77.5	1.1	2.3
135	69.8	66.0	83.6	0.9	2.9	180	67.3	64.3	80.4	1.0	2.0
136	70.8	67.4	87.0	1.1	2.3	181	69.8	66.8	78.6	0.9	2.1
137	68.7	65.0	85.6	1.0	2.7	182	65.6	62.2	82.6	1.0	2.4
138	64.5	60.7	70.4	1.5	2.3	183	69.3	65.5	77.5	0.8	3.0
139	62.0	58.0	76.0	1.0	3.0						
140	64.7	60.5	68.5	1.6	2.6						
141	66.0	62.2	74.4	1.3	2.7						
142	66.5	57.6	74.4	1.1	3.9						
143	66.0	62.5	74.9	1.0	2.5						
144	67.5	63.9	81.9	1.0	2.6						
145	68.3	64.7	80.3	1.1	2.5						

[b] There was an error in the coke weights in Run 114. This run was not used for basing results on drying tests.

Table 32.—Coke Oven Operation and Results
Part C. Screen Sizes of Coke Produced
(Percent of total coke)

Run No.	+4″	4″ x 3″	3″ x 2″	2″ x 1″	1″ x ½″	−½″
1	0.7	21.0	46.7	27.0	2.2	2.4
2	8.9	35.0	39.0	13.6	1.4	2.1
3	11.6	31.7	36.2	13.2	0.8	6.5
4	9.8	30.5	37.7	14.4	0.9	6.7
5	13.5	31.3	32.5	16.4	0.9	5.4
6	15.5	35.3	27.1	15.3	0.9	5.9
7	11.1	33.5	31.8	16.9	1.1	5.6
8	14.6	30.4	30.7	17.2	1.1	6.0
9	14.9	33.5	29.8	16.2	1.0	4.6
10	25.4	30.6	28.7	9.8	0.8	4.7
11	15.0	31.6	32.4	14.1	0.8	6.1
12	23.6	36.0	25.2	9.3	1.2	4.7
13	11.6	29.8	37.2	12.4	1.0	8.0
14	4.1	27.4	38.5	25.1	1.1	3.8
15	0.0	26.2	41.2	27.2	1.4	4.0
16	8.7	35.8	38.3	13.6	0.9	2.7
17	19.7	27.5	30.4	14.8	0.9	6.7
18	4.8	18.0	45.2	26.6	2.1	3.3
19	6.4	27.8	40.0	17.3	1.9	6.6
20	2.4	17.2	47.4	26.5	1.7	4.8
21	4.5	21.9	45.8	21.0	1.5	5.3
22	8.6	28.2	40.6	14.4	1.9	6.3
23	10.9	35.9	34.7	14.1	1.6	2.8
24	15.0	32.5	37.6	10.6	1.3	3.0
25	48.6	24.5	14.6	2.9	0.8	8.6
26	14.8	45.0	29.5	6.8	0.9	3.0
27	17.3	31.1	34.6	9.6	1.1	6.3
28	3.6	26.8	43.3	20.2	1.3	4.8
29	1.5	12.6	45.0	32.1	3.4	5.4
30	21.0	36.8	29.5	8.4	1.4	2.9
31	21.5	39.8	24.8	9.0	1.6	3.3
32	14.6	34.0	30.7	11.8	1.1	7.8
33	17.2	33.8	30.2	11.3	1.0	6.5
34	38.4	33.6	15.5	6.2	2.1	4.2
35	39.1	32.2	17.1	5.3	2.1	4.2
36	20.8	39.0	25.8	7.7	1.2	5.5
37	42.7	30.7	13.4	2.1	1.0	10.1
38	22.6	38.3	26.4	7.5	1.7	3.5
39	15.1	38.4	32.6	9.4	1.7	2.8
40	9.1	36.6	35.7	12.1	1.6	4.9
41	10.6	32.8	36.6	14.7	1.0	4.3
42	5.0	26.4	44.9	18.9	1.2	3.6
43	7.1	29.6	40.1	18.0	1.7	3.5
44	6.1	31.6	41.7	15.9	1.2	3.5
45	27.4	39.3	20.1	6.3	1.6	5.3
46	30.0	35.5	22.6	6.0	1.6	4.3
47	5.9	34.5	40.0	14.0	1.5	4.1
48	6.8	27.6	45.3	15.6	1.2	3.5
49	9.1	28.7	39.7	16.9	0.7	4.9
50	12.4	37.2	32.0	12.3	1.1	5.0
51	16.3	34.6	34.3	9.3	1.1	4.4
52	15.7	33.4	32.7	12.8	1.1	4.3
53	15.7	41.0	29.3	9.1	1.0	3.9
54	7.2	39.0	39.4	10.7	1.0	2.7
55	11.9	37.2	37.0	9.2	1.1	3.6
56	18.0	36.9	31.0	9.4	1.1	3.6
57	5.6	33.4	43.3	13.6	0.9	3.2
58	4.5	31.2	45.4	14.9	1.2	2.8
59	10.7	34.8	38.5	11.0	1.0	4.0
60	6.7	35.0	40.8	11.9	1.4	4.2
61	20.0	35.4	29.0	10.3	1.2	4.1
62	14.7	35.8	33.5	10.7	1.7	3.6
63	17.4	35.5	31.8	9.7	1.4	4.2
64	19.7	36.6	28.8	9.4	1.3	4.2
65	10.0	34.7	36.4	11.1	1.1	6.7
66	11.1	35.6	37.4	9.4	1.3	5.2
67	15.8	33.5	35.7	10.0	1.5	3.5
68	11.0	38.3	36.5	10.0	1.2	3.0
69	7.9	33.2	41.8	12.7	1.7	2.7
70	13.9	37.4	35.3	8.9	1.3	3.2
71	8.2	32.2	43.1	11.9	1.7	2.9
72	21.6	40.5	26.7	7.1	1.1	3.0
73	20.3	38.9	29.6	7.0	1.3	2.9
74	21.5	37.7	27.3	8.4	1.5	3.6
75	12.6	35.0	38.4	8.7	1.7	3.6
76	27.2	40.9	23.5	4.8	1.1	2.5
77	9.3	35.4	38.8	11.0	1.0	4.5
78	7.3	35.5	40.9	11.9	1.1	3.3
79	19.9	36.1	29.4	9.4	1.2	4.0
80	7.1	22.3	42.1	21.8	2.5	4.2
81	3.3	26.2	39.8	24.0	3.1	3.7
82	8.1	21.5	39.6	24.1	2.1	4.6
83	13.2	37.3	33.3	11.9	1.2	3.1
84	19.4	42.9	26.7	6.8	1.2	3.0
85	21.9	38.3	27.5	7.6	0.9	3.8
86	5.2	37.1	39.6	10.7	0.8	6.6
87	10.3	41.3	35.0	8.8	1.5	3.1
88	19.8	37.5	28.2	9.7	1.4	3.4
89	20.9	34.8	31.1	8.5	1.4	3.3
90	17.9	37.7	29.7	10.3	1.1	3.3
91	13.9	35.1	34.8	11.1	1.9	3.2
92	5.8	29.0	48.6	12.5	1.3	2.8
93	4.4	24.0	53.5	14.0	1.5	2.6
94	3.6	30.4	48.2	13.9	1.1	2.8
95	5.7	30.4	43.4	15.6	1.6	3.3
96	3.7	24.2	47.6	19.8	1.6	3.1
97	3.8	20.2	55.3	16.2	1.4	3.1
98	20.0	35.5	28.9	11.3	1.3	3.0
99	8.5	38.9	34.7	13.7	1.2	3.0
100	6.5	35.2	41.5	13.2	1.1	2.5

Table 32.—Part C.—(Concluded)

Run No.	+4″	4″ x 3″	3″ x 2″	2″ x 1″	1″ x ½″	−½″
101	4.1	32.8	44.0	15.0	1.0	3.1
102	6.4	42.0	38.8	8.6	1.0	3.2
103	4.9	33.1	45.8	11.9	1.3	3.0
104	15.7	38.9	33.5	7.8	1.1	3.0
105	7.9	29.5	45.1	11.7	1.5	4.3
106	8.0	31.2	44.6	10.6	1.4	4.2
107	8.1	35.8	40.8	11.0	0.9	3.4
108	2.4	29.1	52.2	11.7	1.6	3.0
109	5.3	32.1	43.3	14.2	1.4	3.7
110	12.1	34.8	37.7	11.5	1.1	2.8
111	4.9	28.2	48.7	12.9	1.4	3.9
112	13.1	41.5	33.3	8.3	1.1	2.7
113	4.1	27.5	47.7	16.5	1.3	2.9
114	0.0	25.5	54.5	15.5	1.3	3.2
115	4.0	24.9	48.0	18.7	1.2	3.2
116	1.8	27.4	49.0	17.0	1.4	3.4
117	4.2	28.5	47.2	15.5	1.2	3.4
118	2.8	26.9	47.4	18.3	1.4	3.2
119	2.8	22.4	50.2	19.9	1.7	3.0
120	4.0	22.0	49.8	19.8	1.4	3.0
121	1.8	24.4	49.5	19.8	1.4	3.1
122	3.8	28.4	49.6	13.4	1.7	3.1
123	4.6	28.8	44.9	16.5	1.9	3.3
124	2.7	25.2	46.1	20.4	1.5	4.1
125	0.6	14.7	59.4	19.8	1.8	3.7
126	1.0	16.5	55.6	21.4	2.2	3.3
127	1.1	21.8	52.7	19.2	1.6	3.6
128	1.3	19.8	55.6	18.4	1.3	3.6
129	0.6	15.1	61.1	18.1	1.5	3.6
130	3.6	24.0	51.8	14.2	1.7	4.7
131	2.3	22.3	52.0	17.7	1.5	4.2
132	13.7	29.6	41.5	11.4	1.1	2.7
133	15.4	33.8	37.4	9.5	1.3	2.6
134	0.9	23.8	50.9	19.3	1.6	3.5
135	9.1	27.6	42.4	15.4	1.3	4.2
136	6.5	36.6	39.8	12.4	1.5	3.2
137	7.3	32.1	41.4	13.7	1.5	4.0
138	0.0	12.3	54.0	27.9	2.3	3.5
139	1.5	12.2	57.5	22.3	1.6	4.9
140	1.1	11.1	51.9	29.4	2.4	4.1
141	0.6	19.9	49.5	24.0	1.9	4.1
142	0.6	17.1	50.5	23.7	1.8	6.3
143	1.0	17.5	52.5	23.7	1.5	3.8
144	0.9	25.5	51.1	17.2	1.5	3.8
145	3.7	26.0	43.8	21.4	1.5	3.6
146	2.0	17.1	50.2	25.6	1.6	3.5
147	1.8	21.8	46.8	25.2	1.2	3.2
148	1.3	16.2	54.2	23.1	1.5	3.7
149	1.5	12.8	56.2	24.7	1.5	3.3
150	0.8	15.3	52.1	26.6	1.8	3.4
151	2.1	21.9	46.5	24.8	1.6	3.1
152	3.0	20.2	50.4	20.5	1.8	4.1
153	0.8	14.3	55.3	24.2	1.9	3.5
154	3.2	27.6	47.3	16.8	1.7	3.4
155	0.7	22.4	53.1	18.5	1.9	3.4
156	1.0	20.2	55.9	17.8	1.6	3.5
157	3.1	30.2	46.9	15.0	1.5	3.3
158	1.6	12.9	57.2	22.9	1.7	3.7
159	5.3	31.1	43.6	14.2	2.3	3.5
160	0.9	16.2	52.7	22.9	3.4	3.9
161	4.9	27.4	48.7	13.7	1.8	3.5
162	2.8	33.8	42.1	14.7	1.7	4.9
163	5.0	38.2	41.4	10.6	1.6	3.2
164	4.9	29.6	43.9	16.4	1.5	3.7
165	3.8	26.3	48.6	15.7	1.7	3.9
166	4.1	27.8	45.8	16.3	1.3	4.7
167	4.7	31.0	45.8	13.5	2.0	3.0
168	7.0	32.1	42.2	13.8	1.7	3.2
169	Coke burned on wharf.					
170	6.2	33.2	43.5	11.8	1.5	3.8
171	4.1	30.3	46.4	14.5	1.6	3.1
172	3.1	24.4	49.6	17.4	2.2	3.3
173	4.2	30.1	46.5	13.4	2.3	3.5
174	18.1	35.2	32.2	9.0	1.4	4.1
175	3.8	33.8	46.0	11.6	1.5	3.3
176	5.2	28.7	50.3	11.6	1.4	2.8
177	6.2	33.6	41.6	14.6	1.1	2.9
178	4.1	27.6	46.0	17.5	1.4	3.4
179	2.7	24.7	50.2	17.2	1.7	3.5
180	3.6	23.2	50.0	18.7	1.5	3.0
181	4.7	21.7	48.8	20.4	1.3	3.1
182	3.2	22.5	52.6	16.4	1.6	3.7
183	5.6	27.2	40.5	21.2	1.1	4.4

TABLE 32.—COKE OVEN OPERATION AND RESULTS
PART D. COKE—ANALYSES
(On the Dry Basis)

Run No.	Size	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	Ash softening temp. °F.
1	+½″	1.5	89.7	8.8	0.76	12981	2124
2	+½″	1.1	90.2	8.7	0.69	13205	2120
3	+1″	1.7	87.5	10.8	0.76	12851	2156
4	+1″	1.2	89.2	9.6	0.73	12977	2160
5	+1″	0.9	90.3	8.8	0.69	13172	2146
6	+1″	1.9	86.8	11.3	0.70	12826	2099
7	+1″	1.7	89.2	9.1	0.65	13054	2131
8	+1″	1.4	89.8	8.8	0.60	13171	2145
9	+1″	1.2	89.3	9.5	0.67	13103	2140
10	+1″	1.6	88.6	9.8	0.65	13013	2135
11	+1″	1.8	88.3	9.9	0.72	12944	2134
12	+1″	1.2	88.4	10.4	0.72	12904	2156
13	+1″	1.4	89.3	9.3	0.66	12993	2140
14	+1″	1.2	89.3	9.5	0.66	12890	2135
15	+1″	1.1	90.3	8.6	0.62	13034	2135
16	+1″	1.5	88.8	9.7	0.78	12937	2193
17	+1″	2.2	85.2	12.6	0.88	12669	2158
18	+1″	1.5	88.6	9.9	1.02	12860	2203
19	+1″	1.2	89.8	9.0	1.22	13043	2248
20	+1″	1.6	89.2	9.2	1.04	12996	2285
21	+1″	1.1	90.6	8.3	1.18	13093	2190
22	+1″	0.9	90.4	8.7	1.11	13056	2144
23	+1″	1.1	91.8	7.1	0.69	13398	2152
24	+1″	1.2	92.4	6.4	0.71	13557	2154
25	+1″	1.5	89.3	9.2	0.72	13133	2187
26	+1″	1.1	91.0	7.9	1.14	13293	2195
27	+1″	1.1	90.9	8.0	1.11	13284	2173
28	+1″	2.0	87.0	11.0	0.76	12725	2141
29	+1″	1.5	87.1	11.4	0.51	12696	2358
30	+1″	1.2	91.4	7.4	0.62	13327	2122
31	+1″	1.3	90.2	8.5	0.67	13324	2200
32	+1″	2.0	88.2	9.8	0.72	13062	2253
33	+1″	1.2	89.1	9.7	0.73	13183	2237
34	+1″	1.0	85.8	13.2	0.66	12541	2555
35	+1″	0.9	85.7	13.4	0.66	12521	2555
36	+1″	1.3	88.0	10.7	0.69	12871	2188
37	+1″	1.8	86.9	11.3	0.85	12863	2240
38	+1″	1.2	88.7	10.1	0.75	12976	2393
39	+1″	1.2	88.9	9.9	0.74	13094	2502
40	+1″	1.0	90.2	8.8	1.04	13181	2299
41	+1″	1.8	89.3	8.9	0.63	13346	2308
42	+1″	1.5	90.7	7.8	0.65	13443	2261
43	+1″	1.0	91.4	7.6	1.12	13336	2288
44	+1″	1.8	89.3	8.9	0.69	13136	2353
45	+1″	1.6	86.3	12.1	0.96	12751	2403
46	+1″	1.4	86.5	12.1	0.90	12843	2378
47	+1″	2.2	87.3	10.5	0.71	12981	2204
48	+1″	1.8	88.7	9.5	0.72	13148	2446
49	+1″	1.8	89.9	8.3	0.76	13336	2251
50	+1″	1.6	87.5	10.9	0.70	12852	2533

