STATE OF ILLINOIS
HENRY HORNER, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
JOHN J. HALLIHAN, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*
URBANA

REPORT OF INVESTIGATIONS—NO. 55

EFFECT OF PREPARATION ON ASH FUSIBILITY OF SELECTED ILLINOIS COALS

BY

L. C. McCABE AND O. W. REES

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1939

STATE OF ILLINOIS
HON. HENRY HORNER, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
HON. JOHN J. HALLIHAN, *Director*

BOARD OF
NATURAL RESOURCES AND CONSERVATION
HON. JOHN J. HALLIHAN, *Chairman*

EDSON S. BASTIN, Ph.D., *Geology*
WILLIAM A. NOYES, Ph.D., LL.D., Chem. D., D.Sc., *Chemistry*
LOUIS R. HOWSON, C.E., *Engineering*
WILLIAM TRELEASE, D.Sc., LL.D., *Biology*
HENRY C. COWLES, Ph.D., D.Sc., *Forestry*
ARTHUR CUTTS WILLARD, D.Engr., LL.D., *President of the University of Illinois*

STATE GEOLOGICAL SURVEY DIVISION
Urbana
M. M. LEIGHTON, Ph.D., *Chief*
ENID TOWNLEY, M.S., *Assistant to the Chief*
JANE TITCOMB, M.A., *Geological Assistant*

GEOLOGICAL RESOURCES

Coal
G. H. CADY, Ph.D., *Senior Geologist*
L. C. MCCABE, Ph.D.
JAMES M. SCHOPF, Ph.D.
EARLE F. TAYLOR, M.S.
CHARLES C. BOLEY, M.S.

Industrial Minerals
J. E. LAMAR, B.S.
H. B. WILLMAN, Ph.D.
ROBERT M. GROGAN, M.S.
J. S. TEMPLETON, A.B.

Oil and Gas
A. H. BELL, Ph.D.
G. V. COHEE, Ph.D.
FREDERICK SQUIRES, B.S.
CHARLES W. CARTER, Ph.D.
F. C. MACKNIGHT, Ph.D.
JAMES L. CARLTON, B.S.
FRANK E. TIPPIE, B.S.
ROY B. RALSTON, B.A.

Areal and Engineering Geology
GEORGE E. EKBLAW, Ph.D.
RICHARD F. FISHER, B.A.

Subsurface Geology
L. E. WORKMAN, M.S.
J. NORMAN PAYNE, Ph.D.
ELWOOD ATHERTON, Ph.D.
MERLYN B. BUHLE, M.S.
GORDON PRESCOTT, B.S.

Stratigraphy and Paleontology
J. MARVIN WELLER, Ph.D.
CHALMER L. COOPER, M.S.

Petrography
RALPH E. GRIM, Ph.D.
RICHARDS A. ROWLAND, Ph.D.

Physics
R. J. PIERSOL, Ph.D.
M. C. WATSON, Ph.D.
DONALD O. HOLLAND, M.S.

GEOCHEMISTRY

FRANK H. REED, Ph.D., *Chief Chemist*
W. F. BRADLEY, Ph.D.
G. C. FINGER, Ph.D.
HELEN F. AUSTIN, B.S.

Fuels
G. R. YOHE, Ph.D.
CARL HARMAN, B.S.

Non-Fuels
J. S. MACHIN, Ph.D.
JAMES F. VANECEK, M.S.

Analytical
O. W. REES, Ph.D.
GEORGE W. LAND, B. Ed.
P. W. HENLINE, B.S.
MATHEW KALINOWSKI, B.S.
A. J. VERAGUTH, M.S.

MINERAL ECONOMICS

W. H. VOSKUIL, Ph.D., *Mineral Economist*
GRACE N. OLIVER, A.B.

EDUCATIONAL EXTENSION

DON L. CARROLL, B.S.