TABLE 32.—PART D.—(CONTINUED)

Run No.	Size	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	Ash softening temp. °F.
51	+1″	1.7	88.3	10.0	0.67	13099	2301
52	+1″	1.6	88.4	10.0	0.76	13029	2353
53	+1″	1.4	88.6	10.0	0.75	13120	2341
54	+1″	1.6	87.8	10.6	1.29	12989	2090
55	+1″	1.7	86.8	11.5	0.88	12786	2393
56	+1″	1.5	88.7	9.8	0.99	13111	2358
57	+1″	1.6	88.8	9.6	0.74	13054	2180
58	+1″	1.6	90.6	7.8	0.72	13445	2214
59	+1″	1.7	89.0	9.3	0.74	13078	2323
60	+1″	1.6	88.7	9.7	0.78	13094	2274
61	+1″	1.7	87.3	11.0	0.86	12935	2458
62	+1″	1.1	90.2	8.7	0.72	13239	2419
63	+1″	1.5	88.3	10.2	0.71	13022	2454
64	+1″	1.8	88.4	9.8	0.76	13075	2387
65	+1″	1.5	88.2	10.3	0.98	13014	2232
66	+1″	1.6	87.3	11.1	1.04	12859	2203
67	+1″	1.6	89.1	9.3	0.78	13179	2387
68	+1″	1.2	88.2	10.6	0.74	12953	2308
69	+1″	1.6	90.6	7.8	0.75	13311	2214
70	+1″	1.2	89.6	9.2	0.74	13149	2368
71	+1″	1.7	89.7	8.6	0.76	13275	2273
72	+1″	1.2	89.4	9.4	0.82	13090	2417
73	+1″	1.1	89.0	9.9	0.72	12997	2486
74	+1″	1.5	89.6	8.9	0.76	13213	2441
75	+1″	1.6	89.3	9.1	0.73	13193	2389
76	+1″	1.1	88.5	10.4	0.63	12996	2402
77	+1″	1.6	88.0	10.6	0.74	12992	2378
78	+1″	1.4	91.8	6.8	0.64	13465	2345
79	+1″	1.7	88.1	10.2	0.70	13023	2326
80	+1″	2.0	84.8	13.2	0.74	12471	2204
81	+1″	2.0	85.8	12.2	0.76	12611	2201
82	+1″	1.7	85.9	12.4	0.79	12587	2242
83	+1″	1.3	89.8	8.9	0.66	13189	2396
84	+1″	1.6	89.6	8.8	0.76	13176	2356
85	+1″	1.6	87.5	10.9	0.69	12866	2408
86	+1″	1.6	89.5	8.9	0.53	13184	2414
87	+1″	1.6	88.1	10.3	0.73	13002	2330
88	+1″	1.3	89.5	9.2	0.72	13165	2362
89	+1″	1.3	88.6	10.1	0.68	13069	2320
90	+1″	1.4	88.2	10.4	0.68	12946	2333
91	+1″	1.2	90.4	8.4	0.70	13284	2384
92	+1″	1.8	86.2	12.0	0.84	12696	2171
93	+1″	1.6	87.0	11.4	1.09	12772	2202
94	+1″	1.7	86.5	11.8	0.80	12660	2218
95	+1″	1.4	85.1	13.5	0.68	12513	2356
96	+1″	1.9	86.1	12.0	0.70	12574	2356
97	+1″	1.7	86.0	12.3	0.95	12682	2237
98	+1″	1.4	89.6	9.0	0.70	12949	2382
99	+1″	1.6	88.8	9.6	0.83	13082	2540
100	+1″	1.4	89.0	9.6	0.80	12925	2222

TABLE 32.—PART D.—(CONTINUED)

Run No.	Size	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	Ash softening temp. °F.
101	+1″	1.4	86.0	12.6	0.71	12596	2320
102	+1″	1.0	87.8	11.2	0.69	12861	2233
103	+1″	1.6	87.3	11.1	0.76	12729	2210
104	+1″	1.3	88.4	10.3	0.69	12994	2379
105	+1″	1.1	87.1	11.8	0.80	12788	2249
106	+1″	1.3	87.6	11.1	0.67	12869	2350
107	+1″	1.1	88.1	10.8	0.73	12916	2344
108	+1″	1.4	86.4	12.2	0.71	12739	2215
109	+1″	1.5	87.3	11.2	0.70	12887	2262
110	+1″	1.4	89.6	9.0	0.84	13209	2389
111	+1″	1.3	87.7	11.0	0.74	12836	2218
112	+1″	1.2	91.1	7.7	0.73	13323	2375
113	+1″	1.2	90.9	7.9	0.83	13323	2359
114	+1″	1.4	91.0	7.6	0.75	13403	2232
115	+1″	1.8	90.5	7.7	0.75	13346	2397
116	+1″	1.1	91.3	7.6	0.73	13330	2350
117	+1″	1.9	90.5	7.6	0.72	13363	2368
118	+1″	1.7	92.1	6.2	0.68	13577	2391
119	+1″	1.6	92.1	6.3	0.76	13540	2373
120	+1″	1.6	92.5	5.9	0.61	13613	2361
121	+1″	1.6	92.3	6.1	0.61	13519	2341
122	+1″	1.3	87.5	11.2	0.67	12870	2268
123	+1″	1.7	87.1	11.2	0.69	12802	2208
124	+1″	1.4	87.4	11.2	0.63	12791	2232
125	+1″	1.5	86.9	11.6	0.66	12741	2360
126	+1″	1.7	86.5	11.8	0.67	12741	2284
127	+1″	1.4	87.0	11.6	0.83	12756	2390
128	+1″	1.4	86.7	11.9	0.78	12695	2459
129	+1″	1.3	86.5	12.2	0.69	12658	2403
130	+1″	1.3	87.2	11.5	0.66	12729	2209
131	+1″	1.2	88.7	10.1	0.61	12984	2224
132	+1″	1.9	90.4	7.7	0.65	13418	2180
133	+1″	0.9	91.2	7.9	0.63	13326	2177
134	+1″	1.7	87.9	10.4	0.78	13008	2194
135	+1″	1.5	87.4	11.1	0.67	12868	2450
136	+1″	1.1	88.4	10.5	0.68	12859	2493
137	+1″	1.1	88.4	10.5	0.64	12904	2493
138	+1″	1.4	87.7	10.9	0.67	12833	2204
139	+1″	1.4	89.1	9.5	0.68	13031	2411
140	+1″	1.7	87.5	10.8	0.71	12864	2309
141	+1″	1.6	87.1	11.3	0.66	12722	2199
142	+1″	1.1	91.1	7.8	0.56	13265	2507
143	+1″	1.1	88.0	10.6	0.70	12786	2191
144	+1″	1.1	88.0	10.9	0.70	12804	2205
145	+1″	1.1	88.4	10.5	0.71	12838	2200
146	+1″	1.4	87.6	11.0	0.69	12853	2176
147	+1″	1.2	88.3	10.5	0.70	12899	2204
148	+1″	1.1	87.8	11.1	0.77	12783	2234
149	+1″	1.4	88.1	10.5	0.69	12875	2203
150	+1″	1.3	87.9	10.8	0.70	12795	2205

Table 32.—Part D.—(Concluded)

Run No.	Size	Volatile matter %	Fixed carbon %	Ash %	Total sulfur %	B.t.u. per lb.	Ash softening temp. °F.
151	+1″	1.3	88.5	10.2	0.68	12869	2217
152	+1″	1.2	88.4	10.4	0.68	12841	2215
153	+1″	1.3	88.0	10.7	0.69	12802	2217
154	+1″	1.5	87.5	11.0	0.84	12765	2207
155	+1″	1.0	86.1	12.9	1.0	12476	2418
156	+1″	1.1	87.1	11.8	0.87	12699	2412
157	+1″	1.3	86.6	12.1	0.89	12640	2475
158	+1″	1.3	86.9	11.8	0.82	12604	2194
159	+1″	1.1	87.8	11.1	1.35	12787	2114
160	+1″	1.2	87.1	11.7	1.38	12657	2102
161	+1″	1.1	87.2	11.7	1.30	12709	2102
162	+1″	1.4	88.1	10.5	0.64	12832	2465
163	+1″	1.1	89.2	9.7	1.28	13055	2102
164	+1″	1.1	89.2	9.7	0.74	12948	2183
165	+1″	1.1	87.8	11.1	0.79	12715	2272
166	+1″	1.2	88.8	10.0	0.74	12848	2241
167	+1″	1.3	87.7	11.0	0.73	12745	2192
168	+1″	1.3	87.5	11.2	0.69	12687	2270
169	Coke burned on wharf.						
170	+1″	1.8	87.7	10.5	0.67	12873	2212
171	+1″	1.4	87.8	10.8	0.84	12899	2160
172	+1″	1.5	86.2	12.3	0.89	12634	2181
173	+1″	1.3	86.3	12.4	1.08	12585	2158
174	+1″	1.4	87.2	11.4	0.92	12682	2212
175	+1″	1.3	87.0	11.7	1.01	12738	2148
176	+1″	1.6	84.6	13.9	2.14	12424	2063
177	+1″	1.1	86.7	12.2	1.69	12702	2148
178	+1″	1.3	88.1	10.6	0.87	12932	2185
179	+1″	1.2	87.4	11.4	0.74	12776	2185
180	+1″	1.3	88.1	10.6	1.33	12861	2070
181	+1″	1.2	89.0	9.8	1.21	13024	2095
182	+1″	1.3	86.3	12.4	0.96	12666	2207
183	+1″	1.6	87.3	11.1	0.89	12813	2249

Table 32.—Coke Oven Operation and Results
Part E. Coke—Physical Tests

Run No.	Shatter test % + 2″	Shatter test % + 1½″	Tumbler test % + 1″	Tumbler test % + ¼″	Apparent specific gravity	True specific gravity	Porosity %
1	47.6	73.7	32.0	66.0	0.893	1.92	53.5
2	60.4	83.3	47.7	69.1	0.895	1.92	53.4
3	57.2	85.1	49.5	65.0	0.798	1.93	58.7
4	59.7	86.0	51.4	65.9	0.811	1.93	58.0
5	62.3	86.0	51.6	68.0	0.827	1.95	57.6
6	61.3	82.8	51.4	66.4	0.850	1.95	56.4
7	58.4	82.5	47.1	69.5	0.850	1.93	56.0
8	62.2	85.5	50.0	68.2	0.843	1.93	56.3
9	60.7	85.9	52.2	69.1	0.850	1.94	56.2
10	65.8	87.0	50.5	64.6	0.802	1.93	58.4
11	61.4	85.8	52.0	66.8	0.821	1.91	57.0
12	69.6	86.3	46.7	65.5	0.834	1.94	57.0
13	57.2	84.2	47.6	60.2	0.795	1.93	58.8
14	50.2	79.0	47.8	70.0	0.867	1.92	54.8
15	45.6	77.5	47.1	70.8	0.837	1.92	56.4
16	64.3	86.5	46.2	63.5	0.813	1.92	57.7
17	64.2	85.3	46.2	62.4	0.830	1.92	56.8
18	37.0	70.4	26.6	65.2	0.775	1.91	59.4
19	58.9	82.1	35.3	58.7	0.787	1.93	59.2
20	46.8	75.7	39.3	66.8	0.794	1.92	58.6
21	48.2	76.1	39.5	61.3	0.789	1.91	58.7
22	53.0	78.6	35.9	59.3	0.856	1.91	55.2
23	54.4	80.3	40.7	65.1	0.828	1.90	56.4
24	60.9	82.0	45.6	66.9	0.863	1.90	54.6
25	83.8	94.2	56.2	59.2	0.851	1.92	55.7
26	64.6	87.8	46.9	60.0	0.877	1.92	54.3
27	62.9	85.9	49.9	61.9	0.892	1.93	53.8
28	57.4	79.6	53.7	68.5	0.799	1.93	58.6
29	30.4	62.9	22.0	68.2	0.747	1.93	61.3
30	66.6	86.1	43.8	65.8	0.847	1.91	55.7
31	69.2	85.9	45.4	65.1	0.869	1.89	54.0
32	71.3	90.2	53.1	62.7	0.843	1.92	56.1
33	62.1	89.3	52.7	63.4	0.818	1.93	57.6
34	74.6	86.7	37.7	56.8	0.869	1.93	55.0
35	79.4	87.7	36.2	58.6	0.861	1.96	56.1
36	71.0	87.8	50.6	64.5	0.820	1.95	57.9
37	85.6	92.3	50.7	54.3	0.839	1.93	56.5
38	72.5	87.6	43.2	60.6	0.820	1.90	56.8
39	69.1	84.4	42.8	63.4	0.862	1.91	54.9
40	58.7	82.6	44.1	61.6	0.830	1.85	55.1
41	66.5	91.3	58.3	65.7	0.819	1.90	56.9
42	68.5	90.3	59.0	68.1	0.833	1.93	56.8
43	60.2	84.3	45.3	65.5	0.868	1.87	53.6
44	64.0	91.0	57.1	68.4	0.812	1.89	57.0
45	76.7	89.5	42.1	57.9	0.866	1.93	55.1
46	76.9	88.7	42.5	59.8	0.815	1.94	58.0
47	64.0	85.8	47.7	68.5	0.879	1.94	54.7
48	54.7	82.4	43.8	68.6	0.782	1.91	59.1
49	65.6	87.4	57.8	66.8	0.854	1.92	55.5
50	69.6	89.7	53.5	66.2	0.843	1.94	56.3

TABLE 32.—PART E.—(CONTINUED)

Run No.	Shatter test % + 2″	Shatter test % + 1½″	Tumbler test % + 1″	Tumbler test % + ¼″	Apparent specific gravity	True specific gravity	Porosity %
51	66.8	87.6	55.5	67.2	0.833	1.91	56.4
52	67.4	89.6	53.6	67.2	0.840	1.94	56.7
53	67.8	87.1	54.9	68.4	0.836	1.92	56.5
54	71.8	91.7	58.0	65.8	0.850	1.94	56.2
55	70.7	88.5	56.4	68.3	0.840	1.92	56.2
56	66.5	89.4	54.7	67.9	0.872	1.92	54.6
57	66.1	88.2	54.7	67.5	0.866	1.90	54.4
58	62.7	84.2	50.6	68.8	0.879	1.90	53.7
59	63.9	90.6	58.8	67.3	0.838	1.93	56.6
60	66.8	89.4	56.4	66.8	0.808	1.92	57.9
61	70.8	89.1	56.6	67.9	0.859	1.92	55.3
62	69.0	87.5	53.3	68.2	0.855	1.91	55.2
63	72.7	88.7	53.7	65.6	0.842	1.92	56.1
64	70.3	89.4	54.3	66.1	0.829	1.89	56.1
65	67.3	89.9	54.8	63.4	0.832	1.92	56.7
66	69.2	89.9	55.1	65.3	0.807	1.94	58.4
67	70.9	89.8	55.9	66.9	0.842	1.91	55.9
68	63.0	85.6	48.3	68.2	0.879	1.93	54.5
69	60.5	83.8	48.6	66.6	0.875	1.89	53.7
70	69.2	90.1	57.0	68.9	0.846	1.89	55.2
71	57.4	82.6	48.2	67.9	0.906	1.86	51.3
72	74.7	91.9	57.8	67.5	0.832	1.90	56.2
73	75.0	91.9	57.6	67.4	0.877	1.93	54.6
74	62.5	86.1	50.0	67.0	0.846	1.90	55.5
75	64.3	84.7	47.1	66.4	0.839	1.90	55.8
76	76.9	88.8	51.0	62.1	0.846	1.92	55.9
77	66.6	89.1	59.1	70.5	0.847	1.91	55.7
78	66.4	87.6	54.1	67.8	0.843	1.89	55.4
79	72.0	87.0	58.4	70.8	0.878	1.90	53.8
80	43.0	70.0	15.9	68.8	0.785	1.95	59.7
81	37.3	67.9	16.1	68.1	0.765	1.94	60.6
82	51.1	77.5	22.2	67.1	0.754	1.94	61.1
83	63.5	84.6	53.1	68.2	0.878	1.91	54.0
84	73.1	90.6	53.1	65.6	0.805	1.90	57.6
85	78.7	90.6	58.0	67.9	0.846	1.92	55.9
86	68.2	91.0	54.3	62.7	0.830	1.91	56.5
87	58.5	88.2	49.2	65.6	0.869	1.89	54.0
88	66.7	88.3	47.3	65.9	0.871	1.93	54.9
89	68.4	88.9	46.9	64.7	0.846	1.93	56.2
90	65.0	85.6	49.4	67.4	0.848	1.93	56.1
91	61.0	85.1	46.8	67.4	0.875	1.92	54.4
92	55.2	84.8	39.5	69.4	0.808	1.94	58.4
93	58.3	84.8	41.6	66.2	0.782	1.92	59.3
94	58.2	83.8	47.4	67.6	0.813	1.94	58.1
95	60.4	85.4	40.3	65.3	0.878	1.97	55.4
96	50.9	80.3	39.7	69.6	0.792	1.94	59.2
97	53.0	85.5	42.9	66.8	0.793	1.93	58.9
98	67.1	89.9	52.9	65.9	0.845	1.91	55.8
99	66.7	88.3	52.5	68.2	0.853	1.91	55.3
100	62.6	81.3	47.5	67.6	0.871	1.90	54.2

TABLE 32.—PART E.—(CONTINUED)

Run No.	Shatter test % + 2″	Shatter test % + 1½″	Tumbler test % + 1″	Tumbler test % + ¼″	Apparent specific gravity	True specific gravity	Porosity %
101	69.1	87.7	54.5	67.6	0.796	1.96	59.4
102	63.6	88.1	49.0	66.8	0.802	1.90	57.8
103	69.9	88.7	48.8	66.7	0.801	1.94	58.7
104	74.4	89.6	49.3	63.2	0.830	1.92	56.8
105	60.0	85.1	45.3	67.5	0.797	1.92	58.5
106	60.5	86.8	45.5	65.1	0.773	1.92	59.7
107	54.6	82.4	54.3	67.9	0.819	1.94	57.8
108	60.4	83.8	51.3	67.9	0.812	1.92	57.7
109	61.9	85.1	53.3	68.7	0.794	1.92	58.6
110	69.7	89.2	52.9	66.9	0.838	1.93	56.6
111	61.7	88.3	53.4	69.2	0.798	1.93	58.7
112	68.5	86.9	50.2	64.4	0.840	1.91	56.0
113	64.0	88.8	55.9	69.2	0.824	1.90	56.6
114	74.6	89.5	55.6	68.4	0.829	1.89	56.1
115	70.3	88.2	53.0	67.1	0.837	1.93	56.6
116	68.2	87.8	55.4	68.9	0.825	1.91	56.8
117	62.7	88.1	51.8	67.5	0.847	1.95	56.6
118	65.3	88.9	55.0	67.9	0.842	1.87	55.0
119	64.8	87.0	55.3	69.6	0.838	1.90	55.9
120	61.8	86.9	51.7	67.9	0.849	1.89	55.1
121	61.5	85.9	53.8	68.5	0.843	1.89	55.4
122	63.4	86.0	47.9	65.1	0.815	1.89	56.9
123	70.6	88.1	47.2	65.5	0.820	1.91	57.1
124	60.9	83.6	48.8	67.7	0.798	1.93	58.7
125	61.4	84.8	50.7	67.8	0.791	1.91	58.6
126	58.2	83.5	48.2	67.4	0.803	1.89	57.5
127	61.2	86.5	51.3	68.3	0.817	1.94	57.9
128	61.8	86.3	50.8	67.7	0.821	1.94	57.7
129	63.5	84.1	43.9	66.5	0.826	1.93	57.2
130	62.3	86.0	46.3	64.9	0.788	1.95	59.6
131	66.5	87.9	54.8	67.2	0.798	1.90	58.0
132	67.4	84.5	43.6	66.3	0.843	1.91	55.9
133	61.6	81.8	42.3	64.7	0.840	1.90	55.8
134	65.4	88.0	49.5	66.0	0.810	1.91	57.6
135	71.3	87.8	51.3	67.8	0.867	1.97	56.0
136	73.6	88.7	46.7	64.7	0.864	1.92	55.0
137	72.0	86.4	48.9	66.3	0.846	1.93	55.2
138	54.3	83.6	45.6	68.4	0.798	1.95	59.1
139	58.1	82.5	39.0	65.1	0.791	1.93	59.0
140	59.8	79.2	37.4	67.4	0.774	1.93	59.9
141	57.5	84.5	47.8	68.0	0.802	1.94	58.7
142	55.9	83.7	43.4	59.0	0.781	1.91	59.1
143	59.9	85.7	49.6	65.9	0.796	1.95	59.2
144	65.1	85.8	51.6	66.6	0.820	1.94	57.7
145	61.0	86.3	52.2	66.8	0.819	1.95	58.0
146	57.8	85.0	51.6	67.2	0.807	1.94	58.4
147	61.2	86.8	53.6	68.2	0.840	1.95	56.9
148	59.7	84.7	49.4	67.1	0.803	1.92	58.2
149	57.7	84.4	50.7	68.3	0.828	1.94	57.3
150	58.7	83.8	49.9	67.6	0.841	1.93	56.4

Table 32.—Part E.—(Concluded)

Run No.	Shatter test % + 2″	Shatter test % + 1½″	Tumbler test % + 1″	Tumbler test % + ¼″	Apparent specific gravity	True specific gravity	Porosity %
151	63.2	85.1	52.7	67.3	0.846	1.93	56.2
152	60.0	85.8	49.2	66.5	0.795	1.93	58.8
153	53.9	84.0	48.7	68.3	0.788	1.94	59.4
154	64.9	89.6	52.2	65.8	0.792	1.93	59.0
155	60.3	85.2	48.8	65.5	0.810	1.91	57.6
156	63.9	87.5	50.5	66.2	0.804	1.93	58.3
157	68.1	90.1	54.6	66.7	0.825	1.95	57.7
158	60.6	85.2	49.1	67.6	0.809	1.94	58.3
159	69.7	87.1	35.8	56.7	0.770	1.96	60.7
160	53.0	80.4	30.2	58.4	0.755	1.96	61.5
161	65.7	86.9	44.1	59.4	0.794	1.95	59.3
162	71.1	90.5	49.6	62.7	0.757	1.90	60.2
163	69.3	89.6	49.9	62.2	0.806	1.94	58.5
164	72.6	90.1	56.9	67.3	0.827	1.95	57.6
165	68.6	88.6	54.3	67.1	0.789	1.95	59.5
166	71.9	89.3	56.3	67.1	0.831	1.93	56.9
167	70.4	87.9	46.6	63.8	0.824	1.93	57.3
168	74.0	90.4	46.3	62.2	0.816	1.94	57.9
169	Coke burned on wharf.						
170	71.4	91.1	50.0	63.3	0.811	1.93	58.0
171	71.1	89.1	51.6	63.4	0.810	1.93	58.0
172	65.3	86.6	45.0	62.9	0.802	1.93	58.4
173	67.6	87.0	43.5	61.4	0.789	1.92	58.9
174	72.7	90.5	48.6	62.8	0.840	1.93	56.5
175	71.7	90.2	47.4	62.5	0.822	1.96	58.1
176	71.4	91.0	51.7	62.2	0.826	1.97	58.1
177	76.3	90.4	55.8	65.6	0.832	1.97	57.8
178	71.8	88.5	53.2	65.1	0.791	1.95	59.4
179	63.1	85.1	49.4	66.4	0.786	1.95	59.7
180	66.2	88.9	53.8	66.8	0.794	1.95	59.3
181	65.8	89.2	53.6	67.1	0.831	1.94	57.2
182	61.6	87.8	50.1	65.3	0.802	1.92	58.2
183	59.4	85.5	52.7	66.3	0.846	1.95	56.6

Table 32.—Coke Oven Operation and Results
Part F. By-Products

Run No.	Gas: Yield cu. ft. per lb. of coal	Gas: B.t.u. per cu. ft.	Gas: B.t.u. in gas per lb. of coal	Tar: Yield gal. per ton coal (dry at 60°F.)	Tar: Gravity at 60°F.
1	5.28	590	3115	5.34	.....
2	5.13	578	2965	8.4	1.19
3	5.22	523	2730	5.43	1.17
4	5.33	517	2756	5.63	1.16
5	5.45	500	2725	5.30	1.16
6	5.38	515	2771	4.2	1.16
7	5.37	517	2776	4.1	1.16
8	5.31	525	2788	6.0	1.16
9	5.27	526	2772	6.3	1.16
10	5.16	532	2745	7.0	1.16
11	5.15	530	2729	5.6	1.165
12	5.23	520	2721	6.0	1.16
13	5.27	516	2719	6.3	1.16
14	5.50	516	2838	5.2	1.16
15	5.66	514	2909	5.2	1.16
16	5.10	542	2764	7.75	1.16
17	5.19	522	2709	5.4	1.16
18	5.05	540	2727	7.1	1.16
19	5.10	529	2698	8.2	1.17
20	5.07	533	2702	7.7	1.17
21	5.04	534	2691	8.3	1.165
22	5.11	532	2718	7.1	1.17
23	5.44	562	3057	6.3	1.16
24	5.34	591	3156	7.2	1.15
25	4.75	553	2627	7.5	1.13
26	5.02	551	2766	8.9	1.15
27	5.08	529	2687	6.0	1.15
28	5.02	559	2806	6.8	1.14
29	4.92	558	2745	7.6	1.14
30	5.11	585	2989	8.4	1.14
31	4.95	586	2901	8.4	1.14
32	4.96	589	2921	5.9	1.145
33	4.96	552	2738	6.1	1.15
34	4.85	583	2827	7.6	1.14
35	4.97	582	2892	7.6	1.15
36	5.00	550	2750	6.05	1.14
37	4.74	550	2607	7.8	1.13
38	5.14	578	2970	8.1	1.145
39	5.05	575	2905	8.6	1.14
40	5.16	535	2760	6.9	1.15
41	5.28	529	2790	5.8	1.14
42	5.21	537	2800	5.65	1.14
43	5.23	545	2845	6.3	1.15
44	5.05	558	2820	6.2	1.145
45	4.90	571	2795	8.0	1.14
46	4.84	575	2780	6.95	1.14
47	5.18	532	2755	6.6	1.14
48	5.00	558	2795	9.1	1.14
49	5.00	550	2750	5.9	1.145
50	4.77	567	2710	7.8	1.14
51	5.00	540	2695	8.0	1.15
52	5.05	558	2820	8.5	1.15
53	5.08	558	2835	7.7	1.15
54	5.17	546	2825	7.4	1.15
55	4.96	544	2700	7.15	1.15
56	4.88	559	2725	7.8	1.15
57	5.16	564	2910	7.8	1.15
58	5.21	583	3040	8.7	1.16
59	5.21	539	2810	6.4	1.15
60	5.08	507	2580	6.8	1.15
61	5.00	563	2810	7.6	1.15
62	5.34	565	3015	8.95	1.15
63	5.28	550	2900	8.5	1.15
64	5.20	550	2860	6.4[a]	1.15
65	5.05	543	2740	6.9	1.16
66	5.33	534	2845	7.4	1.16
67	5.15	559	2875	8.2	1.15
68	5.28	551	2910	9.1	1.16
69	5.33	573	3055	9.6	1.15
70	5.31	565	3000	8.4	1.15
71	5.31	571	3035	9.05	1.15
72	5.16	564	2910	8.4	1.15
73	5.08	554	2815	9.1	1.15
74	5.26	569	2995	9.6	1.15
75	5.17	574	2965	9.4	1.15
76	5.31	522	2775	8.9	1.15
77	5.15	544	2800	8.45	1.15
78	5.34	566	3025	10.0	1.15
79	5.45	540	2940	8.1	1.15
80	5.41	515	2785	8.85	1.145
81	5.57	517	2880	9.2	1.155
82	6.24	488	3050	8.72	1.15
83	5.59	545	3045	9.8	1.15
84	5.84	514	3000	7.9	1.15
85	5.49	514	2820	7.45	1.14
86	5.44	501	2730	6.5	1.14
87	5.52	526	2900	8.0	1.14
88	5.69	523	2975	7.4	1.14
89	5.84	515	3010	6.8	1.15
90	5.82	538	3135	6.5	1.145

[a]Some material lost.