PUBLICATIONS AND RECORDS

GEORGE E. EKBLAW, Ph.D.
CHALMER L. COOPER, M.S.
DOROTHY ROSE, B.S.
ALMA R. SWEENEY, A.B.
M. FRANCES HARPER, M.S.
MEREDITH M. CALKINS

Consultants: *Ceramics*, CULLEN WARNER PARMELEE, M.S., D.Sc., University of Illinois; *Pleistocene Invertebrate Paleontology*, FRANK COLLINS BAKER, B.S., University of Illinois.

Topographic Mapping in Cooperation with the United States Geological Survey.

This Report is a Contribution of the Section of Geological Resources, Coal Division.

2
August 1, 1939
(A4188—1500—8-39)

CONTENTS

ILLUSTRATIONS

TABLES

EFFECT OF PREPARATION ON ASH FUSIBILITY OF SELECTED ILLINOIS COALS*

BY

L. C. McCABE AND O. W. REES

INTRODUCTION

STUDIES of the characteristics of the ash of coal have increased in recent years in the hope that they may provide criteria for establishing the particular suitability of the coal for specific uses. Ash fusibility tests have been made as part of the ordinary commercial analysis, but uncertainty as to the significance of these values has encouraged other investigations such as those of Nicholls, Selvig and Ricketts[1] into the relation between ash fusibility and clinkering tendencies. The relation of ash composition to ash fusibility[2] and the influence of the mineral components of the coal upon ash fusion[3] have also received some attention. These and other investigations are providing a basis for a better understanding of the complicated relationship between ash composition and ash fusibility and between ash fusibility and clinkering tendencies.

The investigation herein reported was concerned with the effect of preparation upon the softening temperature of coal ash.

*Presented at the Joint A.I.M.E. Coal and A.S.M.E. Fuels Meeting, Chicago, Ill. October 13–15, 1938.

[1]Nicholls, P., Selvig, W. A., and Ricketts, E. B., Clinker formation as related to the fusibility of coal ash: U. S. Bur. Mines Bull. 364, 1934.

[2]Estep, Thomas G., Seltz, Harry, and Osborn, Willard J., Determination of the effect of oxides of sodium, calcium, and magnesium on ash fusion temperatures by the use of synthetic coal ash: Carnegie Inst. Tech. and Min. Met. Advisory Boards, Mining and Metallurgical Investigations, Bull. 74, 1937.

[3]Thiessen, G., Ball, C. G., and Grotts, P. E., Coal ash and coal mineral matter: Ind. Eng. Chem. vol. 28, p. 355, 1936.

ACKNOWLEDGMENTS

The writers are glad to acknowledge the cooperation and assistance of the management of the mines in collecting samples. Dr. F. H. Reed and Dr. G. H. Cady made many helpful suggestions during the course of the investigation and preparation of this report. L. G. Hazen and C. C. Boley assisted in preparing samples and J. W. Robinson, C. S. Westerberg, L. D. McVicker, J. A. McHard, L. H. McCreery, and G. W. Land assisted in obtaining analytical data.

OTHER STUDIES

Few records of similar investigations have come to the attention of the authors. Ball[4] studied the amount and character of mineral matter of No. 6 bed coal from Franklin County, Illinois. Estep et al[5] studied the effect of mixing coals on softening temperature of the ash. Yancey and Fraser[6], in a report on some coal washing studies, referred briefly to the effect of washing on ash fusibility. Selvig et al,[7] in discussing the relationship of

[4]Ball, Clayton G., Mineral matter of No. 6 bed coal at West Frankfort, Franklin County, Illinois: Illinois State Geol. Survey Rept. Inv. 33, 1935.

[5]Estep, Thomas G., Seltz., Harry, Bunker, Henry L. Jr. and Strickler, Herbert S., The effect of mixing coals on the ash fusion temperature of the mixture: Carnegie Inst. Tech. and Min. and Met. Advisory Boards, Mining and Metallurgical Investigations, Bull. 62, 1934.

[6]Yancey, H. F., and Fraser, Thomas, Coal-washing investigations, methods and tests: U. S. Bur. Mines, Bull. 300, 1929.

[7]Selvig, W. A., Nicholls, P., Gardner, W. L., and Muntz, W. E., Fusibility of coal ash as related to clinker formation: Carnegie Inst. Tech. Mining and Metallurgical Investigations, Bull. 29, 1926.