Table 32.—Part F.—(Concluded)

Run No.	Gas			Tar	
	Yield cu. ft. per lb. of coal	B.t.u. per cu. ft.	B.t.u. in gas per lb. of coal	Yield gal. per ton coal (dry at 60°F.)	Gravity at 60°F.
91	5.94	510	3025	8.0	1.15
92	5.66	518	2930	8.5	1.15
93	5.74	488	2800	8.1	1.15
94	5.65	507	2860	8.7	1.15
95	5.89	494	2910	8.1	1.15
96	5.64	504	2840	8.5	1.14
97	5.54	513	2845	9.4	1.145
98	5.62	510	2865	7.0	1.156
99	5.84	521	3045	9.2	1.158
100	6.09	518	3155	8.75	1.153
101	5.63	502	2830	8.6	1.158
102	6.12	495	3033	8.5	1.157
103	5.91	503	2973	8.0	1.153
104	5.79	504	2915	7.6	1.152
105	6.19	486	3010	8.3	1.151
106	6.63	503	2835	8.3	1.155
107	5.70	509	2900	6.1	1.152
108	5.90	479	2825	9.35	1.153
109	6.05	494	2990	6.3	1.151
110	6.60	478	3155	8.65	1.151
111	5.90	500	2950	7.7	1.150
112	5.75	537	3085	9.1	1.151
113[b]	6.26	486	3045	7.0	1.157
114[b]	5.98	497	2980	8.55	1.154
115[b]	5.70	538	3065	8.15	1.152
116[b]	6.21	496	3080	10.0	1.153
117[b]	5.99	518	3105	8.9	1.154
118[b]	6.01	545	3280	8.9	1.152
119[b]	6.03	541	3260	11.1	1.156
120[b]	5.90	549	3240	9.1	1.155
121[b]	5.92	556	3291	9.1	1.155
122[b]	5.33	539	2870	8.3	1.156
123[b]	5.33	536	2860	7.6	1.158
124[b]	5.40	527	2850	6.75	1.159
125[b]	5.40	526	2840	5.2(?)	1.172
126[b]	5.50	521	2865	7.3	1.160
127	5.15	535	2755	8.1	1.162
128	5.30	542	2870	6.9	1.160
129	5.46	526	2875	7.6	1.161
130	5.40	510	2755	7.0	1.153
131	5.56	508	2830	7.6	1.157
132	6.04	513	3100	8.2	1.157
133	6.57	497	3240	8.9	1.163
134	5.91	512	3025	7.5	1.155
135	6.48	494	3200	6.4	1.163
136	5.89	553	3260	8.5	1.163
137	6.26	484	3030	7.8	1.159
138	5.66	515	2920	8.9	1.157
139	5.54	519	2870	9.6	1.155
140	5.59	510	2850	8.8	1.153
141	5.80	499	2900	8.2	1.154
142	5.78	532	3073	9.2	1.154
143	5.57	510	2840	7.9	1.154
144	5.40	525	2830	7.9	1.156
145	5.91	498	2945	7.7	1.156
146	6.37	479	3055	7.35	1.165
147	5.36	511	2740	6.75	1.163
148	5.71	501	2860	6.7	1.157
149	5.22	522	2730	7.3	1.158
150	5.99	500	2995	7.5	1.162
151	5.84	490	2860	8.2	1.161
152	5.66	506	2870	7.4	1.155
153	5.77	490	2825	8.3	1.154
154	5.59	506	2820	7.4	1.156
155	5.71	511	2920	9.2	1.155
156	5.64	511	2880	9.0	1.154
157	5.43	516	2805	7.4	1.152
158	5.52	502	2775	9.4	1.150
159	5.37	510	2740	9.2	1.154
160	5.87	505	2965	10.3	1.158
161	5.53	524	2900	8.75	1.162
162	5.41	510	2760	8.8	1.150
163	5.81	505	2935	7.1	1.156
164	5.47	503	2755	6.5	1.153
165	5.54	520	2880	8.5	1.148
166	5.42	491	2660	7.9	1.149
167	5.46	528	2890	9.0	1.153
168	5.63	508	2860	9.5	1.154
169	Coke burned on wharf.				
170	5.65	505	2850	9.0	1.149
171	5.32	526	2800	8.5	1.151
172	5.48	523	2860	9.9	1.154
173	5.52	499	2755	8.0	1.151
174	5.66	480	2720	6.0	1.155
175	5.70	500	2850	7.9	1.156
176	5.4	498	2690	8.8	1.158
177	5.71	470	2685	6.75	1.153
178	6.07	450	2730	8.0	1.151
179	6.34	466	2955	6.7	1.156
180	6.76	464	3120	7.6	1.159
181	6.70	460	3080	5.9	1.156
182	5.89	490	2885	6.7	1.154
183	5.95	486	2890	6.1	1.158

[b]Due to operating conditions, results on runs 113 through 126 are less representative than the other runs listed.

Table 33.—Special Coke Analyses.
Carbon and Hydrogen Determinations Compared with Volatile Matter and Coking Temperatures

Run No.	Carbon %	Hydrogen %	Volatile matter %	Final coke temperature °F.	Run No.	Carbon %	Hydrogen %	Volatile matter %	Final coke temperature °F.
2	88.32	0.40	1.1	1824	54	86.28	0.61	1.6	1779
3	86.23	0.52	1.7	1792	55	85.66	0.62	1.7	1778
4	87.38	0.53	1.2	1841	56	87.74	0.54	1.5	1775
5	88.70	0.46	0.9	1837	57	87.95	0.56	1.6	1771
6	85.83	0.73	1.9	1800	58	89.63	0.59	1.6	1772
7	86.95	0.58	1.7	1796	59	87.75	0.60	1.7	1776
8	87.40	0.60	1.4	1791	60	86.58	0.73	1.6	1785
9	87.65	0.55	1.2	1790	61	86.59	0.55	1.7	1776
10	87.15	0.59	1.6	1805	62	88.49	0.59	1.1	1792
11	86.85	0.64	1.8	1795	63	86.86	0.63	1.5	1771
12	86.26	0.51	1.2	1802	64	88.02	0.59	1.8	1787
G.C. 1[a]	86.56	0.41	1.3	....	65	87.27	0.59	1.5	1765
G.C. 2[a]	87.25	0.52	1.2	....	66	85.20	0.60	1.6	1765
13	87.05	0.60	1.4	1797	67	87.55	0.60	1.6	1765
14	87.89	0.45	1.2	1857	68	86.33	0.52	1.2	1769
15	88.67	0.35	1.1	1896	69	89.01	0.67	1.6	1767
16	87.11	0.55	1.5	1776	70	87.74	0.64	1.2	1778
17	84.32	0.63	2.2	1779	71	89.86	0.50	1.7	1776
18	85.84	0.61	1.5	1790	72	87.54	0.58	1.2	1765
19	87.28	0.48	1.2	1772	73	87.12	0.50	1.1	1776
20	86.59	0.54	1.6	1778	74	88.45	0.57	1.5	1774
21	88.12	0.54	1.1	1786	75	87.78	0.63	1.6	1769
G.C. 3[a]	87.53	0.30	1.5	....	77	86.53	0.61	1.6	1780
23	90.18	0.50	1.1	1799	78	89.43	0.69	1.4	1778
26	88.67	0.56	1.1	1787	79	87.28	0.62	1.7	1774
30	89.54	0.59	1.2	1794	80	82.68	0.59	2.0	1782
31	88.45	0.58	1.3	1778	81	83.84	0.53	2.0	1758
36	86.47	0.50	1.3	1768	82	84.08	0.52	1.7	....
40	88.20	0.43	1.0	1871	83	88.19	0.55	1.3	1777
42	89.53	0.58	1.5	1797	84	87.53	0.59	1.6	1771
43	89.60	0.41	1.0	1875	85	85.99	0.57	1.6	1774
44	88.54	0.54	1.8	1798	86	87.63	0.67	1.6	1769
45	84.60	0.61	1.6	1796	87	86.70	0.57	1.6	1807
46	82.65	0.57	1.4	1803	88	88.31	0.45	1.3	1813
47	86.23	0.61	2.2	1795	89	87.23	0.46	1.3	1794
48	87.23	0.59	1.8	1785	90	86.59	0.59	1.4	1801
49	88.77	0.64	1.8	1785	91	88.91	0.51	1.2	1803
50	86.05	0.61	1.6	1772	92	84.07	0.50	1.8	1801
51	87.39	0.55	1.7	1776	93	85 27	0.50	1.6	1807
52	86.86	0.57	1.6	1782	94	83.61	0.58	1.7	1810
53	86.77	0.61	1.4	1773	95	82.84	0.49	1.4	1803

[a]Coke made in Koppers ovens at Granite City.

Table 34.—Properties and Composition of Tars

Part A

(See page 116)

Specific gravity was determined on the dry tar for runs 3 to 13, on a dry tar-toluene mixture and calculated to a dry tar basis for runs 14 to 84, and on a wet tar-toluene mixture and calculated to a dry tar basis for runs 85 to 183. Free carbon was determined on the dry tar for runs 3 to 15, on a dry tar-toluene mixture and calculated to a dry tar basis for runs 16 to 68, and on the wet tar and calculated to a dry tar basis for runs 69 to 183. Loss on manipulation represents the difference between the distillate and the sum of neutrals, bases and acids isolated therefrom.

Table 34.—Properties and Composition of Tars (See page 115)
Part A

Run No.	Tar yield (gal. dry tar per ton of coal as charged)	Moisture (% by vol. of wet tar)	Specific gravity dry tar at 60°F.	Free carbon (% by wt. of dry tar)	Distillate to 350° C. (% by wt. of dry tar)	Loss on manipulation (% by wt. of dry tar)
1	5.3	31.9	.....	...	....	...
2	8.4	22.1	.....	...	35.0	2.2
3	5.4	21.5	1.176	7.8	45.0	6.4
4	5.6	16.8	1.166	8.8	39.4	−0.5
5	5.3	19.2	1.168	5.9	40.3	1.6
6	4.2	11.5	1.167	4.0	41.0	1.2
7	4.1	19.4	1.170	5.5	42.7	1.7
8	6.0	15.5	1.169	5.0	44.3	2.1
9	6.3	15.3	1.171	4.9	42.8	2.0
10	7.0	13.8	1.168	5.7	41.4	2.6
11	5.6	20.4	1.173	5.1	39.4	3.1
12	6.0	16.1	1.166	5.0	42.2	4.7
13	6.3	15.3	1.171	5.6	41.8	2.4
14	5.2	14.4	1.167	4.5	44.6	2.4
15	5.2	19.0	1.172	5.0	41.4	1.7
16	7.75	13.2	1.166	6.3	41.7	1.7
17	5.4	14.8	1.170	7.1	41.6	3.5
18	7.1	9.0	1.170	6.2	40.0	2.1
19	8.2	12.9	1.178	8.7	39.7	1.4
20	7.7	9.5	1.176	8.4	38.9	2.5
21	8.3	7.5	1.175	7.0	40.0	1.9
22	7.1	10.6	1.176	6.7	41.3	2.8
23	6.3	8.4	1.170	7.8	39.2	2.5
24	7.2	8.8	1.162	6.2	41.4	2.0
25	7.5	4.9	1.143	3.9	47.9	3.0
26	8.9	7.8	1.163	5.8	39.7	2.6
27	6.0	6.3	1.161	6.3	40.5	2.6
28	6.8	7.8	1.147	4.4	44.0	2.7
29	7.6	4.7	1.151	5.2	47.0	3.2
30	8.4	8.5	1.150	5.8	42.2	2.2
31	8.4	5.6	1.149	4.3	42.7	2.3
32	5.9	9.1	1.155	4.8	42.3	1.4
33	6.1	9.3	1.156	5.3	43.4	2.3
34	7.6	6.8	1.154	5.1	43.2	1.8
35	7.6	5.3	1.156	4.5	42.5	1.6
36	6.05	9.2	1.151	4.8	44.2	2.0
37	7.8	3.4	1.136	3.1	48.3	4.7
38	8.1	6.8	1.155	5.6	43.5	2.3
39	8.6	11.2	1.154	5.5	43.3	2.0
40	6.9	11.9	1.163	4.7	40.4	1.6
41	5.8	6.3	1.154	4.0	41.8	1.4
42	5.65	9.5	1.153	7.5	45.5	2.7
43	6.3	9.1	1.162	3.9	40.4	0.9
44	6.2	7.5	1.155	4.0	42.6	1.4
45	8.0	5.4	1.154	4.5	44.2	0.9
46	6.95	5.7	1.154	4.5	43.9	1.8
47	6.6	8.7	1.148	5.2	43.1	1.5
48	9.1	3.6	1.153	5.8	44.0	3.1
49	5.9	10.9	1.155	5.9	44.9	2.3
50	7.8	6.5	1.154	4.8	42.7	1.5

TABLE 34.—PART A.—(CONTINUED)

Run No.	Tar yield (gal. dry tar per ton of coal as charged)	Moisture (% by vol. of wet tar)	Specific gravity dry tar at 60°F.	Free carbon (% by wt. of dry tar)	Distillate to 350° C. (% by wt. of dry tar)	Loss on manipulation (% by wt. of dry tar)
51	8.0	13.5	1.158	5.8	43.4	0.6
52	8.5	7.8	1.158	5.1	43.4	0.9
53	7.7	7.8	1.158	4.2	38.7	([a])
54	7.4	8.0	1.159	5.5	43.8	1.1
55	7.15	9.4	1.158	3.9	43.3	1.0
56	7.8	10.7	1.159	3.8	42.9	0.7
57	8.7	16.3	1.162	3.5	39.3	1.3
58	9.3	15.8	1.166	5.2	38.7	0.6
59	6.4	11.5	1.160	3.9	42.6	0.5
60	6.8	15.0	1.158	4.4	42.6	1.6
61	7.6	13.5	1.159	3.6	40.7	0.3
62	8.95	12.8	1.159	4.3	43.0	1.4
63	8.5	11.2	1.161	3.3	42.7	0.6
64	[a]6.4	16.8	1.158	3.7	43.0	0.8
65	6.9	20.7	1.167	4.1	40.6	0.6
66	7.4	19.3	1.167	4.2	42.6	0.9
67	8.2	16.2	1.157	3.4	42.7	0.5
68	9.1	18.7	1.167	3.4	40.0	0.5
69	9.6	18.6	1.162	3.4	40.4	1.0
70	8.4	19.0	1.160	3.5	40.1	0.2
71	9.05	21.7	1.158	3.3	39.9	0.9
72	8.4	22.8	1.156	2.9	41.0	0.8
73	9.1	17.6	1.158	3.3	39.8	0.6
74	9.6	13.5	1.160	3.3	41.0	0.8
75	9.4	14.2	1.158	3.3	41.7	0.9
76	8.9	13.4	1.158	3.6	43.5	0.9
77	8.45	13.1	1.156	3.3	43.0	0.8
78	10.0	10.1	1.156	3.2	42.4	1.0
79	8.1	11.0	1.161	4.3	43.2	1.3
80	8.85	10.0	1.155	2.7	45.2	1.2
81	9.2	11.1	1.165	3.3	46.5	1.3
82	8.7	9.3	1.162	2.9	48.2	1.8
83	9.8	10.9	1.161	2.7	45.3	0.5
84	7.9	13.2	1.164	3.9	43.8	1.0
85	7.45	11.8	1.149	3.6	45.7	1.0
86	6.5	12.8	1.154	2.8	45.8	1.1
87	8.0	9.6	1.151	3.5	44.4	1.0
88	7.4	6.1	1.150	3.3	41.8	0.8
89	6.8	13.3	1.157	4.0	42.9	0.7
90	6.5	9.7	1.155	3.2	43.5	0.8
91	8.0	9.9	1.158	2.8	41.3	0.6
92	8.5	11.5	1.156	3.1	43.9	0.8
93	8.1	13.1	1.159	4.0	44.4	1.3
94	8.7	13.6	1.157	4.2	44.7	1.4
95	8.1	12.4	1.159	4.0	43.8	1.2
96	8.5	10.5	1.152	3.0	44.9	1.1
97	9.4	10.3	1.155	3.6	44.4	0.9
98	7.0	11.9	1.156	4.5	44.0	0.8
99	9.2	11.3	1.158	4.2	42.9	1.0
100	8.75	12.6	1.153	4.5	39.8	0.7

[a]Part of material was lost in laboratory accident.

TABLE 34.—PART A.—(CONTINUED)

Run No.	Tar yield (gal. dry tar per ton of coal as charged)	Moisture (% by vol. of wet tar)	Specific gravity dry tar at 60°F.	Free carbon (% by wt. of dry tar)	Distillate to 350° C. (% by wt. of dry tar)	Loss on manipulation (% by wt. of dry tar)
101	8.6	8.8	1.158	4.2	44.7	0.6
102	8.5	11.4	1.157	3.7	44.0	0.6
103	8.0	15.3	1.153	4.0	43.5	−0.1
104	7.6	12.6	1.152	3.5	44.3	0.4
105	8.3	11.9	1.151	4.1	44.2	1.1
106	8.3	12.8	1.155	4.2	45.5	1.3
107	6.1	12.2	1.152	3.7	45.1	1.0
108	9.35	9.9	1.153	3.5	45.4	1.3
109	6.3	19.2	1.151	4.1	43.3	1.0
110	8.65	13.3	1.151	3.8	44.3	0.8
111	7.7	8.8	1.150	3.5	46.5	1.1
112	9.1	9.1	1.151	2.8	43.8	1.0
113[b]	7.0	24.3	1.157	3.9	41.5	1.2
114[b]	8.55	16.3	1.154	3.7	43.8	1.6
115[b]	8.15	14.8	1.152	3.5	43.2	0.6
116[b]	10.0	16.0	1.153	3.7	41.4	0.8
117[b]	8.9	14.5	1.154	3.7	42.2	1.2
118[b]	8.9	14.1	1.152	4.1	42.3	0.8
119[b]	11.1	14.3	1.156	3.6	42.5	0.9
120[b]	9.1	11.8	1.155	3.2	40.9	0.8
121[b]	9.1	9.7	1.155	3.3	41.4	0.9
122[b]	8.3	9.1	1.156	3.2	42.7	1.1
123[b]	7.6	15.7	1.158	2.9	42.7	0.6
124[b]	6.75	18.7	1.159	3.6	43.4	0.8
125[b]	5.2(?)	41.5	1.172	14.0	38.2	0.8
126[b]	7.3	14.2	1.160	3.4	42.5	0.6
127	8.1	14.6	1.162	3.5	43.1	0.6
128	6.9	9.4	1.160	2.9	43.2	0.4
129	7.6	9.4	1.161	3.2	40.8	0.9
130	7.0	8.7	1.153	2.8	45.1	0.8
131	7.6	13.4	1.157	3.2	43.4	0.7
132	8.2	14.9	1.157	3.9	41.5	0.9
133	8.9	12.6	1.163	3.7	40.5	0.7
134	7.5	14.3	1.155	3.8	42.0	0.8
135	6.4	18.6	1.163	4.1	41.1	0.7
136	8.5	18.0	1.163	4.1	40.5	0.1
137	7.8	16.1	1.159	3.7	41.5	0.6
138	8.9	9.5	1.157	3.1	42.6	1.0
139	9.6	7.9	1.155	3.3	44.2	0.9
140	8.8	9.7	1.153	3.2	44.8	[c]1.1
141	8.2	9.6	1.154	3.0	44.8	1.6
142	9.3	7.7	1.154	3.2	44.9	1.4
143	7.9	13.0	1.154	4.0	44.0	1.4
144	7.9	11.6	1.156	3.7	43.7	1.0
145	7.7	12.2	1.156	3.7	43.2	1.0
146	7.35	15.4	1.165	3.8	41.2	1.1
147	6.75	18.8	1.163	3.9	41.3	1.6
148	6.7	16.5	1.157	3.3	44.4	1.2
149	7.3	15.8	1.158	3.2	43.9	1.3
150	7.5	15.9	1.162	3.3	40.5	1.0

[b]Due to operating conditions, results on runs 113 through 126 are less representative than the other runs listed.
[c]Tar acids lost. Loss on manipulation assumed to be average in order to estimate total tar acids.

TABLE 34.—PART A.—(CONCLUDED)

Run No.	Tar yield (gal. dry tar per ton of coal as charged)	Moisture (% by vol. of wet tar)	Specific gravity dry tar at 60°F.	Free carbon (% by wt. of dry tar)	Distillate to 350° C. (% by wt. of dry tar)	Loss on manipulation (% by wt. of dry tar)
151	8.2	12.1	1.161	3.1	40.9	0.8
152	7.4	13.0	1.155	2.8	43.8	1.4
153	8.3	10.2	1.154	2.7	42.5	1.1
154	7.4	11.4	1.156	3.1	45.8	0.9
155	9.2	9.4	1.155	3.0	45.0	1.1
156	9.0	10.1	1.154	3.2	44.6	1.1
157	7.4	9.5	1.152	3.1	45.5	1.0
158	9.35	88.0	1.150	2.9	44.6	1.1
159	9.2	11.7	1.154	3.8	42.7	1.1
160	10.3	7.3	1.158	4.5	41.8	0.7
161	8.75	11.7	1.162	4.0	41.1	0.8
162	8.8	9.5	1.150	3.9	44.0	1.1
163	7.1	13.9	1.156	4.3	43.2	0.8
164	6.5	12.4	1.153	4.0	44.4	0.8
165	8.5	8.6	1.148	3.1	45.4	1.0
166	7.9	9.9	1.149	3.1	47.2	1.0
167	9.0	7.6	1.153	3.1	45.3	0.9
168	9.5	7.1	1.154	3.3	44.7	1.0
169	9.9	7.6	1.152	...	....[d]	...
170	9.0	9.0	1.149	2.9	45.7	1.0
171	8.5	7.9	1.151	2.8	45.1	1.1
172	9.9	8.7	1.154	3.5	43.0	0.9
173	8.0	10.8	1.151	2.9	45.2	1.1
174	6.0	15.2	1.155	4.2	44.5	0.8
175	7.9	14.9	1.156	4.0	44.4	0.9
176	8.8	11.0	1.158	3.4	44.2	1.0
177	6.75	13.3	1.153	3.5	45.1	0.9
178	8.0	13.0	1.151	5.8	46.0	1.1
179	6.7	15.0	1.156	3.7	45.3	1.0
180	7.6	15.4	1.159	5.5	43.9	0.9
181	5.9	15.4	1.156	4.0	43.3	0.9
182	6.7	13.1	1.154	3.5	44.9	0.9
183	6.1	10.3	1.158	3.5	45.3	0.6

[d]Data not taken because coke burned on wharf.

TABLE 34.—PROPERTIES AND COMPOSITION OF TARS

PART B

(See page 120)

All values in this part of table 34 are percentages by weight of dry tar.

One naphthalene fraction, 205-225° C. (uncorrected) was cut for runs 3 to 62, and the percentage of $C_{10}H_8$ determined from its freezing point, the remainder being assigned to the residue. On runs 63 to 183, two naphthalene fractions were cut, one from 195° C. to the naphthalene plateau, the other from the naphthalene plateau to 230° C. $C_{10}H_8$ contents of these were determined from freezing point data and the difference assigned to light oil and residue, respectively.

The temperature of 216° C. under tar acids is accurate only to ± 3° C.

The extraction procedure described in the Appendix B of this report was followed on runs 37 to 183. The values of total acids, bases, and neutrals on runs before no. 37 are less reliable.

TABLE 34.—PROPERTIES AND COMPOSITION OF TARS (See page 119)
PART B

Run No.	Neutrals				Bases	Acids		
	Total	Light oil	$C_{10}H_8$	Residue	Total	Total	B.P. < 216° C.	B.P. > 216° C.
1	....	....	....	....	....	....	....	....
2	27.2	....	....	....	1.2	4.4	....	....
3	31.4	2.8	8.0	20.6	1.7	5.5	3.1	2.4
4	32.0	3.1	7.7	21.2	2.1	5.8	3.3	2.4
5	31.7	2.7	8.1	20.9	1.3	5.7	3.3	2.4
6	31.4	2.8	7.8	20.8	2.1	6.3	4.0	2.3
7	32.5	2.7	8.1	21.7	2.3	6.2	3.7	2.5
8	33.3	3.0	7.3	23.0	2.2	6.7	4.4	2.3
9	32.0	2.9	7.5	21.6	2.2	6.6	4.1	2.5
10	30.4	2.8	8.1	19.5	2.0	6.4	3.9	2.5
11	29.7	2.6	8.1	19.0	1.3	5.3	2.9	2.4
12	31.0	2.8	8.2	20.0	1.9	4.6	2.3	2.3
13	32.4	2.6	8.0	21.8	2.0	5.0	2.8	2.2
14	34.5	2.6	8.1	23.8	2.0	5.7	3.5	2.2
15	32.4	2.3	8.9	21.2	1.9	5.4	3.5	1.9
16	32.2	3.5	7.2	21.5	2.1	5.7	3.5	2.2
17	31.8	2.5	8.4	20.9	2.0	4.3	3.0	1.3
18	30.4	3.1	7.8	19.5	2.0	5.5	3.5	2.0
19	30.5	2.7	7.4	20.4	2.1	5.7	3.6	2.1
20	28.9	2.5	6.6	19.8	1.9	5.6	3.6	2.0
21	29.6	2.6	6.6	20.4	2.8	5.7	3.6	2.1
22	30.6	2.5	7.2	20.9	2.0	5.9	3.7	2.2
23	29.9	2.6	7.4	19.9	1.7	5.1	3.3	1.8
24	31.0	3.7	6.5	20.8	2.3	6.1	3.8	2.3
25	32.0	4.5	4.6	22.9	2.4	10.5	6.2	4.3
26	26.0	2.9	5.1	18.0	2.5	8.6	6.3	2.3
27	27.4	2.9	5.5	19.0	2.6	7.9	5.3	2.6
28	29.7	2.4	6.1	21.2	2.6	9.0	6.2	2.8
29	28.9	3.4	5.0	20.5	3.1	11.8	7.3	4.5
30	28.9	3.7	5.7	19.5	2.4	8.7	6.0	2.7
31	29.9	4.0	5.7	20.2	2.6	7.9	5.2	2.7
32	29.1	3.3	5.9	19.9	3.0	8.8	6.0	2.8
33	30.5	3.4	6.5	20.6	2.5	8.1	5.8	2.3
34	31.0	3.7	6.9	20.4	2.3	8.1	5.6	2.5
35	31.0	3.7	6.9	20.4	2.5	7.4	5.2	2.2
36	30.4	3.6	6.2	20.6	2.5	9.3	6.5	2.8
37	29.2	4.0	4.1	21.1	3.0	11.4	8.1	3.3
38	30.3	3.4	6.1	20.8	2.6	8.3	6.3	2.0
39	30.4	3.6	5.7	21.1	2.4	8.5	6.3	2.2
40	28.6	2.9	6.4	19.3	2.3	7.9	6.0	1.9
41	29.7	2.9	6.3	20.5	2.3	8.4	6.4	2.0
42	31.2	3.2	5.7	22.3	2.7	8.9	6.7	2.2
43	27.8	2.7	5.8	19.3	2.3	9.4	7.0	2.4
44	29.5	3.3	5.7	20.5	2.6	9.1	6.7	2.4
45	32.5	4.0	6.4	22.1	2.3	8.5	6.0	2.4
46	32.4	3.5	6.5	22.4	2.1	7.6	5.7	1.9
47	29.6	3.5	5.6	20.5	2.5	9.5	7.0	2.5
48	28.3	3.8	5.0	19.5	2.7	9.9	7.2	2.7
49	30.9	3.5	6.2	21.2	2.5	9.2	6.7	2.5
50	30.9	3.6	6.3	21.0	2.3	8.0	5.9	2.1

Table 34.—Part B.—(Continued)

Run No.	Neutrals				Bases	Acids		
	Total	Light oil	$C_{10}H_8$	Residue	Total	Total	B.P. < 216° C.	B.P. > 216° C.
51	31.9	2.7	6.5	22.7	2.6	8.3	5.9	2.4
52	31.9	3.8	6.4	21.5	2.3	8.3	5.8	2.5
53	Material lost in laboratory accident.							
54	32.6	3.2	6.1	23.3	2.5	7.6	5.4	2.2
55	32.9	3.8	5.8	23.3	2.5	6.9	4.9	2.0
56	33.5	3.4	5.9	24.2	2.6	6.1	3.9	2.2
57	30.7	3.7	5.3	21.7	2.1	5.2	2.7	2.5
58	31.2	4.3	5.6	21.3	1.9	5.0	3.1	1.9
59	34.0	3.8	6.6	23.6	2.5	5.6	3.5	2.1
60	31.6	3.4	5.6	22.6	2.5	6.9	4.2	2.7
61	32.4	3.4	6.0	23.0	2.1	5.9	3.3	2.6
62	33.8	3.9	6.1	23.8	2.1	5.7	3.4	2.3
63	34.3	4.3	6.6	23.4	2.1	5.7	3.3	2.4
64	34.1	4.5	6.5	23.1	2.2	5.9	3.2	2.7
65	33.3	3.7	6.9	22.7	2.2	4.5	2.6	1.9
66	33.4	3.9	6.8	22.7	2.5	5.8	3.3	2.5
67	34.8	4.4	6.6	23.8	2.1	5.3	3.0	2.3
68	32.4	3.8	6.2	22.4	2.0	5.1	2.8	2.3
69	32.3	3.7	6.2	22.4	2.0	5.1	2.8	2.3
70	33.3	4.3	6.2	22.8	1.9	4.7	2.7	2.0
71	32.0	4.1	6.1	21.5	1.9	5.1	3.0	2.1
72	33.4	4.1	6.5	22.8	1.9	4.9	2.6	2.3
73	32.8	4.2	6.4	22.2	1.8	4.6	2.6	2.0
74	33.0	4.4	6.4	22.2	2.0	5.2	3.0	2.2
75	33.2	4.2	6.4	22.6	2.0	5.6	3.4	2.2
76	33.8	4.2	6.4	23.2	2.1	6.7	4.3	2.4
77	32.9	4.3	6.2	22.4	2.1	7.2	4.6	2.6
78	32.1	4.2	6.0	21.9	2.1	7.2	4.7	2.5
79	33.0	4.0	6.3	22.7	2.0	6.9	4.7	2.2
80	31.3	4.1	5.5	21.7	2.7	10.0	6.6	3.4
81	31.1	4.1	5.3	21.7	2.7	11.4	7.5	3.9
82	32.1	4.2	5.0	22.9	2.2	12.1	8.1	4.0
83	32.0	4.3	5.5	22.2	2.9	9.9	6.8	3.1
84	32.4	3.9	6.5	22.0	2.1	8.3	5.7	2.6
85	33.8	3.8	6.1	23.9	2.3	8.6	5.5	3.1
86	34.1	3.7	6.7	23.7	2.5	8.1	5.2	2.9
87	32.8	3.8	6.0	23.0	2.3	8.3	5.5	2.8
88	32.8	3.3	6.8	22.7	1.9	6.3	4.2	2.1
89	33.3	3.6	7.0	22.7	2.2	6.7	4.5	2.2
90	33.2	3.4	7.0	22.8	2.3	7.2	4.8	2.4
91	32.0	3.6	7.0	21.4	2.1	6.6	4.6	2.0
92	31.6	3.8	6.2	21.6	2.5	9.0	6.0	3.0
93	31.3	3.5	6.0	21.8	2.5	9.3	6.2	3.1
94	31.2	3.8	5.8	21.6	2.5	9.6	6.8	2.8
95	31.2	3.6	6.0	21.6	2.5	8.9	6.2	2.7
96	31.1	4.2	5.6	21.3	2.6	10.1	6.8	3.3
97	30.9	4.1	5.9	20.9	2.6	10.0	6.8	3.2
98	32.9	4.5	6.8	21.6	2.3	8.0	5.7	2.3
99	32.0	3.8	6.0	22.2	2.2	7.7	5.5	2.2
100	30.1	3.8	5.7	20.6	2.0	7.0	5.0	2.0

TABLE 34.—PART B.—(CONTINUED)

Run No.	Neutrals				Bases	Acids		
	Total	Light oil	$C_{10}H_8$	Residue	Total	Total	B.P. < 216° C.	B.P. > 216° C.
101	32.2	4.0	5.4	22.8	2.6	9.3	6.0	3.3
102	31.6	4.3	5.9	21.4	2.6	9.2	6.3	2.9
103	32.1	4.0	6.2	21.9	2.6	8.9	5.9	3.0
104	33.5	4.1	6.7	22.7	2.4	8.0	5.3	2.7
105	31.2	3.9	6.2	21.1	2.6	9.3	6.4	2.9
106	32.1	3.9	6.3	21.9	2.7	9.4	6.3	3.1
107	32.5	4.1	6.6	21.8	2.6	9.0	6.2	2.8
108	32.0	4.4	6.2	21.4	2.7	9.4	6.6	2.8
109	30.3	3.8	6.3	20.2	2.6	9.4	6.6	2.8
110	32.3	4.2	6.2	21.9	2.4	8.8	6.0	2.8
111	32.6	4.2	6.2	22.2	2.7	10.1	7.1	3.0
112	32.1	4.3	6.4	21.4	2.3	8.4	5.8	2.6
113[a]	31.3	3.7	6.4	21.2	2.1	6.9	4.6	2.3
114[a]	32.8	4.1	5.8	22.9	2.2	7.2	4.5	2.7
115[a]	32.6	4.2	5.8	22.6	2.2	7.8	5.1	2.7
116[a]	31.7	3.7	6.3	21.7	2.1	6.8	4.3	2.5
117[a]	32.1	4.1	6.2	21.8	2.2	6.7	4.4	2.3
118[a]	31.9	4.0	6.0	21.9	2.2	7.4	4.9	2.5
119[a]	32.2	4.1	6.2	21.9	2.1	7.3	4.8	2.5
120[a]	31.3	3.9	5.7	21.7	2.3	6.5	4.1	2.4
121[a]	31.8	4.2	6.3	21.3	1.9	6.8	4.5	2.3
122[a]	31.0	4.1	6.1	20.8	2.4	8.2	5.9	2.3
123[a]	31.4	3.8	6.3	21.3	2.4	8.3	5.4	2.9
124[a]	32.4	3.8	6.6	22.0	2.5	7.7	5.9	2.8
125[a]	31.6	3.4	6.0	22.2	1.9	3.9	1.9	2.0
126[a]	33.0	3.8	6.2	23.0	2.6	6.3	3.4	2.9
127	32.9	3.6	6.6	22.7	2.6	7.0	4.6	2.4
128	32.2	3.6	6.7	21.9	2.9	7.7	5.1	2.6
129	29.3	3.2	5.8	20.3	2.6	8.0	5.6	2.4
130	32.8	3.7	6.2	22.9	2.8	8.7	5.7	3.0
131	31.8	3.4	6.8	21.6	2.6	8.3	5.6	2.7
132	31.0	3.5	6.8	20.7	2.3	7.3	5.1	2.2
133	30.5	3.6	6.3	20.6	2.1	7.2	4.9	2.3
134	30.5	3.9	6.0	20.6	2.4	8.3	5.4	2.9
135	31.6	3.3	7.0	21.3	2.2	6.6	4.6	2.0
136	31.9	3.7	6.8	21.4	2.0	6.5	4.0	2.5
137	32.0	3.5	6.4	22.1	2.2	6.7	4.3	2.4
138	30.9	3.7	6.1	21.1	2.5	8.2	5.5	2.7
139	31.5	3.8	6.2	21.5	2.6	9.2	6.0	3.2
140	31.4	3.8	6.2	21.4	2.6	9.7[b]	[b]	[b]
141	31.6	3.7	6.3	21.6	2.4	9.2	6.2	3.0
142	32.7	3.9	6.7	22.1	2.4	8.4	5.6	2.8
143	31.2	4.0	6.1	21.1	2.4	9.0	6.0	3.0
144	31.5	3.7	6.4	21.4	2.4	8.8	5.9	2.9
145	31.3	3.7	6.4	21.2	2.3	8.6	5.8	2.8
146	29.8	3.4	5.8	20.6	2.3	8.0	5.3	2.7
147	29.8	3.1	6.1	20.6	2.3	7.6	5.1	2.5
148	31.5	3.8	5.5	22.2	2.5	9.2	5.8	2.4
149	31.0	3.2	5.9	21.9	2.5	9.1	6.2	2.9
150	30.8	3.3	6.4	21.1	2.2	6.5	4.1	2.4

[a]Due to operating conditions, results on runs 113 through 126 are less representative than the other runs listed.
[b]Acids lost. Estimation of total acids based on assumption of loss on manipulation of 1.1%.

TABLE 34.—PART B.—(CONCLUDED)

Run No.	Neutrals				Bases	Acids		
	Total	Light oil	$C_{10}H_8$	Residue	Total	Total	B.P.< 216° C.	B.P.> 216° C.
151	31.0	3.3	6.3	21.4	2.3	6.8	4.4	2.4
152	32.0	3.6	6.2	22.2	2.6	7.8	4.8	3.0
153	30.2	4.0	5.5	20.7	2.5	8.7	5.7	3.0
154	33.0	4.0	6.1	22.9	2.6	9.3	6.1	3.2
155	31.5	3.9	5.9	21.7	2.6	9.8	6.5	3.3
156	31.9	4.1	5.9	21.9	2.5	9.1	5.9	3.2
157	32.8	4.3	6.1	22.4	2.5	9.2	5.8	3.4
158	30.8	4.2	5.3	21.3	2.5	10.2	6.5	3.7
159	30.4	3.7	5.8	20.9	2.1	9.1	5.7	3.4
160	30.7	4.0	5.6	21.1	2.0	8.4	5.1	3.3
161	31.0	3.7	6.5	20.8	2.0	7.3	4.5	2.8
162	32.5	4.1	6.5	21.9	2.3	8.1	3.4	4.7
163	32.9	3.6	6.6	22.7	2.0	7.5	4.4	3.1
164	33.8	3.8	6.9	23.1	2.2	7.6	4.7	2.9
165	32.1	4.1	6.4	21.6	2.4	9.9	6.2	3.7
166	34.1	3.9	6.2	24.0	2.4	9.7	6.2	3.5
167	32.3	3.9	5.8	22.6	2.4	9.7	6.5	3.2
168	31.5	4.0	5.9	21.6	2.5	9.7	6.5	3.2
169	Coke burned on wharf.							
170	32.8	3.9	5.8	23.1	2.4	9.5	6.1	3.4
171	31.9	3.8	5.7	22.4	2.3	9.8	6.6	3.2
172	30.0	4.1	5.6	20.3	2.3	9.8	6.6	3.2
173	31.6	3.7	5.8	22.1	2.5	10.0	6.7	3.3
174	33.8	3.1	6.9	23.8	2.3	7.6	4.7	2.9
175	32.5	3.6	6.0	22.9	2.4	8.6	5.4	3.2
176	32.1	4.6	6.2	21.3	2.2	8.9	5.7	3.2
177	33.8	4.3	6.5	23.0	2.2	8.2	5.2	3.0
178	32.6	3.9	6.1	22.6	2.5	9.8	6.3	3.5
179	32.7	3.5	6.7	22.5	2.6	9.0	6.2	2.8
180	31.9	3.7	6.4	21.8	2.5	8.6	5.8	2.8
181	32.2	3.4	6.4	22.4	2.4	7.8	5.4	2.4
182	32.9	3.6	6.9	22.4	2.6	8.5	5.7	2.8
183	35.8	3.7	7.6	24.5	2.4	6.5	3.9	2.6

Table 35.—Phenol and Cresol Content of Tars

Values given are percentage by weight of dry tar. They were determined on samples obtained by combining the tar acid fractions from runs listed in the first column.

Run No.	Phenol	*o*-Cresol	*m*-Cresol	*p*-Cresol
3, 4, 5	0.8	0.4	0.8	0.6
6, 8, 13	0.9	0.4	0.8	0.6
9, 10, 11, 12	0.9	0.4	0.9	0.6
14, 15	0.8	0.5	0.8	0.6
19, 20, 21, 22	0.8	0.4	0.8	0.6
23, 24	0.9	0.4	0.8	0.6
25	1.3	0.7	1.5	1.3
29	1.6	0.8	1.6	1.1
30, 31	1.2	0.6	1.2	0.9
32, 33	1.8	0.6	1.2	1.0
34, 35, 38, 39	1.4	0.3	1.0	0.7
37	2.0	0.9	1.8	1.3
41, 42	2.3	0.8	1.2	1.0
44, 47, 48	1.3	0.6	0.9	0.8
45, 46	1.7	0.6	1.2	1.0
49, 54	1.4	0.7	1.1	1.0
50, 51, 52	1.7	0.6	1.1	1.0
58, 69, 71	0.4	0.4	0.5	0.5
59, 60, 65	0.6	0.5	0.5	0.5
61, 70, 72, 79	0.7	([a])	([a])	([a])
62, 67, 74, 75	0.5	0.4	0.6	0.5
63, 64, 76, 77	0.7	0.5	0.8	0.6
80, 81, 82	1.7	0.8	1.6	1.1
83, 84	1.7	0.7	1.1	0.9
88, 91	1.6	0.6	1.1	0.9
92, 93	1.7	0.6	1.2	1.0
102, 103	1.8	0.7	1.3	0.9
106, 107, 109	1.9	0.7	1.3	1.0
108, 138	1.6	0.7	1.2	0.9
113, 114, 116	1.0	0.5	0.9	0.8
115, 117	1.2	0.6	1.0	0.7
118, 119	1.2	0.6	1.0	0.8
127, 128, 129	1.1	0.6	1.0	0.8
135, 137	1.2	0.5	0.9	0.7
152, 153	1.2	0.6	1.1	0.9
154, 158	1.5	0.7	1.3	1.1
159, 160	1.3	0.5	1.1	0.8

[a]Material lost in laboratory accident

Table 36.—Index to Coals Used in Experimental Coking Runs

Coals are listed alphabetically by name. Under each coal name entry, the coal blends in which it was used are listed by abbreviations; the next column gives the percentages in which these coals were blended, and the last column gives serial numbers of experimental runs in which this blend was coked. (Refer to table 30 for abbreviations.)

Table 36.—Index to Coals Used in Experimental Coking Runs (See bottom of column 1)

Coals	Proportions blended	Coking run numbers
Amherst Eagle		
AE–GR–Ws	25–30–45	73
Buccaneer		
Bc–Mn–MVP–PC	5–70–10–15	161
Bc–OB11	20–80	155
Bc–OB11–PC	15–70–15	157
Bc–OB11–PC	10–80–10	156
Buckhorn		
Bh–PC	80–20	176
Bh–PC	60–40	177
Corban		
C–O1–PDP	50–25–25	135, 137
C–PDP	80–20	45, 46
C–PDP	75–25	34, 35, 38, 39, 136
Eccles		
Ec–O1	15–85	125
Ec–O2–We–Ws	25–25–18–32	110
Ec–O2–Ws	25–25–50	113, 114, 115, 116, 117
Ec-S16	15–85	128
Ec–We–Ws	25–25–50	112
Ec–Ws	25–75	118, 119, 120, 121
Energy No. 5		
E5–PC	70–30	36, 37
E5–PC	60–40	6, 7, 8, 13, 14, 15
E5–PC–Wn	50–20–30	16
Glen Rogers		
GR–AE–Ws	30–35–45	73
GR–O1–Ws	30–25–45	63, 76, 77, 85, 104
GR–O1–Ws	25–25–50	64
GR–O2–We–Ws	25–25–18–32	99
GR–We	30–70	78
GR–We–Ws	30–25–45	67
GR–We–Ws	25–25–50	62, 83, 84
GR–We–Ws	20–25–55	74
GR–We–Ws	15–25–60	75
GR–Ws	30–70	61, 70, 72, 79
Harco No. 47		
H–PC	80–20	180
H–PC	60–40	181
Jefferson No. 20		
J–MVP–PC	70–15–15	175
J–O1–PC	40–40–20	179
J–PC	80–20	173, 178
J–PC	60–40	174
Kentucky White Ash		
KWA–MVP	75–25	142
KWA–O1–PC	25–65–10	139
Madison County		
MC–MVP–O1	20–20–60	101
Majestic No. 14		
M–PC	80–20	182
M–PC	60–40	183

Table 36.—(Continued)

Coals	Proportions blended	Coking run numbers
Medium-Volatile Pocahontas		
MVP–Bc–Mn–PC	9½–5½–70–15	161
MVP–J–PC	15–70–15	175
MVP–KWA	25–75	142
MVP–MC–O1	20–20–60	101
MVP–Mn	20–80	160
MVP–O1	20–80	94, 141
MVP–O1	15–85	108, 126, 138
MVP–O1	10–90	96
MVP–O1–PC	20–70–10	146
MVP–O1–PC	20–60–20	147
MVP–O1–PC	15–70–15	144
MVP–O1–PC	10–80–10	143
MVP–O1–PC	10–70–20	145
MVP–O1–S5	10–75–15	97
MVP–O1–Ws	35–25–40	57, 68
MVP–O1–Ws	25–25–50	87
MVP–O2–We–Ws	35–25–13–27	100
MVP–OB11	20–80	158
MVP–OB14	20–80	172
MVP–OB14–PC	15–70–15	171
MVP–PC–Z	20–20–60	151
MVP–PC–Z	20–10–70	150
MVP–PC–Z	15–15–70	149
MVP–PC–Z	10–10–80	148
MVP–S16	15–85	129
MVP–Sx	20–80	169
MVP–We–Ws	35–25–40	58, 71
MVP–We–Ws	25–35–40	69
MVP–Z	20–80	153
Midvale		
Md–O1–PC	25–65–10	122
Md–O1–PC	17½–65–17½	167, 168
Md–O1–PC	15–70–15	123, 134
Md–O1–PC	15–65–20	170
Minonk		
Mn–Bc–MVP–PC	70–5½–9½–15	161
Mn–MVP	80–20	160
Mn–PC	80–20	159
Mn–PC	60–40	163
Old Ben No. 11		
OB11–Bc	80–20	155
OB11–Bc–PC	80–10–10	156
OB11–Bc–PC	70–15–15	157
OB11–MVP	80–20	158
OB11–PC	80–20	154
OB11–PC	60–40	164
Old Ben No. 14		
OB14–MVP	80–20	172
OB14–MVP–PC	70–15–15	171
OB14–PC	80–20	165
Old Ben No. 14 (Cont'd)		
OB14–PC	60–40	166
Orient No. 1		
O1–C–PDP	25–50–25	135, 137
O1–Ec	85–15	125
O1–GR–Ws	25–30–45	63, 76, 77, 85, 104
O1–GR–Ws	25–25–50	64
O1–J–PC	40–40–20	179
O1–KWA–PC	65–25–10	139
O1–MC–MVP	60–20–20	101
O1–Md–PC	70–15–15	123, 134
O1–Md–PC	65–25–10	122
O1–Md–PC	65–17½–17½	167, 168
O1–Md–PC	65–15–20	170
O1–MVP	90–10	96
O1–MVP	85–15	108, 126, 138
O1–MVP	80–20	94, 141
O1–MVP–PC	80–10–10	143
O1–MVP–PC	70–20–10	146
O1–MVP–PC	70–15–15	144
O1–MVP–PC	70–10–20	145
O1–MVP–PC	60–20–20	147
O1–MVP–S5	75–10–15	97
O1–MVP–Ws	25–35–40	57, 68
O1–MVP–Ws	25–25–50	87
O1–PC	90–10	140
O1–PC	85–15	124, 130
O1–PC	75–25	131
O1–PC	60–40	9, 10, 11, 17, 25, 32, 33
O1–PC	55–45	12
O1–PC–PetC	60–20–20	27
O1–PC–S5	75–10–15	92
O1–PC–S5	65–10–25	93
O1–PC–S16	70–15–15	111
O1–PC–S16	65–10–25	105
O1–PC–S16	60–15–25	109
O1–PC–S16	50–10–40	106
O1–PC–S16	40–20–40	107
O1–PC–Wn	75–10–15	95, 102, 103
O1–PetC	90–10	18
O1–PetC	85–15	20
O1–PetC	80–20	19, 21, 22, 40
O1–PetC–Wn	60–20–20	26
O1–PI–S5	40–35–25	55
O1–PI–Ws	40–35–25	50, 90
O1–PI–Ws	40–30–30	51
O1–PI–Ws	25–35–40	89
O1–PI–Ws	20–35–45	53
O1–PI–Ws	20–30–50	52
O1–S16	80–20	80
O1–S16	70–30	81
O1–S16	60–40	82
Orient No. 2		
O2–Ec–We–Ws	25–25–18–32	110
O2–Ec–Ws	25–25–50	113, 114, 115, 116, 117
O2–GR–We–Ws	25–25–18–32	99

TABLE 36.—(CONTINUED)

Coals	Proportions blended	Coking run numbers
Orient No. 2 (Cont'd)		
O2–MVP–We–Ws	25–35–13–27	100
O2–PI–We–Ws	25–35–13–27	98
Petroleum Coke		
PetC–O1	20–80	19, 21, 22, 40
PetC–O1	15–85	20
PetC–O1	10–90	18
PetC–O1–PC	20–60–20	27
PetC–O1–Wn	20–60–20	26
PetC–S16	20–80	43
Pocahontas-Carswell		
PC–Bc–MVP–Mn	15–5½–9½–70	161
PC–Bc–OB11	15–15–70	157
PC–Bc–OB11	10–10–80	156
PC–Bh	40–60	177
PC–Bh	20–80	176
PC–E5	40–60	6, 7, 8, 13, 14, 15
PC–E5	30–70	36, 37
PC–E5–Wn	20–50–30	16
PC–H	40–60	181
PC–H	20–80	180
PC–J	40–60	174
PC–J	20–80	173, 178
PC–J–O1	20–40–40	179
PC–KWA–O1	10–25–65	139
PC–M	40–60	183
PC–M	20–80	182
PC–Md–O1	20–15–65	170
PC–Md–O1	17½–17½–65	167, 168
PC–Md–O1	15–15–70	123, 134
PC–Md–O1	10–25–65	122
PC–Mn	40–60	163
PC–Mn	20–80	159
PC–MVP–J	15–15–70	175
PC–MVP–O1	20–20–60	147
PC–MVP–O1	20–10–70	145
PC–MVP–O1	15–15–70	144
PC–MVP–O1	10–20–70	146
PC–MVP–O1	10–10–80	143
PC–MVP–OB14	15–15–70	171
PC–MVP–Z	20–20–60	151
PC–MVP–Z	15–15–70	149
PC–MVP–Z	10–20–70	150
PC–MVP–Z	10–10–80	148
PC–O1	45–55	12
PC–O1	40–60	9, 10, 11, 17, 25, 32, 33
PC–O1	25–75	131
PC–O1	15–85	124, 130
PC–O1	10–90	140
PC–O1–PetC	20–60–20	27
PC–O1–S5	10–75–15	92
PC–O1–S5	10–65–25	93
PC–O1–S16	20–40–40	107
PC–O1–S16	15–70–15	111

Coals	Proportions blended	Coking run numbers
Pocahontas–Carswell (Cont'd)		
PC–O1–S16	15–60–25	109
PC–O1–S16	10–65–25	105
PC–O1–S16	10–50–40	106
PC–O1–Wn	10–75–15	95, 102, 103
PC–OB11	40–60	164
PC–OB11	20–80	154
PC–OB14	40–60	166
PC–OB14	20–80	165
PC–S5	30–70	54
PC–S16	40–60	49
PC–S16	35–65	59
PC–S16	30–70	41, 42
PC–S16	20–80	44, 60
PC–S16	15–85	127
PC–S16	10–90	47, 48
PC–S516	35–65	65
PC–S516	20–80	66
PC–Sx	35–65	86
PC–Sx	20–80	162
PC–Wn	30–70	1, 2
PC–Z	50–50	5
PC–Z	40–60	4
PC–Z	30–70	3
PC–Z	20–80	28, 152
Pocahontas-Inland Steel		
PI–O1–S5	35–40–25	55
PI–O1–Ws	35–40–25	50, 90
PI–O1–Ws	35–25–40	89
PI–O1–Ws	35–20–45	53
PI–O1–Ws	30–40–30	51
PI–O1–Ws	30–20–50	52
PI–O2–We–Ws	35–25–13–27	98
PI–S5–Ws	35–25–40	56
PI–We–Ws	35–25–40	91, 132, 133
PI–We–Ws	35–20–45	23, 24, 88
PI–We–Ws	30–20–50	30, 31
Pocahontas-Inland Steel, Defense Plant Corp.		
PDP–C	25–75	34, 35, 38, 39, 136
PDP–C	20–80	45, 46
PDP–C–O1	25–50–25	135, 137
Sahara No. 5 (and No. 4 + No. 5)		
S5–MVP–O1	15–10–75	97
S5–O1–PC	25–65–10	93
S5–O1–PC	15–75–10	92
S5–O1–PI	25–40–35	55
S5–PC	70–30	54
S5–PI–Ws	25–35–40	56
Sahara No. 16		
S16–Ec	85–15	128
S16–MVP	85–15	129

Table 36.—(Concluded)

Coals	Proportions blended	Coking run numbers
Sahara No. 16 (Cont'd)		
S16–O1	40–60	82
S16–O1	30–70	81
S16–O1	20–80	80
S16–O1–PC	40–50–10	106
S16–O1–PC	40–40–20	107
S16–O1–PC	25–65–10	105
S16–O1–PC	25–60–15	109
S16–O1–PC	15–70–15	111
S16–PC	90–10	47, 48
S16–PC	85–15	127
S16–PC	80–20	44, 60
S16–PC	70–30	41, 42
S16–PC	65–35	59
S16–PC	60–40	49
S16–PetC	80–20	43
Sahara No. 5 + No. 16		
S516–PC	80–20	66
S516–PC	65–35	65
Saxton		
Sx–MVP	80–20	169
Sx–PC	80–20	162
Sx–PC	65–35	86
Wharton		
Wn–E5–PC	30–50–20	16
Wn–O1–PC	15–75–10	95, 102, 103
Wn–O1–PetC	20–60–20	26
Wn–PC	70–30	1, 2
Wheelwright (egg)		
We–Ec–O2–Ws	18–25–25–32	110
We–Ec–Ws	25–25–50	112
We–GR	70–30	78
We–GR–O2–Ws	18–25–25–32	99
We–GR–Ws	25–30–45	67
We–GR–Ws	25–25–50	62, 83, 84
We–GR–Ws	25–20–55	74
We–GR–Ws	25–15–60	75
We–MVP–O2–Ws	13–35–25–27	100
We–MVP–Ws	35–25–40	69
We–MVP–Ws	25–35–40	58, 71
We–O2–PI–Ws	13–25–35–27	98
We–PI–Ws	25–35–40	91, 132, 133
We–PI–Ws	20–35–45	23, 24, 88
We–PI–Ws	20–30–50	30, 31
Wheelwright (slack)		
Ws–AE–GR	45–25–30	73
Ws–Ec	75–25	118, 119, 120, 121
Ws–Ec–O2	50–25–25	113, 114, 115, 116 117
Ws–Ec–O2–We	32–25–25–18	110
Ws–Ec–We	50–25–25	112
Ws–GR	70–30	61, 70, 72, 79
Ws–GR–O1	50–25–25	64
Ws–GR–O1	45–30–25	63, 76, 77, 85, 104
Ws–GR–O2–We	32–25–25–18	99
Ws–GR–We	60–15–25	75
Ws–GR–We	55–20–25	74
Ws–GR–We	50–25–25	62, 83, 84
Ws–GR–We	45–30–25	67
Ws–MVP–O1	50–25–25	87
Ws–MVP–O1	40–35–25	57, 68
Ws–MVP–O2–We	27–35–25–13	100
Ws–MVP–We	40–35–25	58, 71
Ws–MVP–We	40–25–35	69
Ws–O1–PI	50–20–30	52
Ws–O1–PI	45–20–35	53
Ws–O1–PI	40–25–35	89
Ws–O1–PI	30–40–30	51
Ws–O1–PI	25–40–35	50, 90
Ws–O2–PI–We	27–25–35–13	98
Ws–PI–S5	40–35–25	56
Ws–PI–We	50–30–20	30, 31
Ws–PI–We	45–35–20	23, 24, 88
Ws–PI–We	40–35–25	91, 132, 133
Zeigler No. 1+ No. 2		
Z	100	29
Z–MVP	80–20	153
Z–MVP–PC	80–10–10	148
Z–MVP–PC	70–20–10	150
Z–MVP–PC	70–15–15	149
Z–MVP–PC	60–20–20	151
Z–PC	80–20	28, 152
Z–PC	70–30	3
Z–PC	60–40	4
Z–PC	50–50	5

APPENDIX B

Laboratory Procedures for Tar Analysis

DRYING (Note 1)

Approximately 2500 grams of wet tar and 170 grams of toluene (Note 2) are accurately weighed into a tared three-liter flask. The mixture is heated to boiling and the vapors are refluxed past a water trap (Note 3). The water is withdrawn continuously until the drying is completed (Note 4). The dried mixture is weighed to check the loss in weight against the weight of water removed (Note 5).

Notes

1. This procedure was used on all tars.
2. Toluene is added to reduce the amount of foaming and spattering of the tar when it is heated to boiling.
3. The water trap is filled with a known weight of water before the drying is begun. When the drying is completed, the water layer remaining in the trap is withdrawn and the organic layer returned to the pot.
4. The water is withdrawn at such a rate that the organic layer continuously returns to the pot. This has been found necessary to prevent excessive foaming and spattering of the boiling tar.
5. The loss in weight of the tar is usually two or three grams more than the weight of water removed. This represents an error of about 0.1 percent.

DISTILLATION

The dry tar-toluene mixture obtained from the drying procedure is distilled in four separate batches from a one-liter distilling flask through an air-cooled condenser at a rate of about two or three drops per second. The distillate to 350° C. is collected in water-cooled receivers. The original flask plus the remaining tar is weighed again so that the weight of tar and toluene distilled may be calculated.

SPECIFIC GRAVITY AND WATER CONTENT (Note 1)

Approximately 200 grams of wet tar and 40 grams of toluene are weighed into a tared flask, thoroughly shaken, and brought to 28° C. The specific gravity of the mixture is measured by means of a Westphal balance. The specific gravity of the dry tar (Note 2) and the water content of the wet tar (Note 3) are calculated from these data and data obtained from the drying procedure.

Notes

1. On tars 3-13, the standard procedure for measuring the specific gravity of the dry tar was used. On tars 14-84, a modified procedure was used, similar to the procedure described here in which the measurement was made on a dry-tar toluene mixture. The above procedure was used on tars 85-183.

2. The specific gravity of the dry tar is calculated by the following formula.

$$S = \frac{dxDT}{(T + t + W)\,dx - D\,(t\alpha x + Wd)}$$

where: d = specific gravity of toluene at 28° C.
x = specific gravity of water at 28° C. (relative to water at 4° C.)
D = specific gravity of the wet tar-toluene mixture at 28° C.
T = weight of dry tar in the wet tar-toluene mixture.
t = weight of toluene added to the wet tar.
W = weight of water in the wet tar-toluene mixture.
α = .985 = an empirical correction factor to correct for the non-additivity of the volumes of tar and toluene.
S = specific gravity of the dry tar at 28° C.

The factor 1.00836 is used to convert the specific gravity at 28° C. to the specific gravity at 60° F.

The ratio of the weights of dry tar to wet tar, obtained from the drying procedure, is used to calculate the weights of dry tar and water used in the specific gravity measurement.

The maximum error in the calculated specific gravity assuming all the errors inherent in the procedure to be acting in the same direction is about $\pm 0.006\ \frac{\text{gms.}}{\text{ml.}}$. The probable error is about $\pm 0.002\ \frac{\text{gms.}}{\text{ml.}}$.

3. The water content is calculated by the formula

$$\%\ H_2O = \frac{WS}{WS + T} \times 100$$

where: W = volume of H_2O removed from the wet tar in the drying procedure.
S = specific gravity of the dry tar at 28° C.
T = weight of dry tar obtained from the drying procedure.

The maximum error in the calculated water content is about ±0.2%.

FREE CARBON (Note 1)

Wet tar, 5 to 10 grams, is accurately weighed into a 100-ml. beaker and digested with 50 ml. of toluene on a steam cone for 30 minutes. The mixture is filtered through a filter cup (Note 2) and extracted with benzene in a soxhlet extractor until the descending solvent is colorless. The cup and its contents are dried at 105° C. for one hour and then weighed (Note 3).

Notes

1. The free carbon determination was carried out on the dry tar for runs 3-15, on a dry tar-toluene mixture for runs 16-68, and on the wet tar on runs 69-183.
2. The filter cup is made by folding two 15 cm. filter papers in the form of a thimble and inserting it in a 25 x 80 mm. extraction thimble. The cup is dried at 105° C. for several hours before being used.
3. The ratio of the weights of wet tar to dry tar obtained from the drying procedure is necessary to calculate the percentage of free carbon.

SEPARATION OF TAR DISTILLATE INTO ACIDIC, BASIC, AND NEUTRAL FRACTIONS

The following aqueous solutions are used:

- 10 percent sodium hydroxide
- 20 percent sulfuric acid saturated with sodium chloride
- 25 percent sodium hydroxide
- 40 percent sulfuric acid
- saturated sodium chloride
- saturated sodium bicarbonate-sodium chloride.

Approximately 2200 grams (weight known accurately) of dried tar are distilled and the distillate below 350° C. is collected in a water-cooled receiver. After weighing, the distillate is extracted successively with the following solutions (Note 1):

1. Two 100 cc. portions of 20 percent sulfuric acid and one 50 cc. portion of salt solution.
2. One 700 cc. and three 100 cc. portions of 10 percent sodium hydroxide and one 50 cc. portion of salt solution (Note 2).
3. One 500 cc. and two 100 cc. portions of 20 percent sulfuric acid and one 50 cc. portion of salt solution.
4. Three 100 cc. portions of 10 percent sodium hydroxide, and one 50 cc. portion of salt solution.
5. Three 100 cc. portions of 20 percent sulfuric acid and one 50 cc. portion of salt solution.
6. One 200 cc. portion of sodium bicarbonate-sodium chloride solution.

The salt wash at the end of each series of extractions is added to the other extracts of that series. After separating extract No. 6, the organic layer (neutrals) is poured into a tared flask.

Extracts Nos. 1, 3 and 5 are combined and extracted with two 150 cc. portions of ether to remove trapped tar acids and neutrals. Extracts Nos. 2 and 4 are combined and extracted with three 150 cc. portions of ether to remove tar bases and neutrals. The ether extracts are combined to give a solution of tar acids, bases and neutrals in ether. This ether solution is extracted with the following solutions:

(a) One 100 cc. and two 50 cc. portions of 10 percent sodium hydroxide

(b) One 100 cc. and one 50 cc. portions of 20 percent sulfuric acid

(c) One 50 cc. portion of 10 percent sodium hydroxide

(d) One 50 cc. portion of salt solution.

Extracts (a) and (c) are added to Nos. 2 and 4, extract (b) is added to Nos. 1, 3 and 5, and extract (d) is discarded. The ether solution now contains neutrals alone. Aqueous extract No. 6, containing some suspended neutrals, is extracted twice with ether, and the aqueous layer is discarded. The ether solutions of neutrals are combined, dried over anhydrous magnesium sulfate, and filtered. Most of the ether is removed by heating on a steam bath, using a one-foot column packed with wire helices. The last traces of ether are removed on a hot plate, using a similar column. (This procedure is followed in all other ether stripping operations.) The residue is added to the main body of the neutrals in the tared flask, which now contains the total neutral fraction plus the toluene added during the drying of the tar.

The combined sulfuric acid extracts (Nos. 1, 3, 5 and b) are neutralized with an excess of 25 percent sodium hydroxide to liberate the tar bases. After cooling, the solution is separated in a separatory funnel. The clean aqueous layer is drawn off, and the upper layer (the organic layer plus insoluble flocculent solid material (Note 3) suspended in water) is filtered through a Büchner funnel (Note 4) to remove the solids, which interfere with the separation during ether extractions. After washing thoroughly with ether and water, the solid material on the filter paper is dried in air and weighed. The filtrate containing the free tar bases and water is separated, and the combined aqueous solutions of tar bases are extracted with four 250 cc. portions of ether. The ether extracts and free bases are combined, dried over anhydrous magnesium sulfate, filtered, and the ether distilled off (Note 5). The weight of the residue plus the weight of the insoluble solids (usually 1 to 2 grams) removed by filtration is assumed to give the total weight of tar bases.

The combined sodium hydroxide extracts (Nos. 2, 4, a and c) are neutralized with an excess of 40 percent sulfuric acid to liberate the tar acids. The solution is then saturated with salt (most easily done while the solution is still hot from the neutralization). After cooling, the organic layer of the tar acids is separated, and the aqueous layer is extracted with five 300 cc. portions of ether. The tar acids and ether extracts are combined and washed once with 200 cc. salt solution to remove traces of sulfuric acid. No attempt is made to collect and weigh the small amounts (1 to 5 grams estimated) of tarry material (Note 2) which usually settles on the walls of the flask or separatory funnel containing the ether solution of tar acids. The salt solution is extracted once with 100 cc. ether which is added to the main ether solution. The ether solution of tar acids is dried over anhydrous magnesium sulfate, filtered, and the ether distilled off. In order to remove the water (1 to 3 grams) not removed from the tar acids by the drying agent, 25 cc. toluene is added to the residue from the ether stripping, and it is given a rough preliminary fractionation through a one-meter column (Note 6), the distillation being carried up to 216° C. The distillate from 145° C. to 216° C. is collected and weighed. The static holdup of the column is determined by rinsing the column with ether and distilling the ether off. The total weight of tar acids is the sum of the weights of the distillate from 145° C. to 216° C., plus the holdup, plus the residue in the stillpot.

The procedure described above was used in runs 37-183 (Note 7). Prior to run 37, the sodium hydroxide and sulfuric acid extracts were subjected to steam distillation, rather than ether extraction, in order to remove trapped organic material. The results before run 37 are considered less reliable than those since.

Notes

1. The procedure employed here is designed for tars containing up to 12 percent acids and 3 percent bases. For tars of higher acid or base content, some changes in the procedure would be necessary.
2. During this and subsequent alkaline extractions, small amounts of flocculent solid material tend to collect on the walls of the separatory funnel in the organic layer. Indications are that care taken to settle as much of this material as possible into the alkaline solution helps to minimize the formation of tarry material during subsequent sulfuric acid extractions. The running of small amounts of the organic layer into the alkaline solution in order to effect this separation is not objectionable, for the organic material is recovered later by ether extraction of the aqueous solution. Using this procedure, the tarry material is carried along with the tar acids and finally settles out on the walls of the flask containing the ether solution of tar acids. Because of the difficulty of collecting the tarry material, no attempt is made to weigh it.
3. The insoluble solid material is of unknown composition. It is soluble in mineral acids and insoluble in water, alkali, and ether. It burns in a flame, leaving an inorganic residue. No further investigation has been made.
4. It has been found that less than 1 gram of tar bases is lost by evaporation during this suction filtration.
5. The U.S.P. ether used in the extraction commonly contains about one percent ethanol. This causes no trouble with tar acids or neutrals, but when stripping ether from the tar bases, it is necessary to continue the stripping until the alcohol (1 to 5 cc.) is removed.
6. The column for the preliminary fractionation is one meter long, 12 mm. i. d., and packed with 3/32 inch Nichrome helices. It has an electrically heated jacket, and the still head has a stopcock take-off. It has a measured efficiency of 25 theoretical plates at total reflux. The fractionation is carried out as rapidly as possible without flooding (approximately 200 cc. per hour take-off). The purpose of the distillation is to remove all the phenol and cresols in order that they may be given a more careful fractionation later on. The distillation is carried arbitrarily up to 216° C. to insure that all the cresols are stripped off. Because of the crudeness of this fractionation procedure, too much significance should not be attached to the relative weights of acids below and above 216° C.
7. In four test runs on identical samples using the procedure described here, the percentages of acids, bases and neutrals checked within $\pm$ 0.1 percent of the mean values (based on dry tar). However, the accuracy of the results is considerably poorer than the reproducibility, for the sum of the weights of acids, bases and neutrals usually falls short of the weight of the original tar distillate by an amount averaging about 1 percent of the dry tar. This discrepancy cannot be explained by the loss of tar bases during suction filtration (Note 4). Furthermore, the ether stripping procedure is considered efficient enough so that no appreciable amounts of tar components are lost during the ether removal. Possible explanations for this loss are: (a) the original tar distillate contains a small amount of water (caused by cracking during the distillation) which is not removed but is weighed along with the distillate; (b) the tarry material (Note 2) formed during the extraction procedure is not weighed; (c) tar bases and acids (especially the latter) may not be completely extracted by ether from the aqueous liquors.

DETERMINATION OF PHENOL AND CRESOLS IN TAR ACIDS

To approximately 200 grams tar acids boiling below 216° C. (Note 1) is added 5 cc. of toluene (to aid in removing the last traces of water) and the mixture is fractionated through a two-meter column (Note 2). The reflux rate is maintained just below the flood point (estimated at

400 cc. per hour) and, unless otherwise noted, the take-off rate is approximately 16 cc. per hour. The following fractions are collected:

F1. *Forerun of toluene and water.*—This fraction is collected up to 145° C. and is assumed to contain no tar acids.

F2. *Forerun of phenol.*—This fraction is collected from 145° C. to the b.p. of phenol. The weight of this fraction (about 2 grams) is assumed to represent pure phenol, although it contains traces of toluene and water.

F3. *Main phenol fraction.*—This fraction is collected until the temperature has risen at least 2° above the phenol b.p. The phenol percentage is determined from the freezing point,[18] (see References to Publications, p. 62) and the remainder is assumed to be *o*-cresol.

F4. *Phenol and o-cresol.*—This fraction is collected until the *o*-cresol b.p. is reached. The cut should be made as soon as the *o*-cresol b.p. is reached in order to leave sufficient *o*-cresol for the next fraction. The *o*-cresol percentage is determined by the cineol method,[19] and the remainder is assumed to be phenol.

F5. *o-, m-, and p-cresols.*—This fraction is collected until a fairly constant plateau is reached, about 10° above the *o*-cresol b.p. The *o*-cresol percentage is determined by the cineol method, and the remainder is assumed to be *m*- and *p*-cresol. The ratio of *m*-cresol to *p*-cresol in this fraction, as well as in F7, is assumed to be the same as the ratio determined in F6.

F6. *m- and p-cresol.* This fraction is collected only on the plateau, during which there is a gradual rise in temperature of 1.5° - 2.0°. The fraction is collected over a range of not more than 2°, and it should be cut as soon as a rise in temperature slightly sharper than the gradual rise is observed. The *m*-cresol percentage is determined by the Raschig nitration method,[20] and the remainder is assumed to be *p*-cresol.

F7. *m- and p-cresol and higher tar acids.*—The take-off rate is reduced to 8 cc. per hour for more efficient fractionation, the distillate is collected in a small graduate, and readings of the volume of distillate vs. temperature are taken until the next plateau is reached, about 7-8° above the *m-p*-cresol b.p. The midpoint of the break is assumed to indicate the amount of *m-p*-cresols in the distillate.

The weights of phenol, *o*-cresol, *m*-cresol and *p*-cresol are calculated for each of the fractions F2 to F7 and added up to give the total weights of each component present. The above procedure was used on all runs (Note 3).

Notes

1. The procedure described here is satisfactory for mixtures containing at least 25 grams each of phenol and the cresols. Much smaller quantities cannot be satisfactorily separated by the column used here. For this reason it is usually necessary to combine the tar acids from two or more similar runs in order to obtain sufficient quantities of acids for the fractionation.

2. The fractionating column used here is two meters long, 9 mm. i.d., and packed with 3/32 inch Nichrome helices. It has an electrically heated jacket, and the still head has an intermittent take-off valve operated by an adjustable automatic timer. It has a measured efficiency of 40 theoretical plates at total reflux.

3. On two test fractionations of a sample of tar acids, the percentages of phenol and the cresols checked within 0.05 percent or less (based on dry tar). But while the fractionation procedure may give accurate values for the phenol and cresol content of the tar acid samples, these values probably do not furnish a completely accurate measure of the composition of the tar itself, as an appreciable quantity of tar acids is probably lost during the extraction procedure.

ANALYSIS OF THE NEUTRAL FRACTION (Note 1)

Approximately 400 grams of the neutral fraction is fractionated through a one-meter column (Note 2). The following fractions are collected:

F1. *Toluene.*—This fraction contains all the toluene that was added to the tar in the drying procedure. The fraction is cut when the calculated weight of toluene, in the 400 gram portion of neutrals and toluene, has been collected.

F2. *Light oil.*—This fraction is collected at total take-off from the boiling point of toluene to 190° C. It is then fractionated from 190° to 195° C. with intermittent take-off.

F3. *Mixture of light oil and naphthalene.*—This fraction is collected at total take-off from 195° C. to the boiling point of naphthalene, sufficient material being collected on the naphthalene plateau to give a satisfactory freezing point (Note 3). The naphthalene content of this fraction is determined by the freezing point (Note 4) and the difference is assumed to be light oil.

F4. *Mixture of naphthalene and compounds boiling above naphthalene.*—This fraction is collected as total take-off until the temperature begins to rise from the naphthalene plateau. It is then collected at intermittent take-off to 230° C. The naphthalene content is determined from the freezing point (Note 4) and the difference is assigned to the residue.

F5. *Residue.*—The residue includes the combined weights of material remaining in the stillpot plus the holdup of the column.

The weight of each fraction is converted to the weight of that fraction in the total neutrals and the percentages calculated. The percentages of light oil, naphthalene, and residue are summed up for each of the fractions F2 to F5 to give the total percentage of each component present.

Notes

1. Only one naphthalene fraction, 205-225° C., was cut on neutrals obtained from tars 3-62. The naphthalene content in this case was determined by the freezing point and the difference assigned to the residue. Approximately 0.6 percent naphthalene remained in the light oil.

2. The fractionation column used here is one meter long, 10 mm. i.d., and packed with 3/32 inch Nichrome helices. It has an electrically heated jacket and a still head with a stopcock take-off. It is rated at about 25 theoretical plates at total reflux.

3. Because the light oil composition may vary and thus affect the accuracy of the freezing point chart, it was thought desirable to have the naphthalene percentage relatively high in this fraction in order to minimize such errors. Freezing points obtained for this fraction were usually in the range of 67-75° C., corresponding to 72.5 to 90 percent naphthalene.

4. The percentage naphthalene is determined from a graph in which the freezing points of naphthalene-naphthalene oil mixtures are plotted against the percent naphthalene. This graph was obtained from the Inland Steel Company.

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