FIG. 1.—Map of Illinois showing location of mines where screenings were sampled.

TABLE 1.—LOCATION, COAL BEDS WORKED, THICKNESS OF BEDS, MINING METHODS, AND TONNAGES OF MINES SAMPLED

Mine	County	Coal bed number	Average thickness Ft.	in.	Mining methods	Daily average (Tons)
A	Henry	1	4	1	Room-and-pillar, coal shot from solid, hand loading	450
B	Woodford	2	2	9	Longwall, hand mining, hand loading	425
C	Peoria	5	4	2	Room-and-pillar, machine mining, hand loading	3,000
D	Vermilion	(Grape Creek)	5	0	Room-and-pillar, machine mining, hand loading	3,000
E	Sangamon	5 (Springfield)	5	9	Room-and-pillar, coal shot from solid, hand loading	1,500
F	Christian	6	7	6	Room-and-pillar, coal shot from solid, hand loading	700
G	St. Clair	6	7	0	Room-and-pillar, machine mining, machine loading	1,300
H	Marion	6	6	4	Room-and-pillar, machine mining, hand loading	1,700
I	Williamson	6	10	0	Room-and-pillar, machine mining, mechanical loading	4,000
J	Saline	5 (Harrisburg)	5	3	Room-and-pillar, machine mining, hand loading	2,000

ash fusibility to clinker formation commented on the effect of washing upon the fusibility and the clinkering characteristics of the coal. The only generalizations of present interest that can be drawn from the last three papers are that ash fusion characteristics vary with the extent to which washing eliminates certain mineral substances. Furthermore, according to these authors, elimination of pyrite usually tends to raise the temperature of fusibility of the washed coal as compared with that of the raw coal.

PRESENT STUDIES

This study of the effect of preparation on ash fusibility of coal screenings from Illinois mines is part of an investigation of washability characteristics, size-range, petrographic, and chemical nature of coal screenings begun by the Illinois Geological Survey in 1935. Ten mines were sampled so that each of the commercially important coal beds as well as the different producing districts in the State was represented (table 1 and fig. 1).

Increments of 12 to 15 pounds were taken from the loading chute at each mine at intervals throughout a day's run. One quarter of the gross sample of 1000 to 1500 pounds was sized and used in float-and-sink tests. Water solutions of zinc chloride were used in the float-and-sink tests of ¾ to ⅜-inch and larger coal, and organic solutions, carbontetrachloride, benzene and bromoform mixtures were used for the sizes smaller than ⅜-inch. Results and details of procedure of the sizing[8] and washability tests[9] have been published.

From the float-and-sink fractions, samples were taken which have furnished a fund of data on the ash fusion character-

[8]McCabe, L. C., Mitchell, D. R., and Cady, G. H., Proximate analyses and screen tests of coal mine screenings produced in Illinois: Illinois State Geol. Survey, Rept. Inv. 38, 1935.

[9]Mitchell, D. R., and McCabe, L. C., Washability characteristics of Illinois coal screenings: Illinois State Geol. Survey, Rept. Inv. 48, 1937.

istics and ash composition of these coals. Only the data pertaining to the effect of sizing and heavy liquid separation on ash fusion temperatures are presented here. Ash composition and its relation to ash fusion characteristics will be treated in another publication.

The screenings sample from each mine was sized as follows:

1¼ to ¾-inch
¾ to ⅜-inch
⅜ inch to 10-mesh
10 to 48-mesh
minus 48-mesh

Round-hole screens were used in sizing at ⅜-inch and above and Tyler standard sieves for sizing below ⅜-inch.

Each size was separated by heavy liquids of 1.30, 1.35, 1.40, 1.50 and 1.70 specific gravity into the following fractions:

1.30 Specific gravity float
1.30 to 1.35 Specific gravity float
1.35 to 1.40 Specific gravity float
1.40 to 1.50 Specific gravity float
1.50 to 1.70 Specific gravity float
1.70 Specific gravity sink

The ash and sulfur values for the coals were obtained according to American Society for Testing Materials procedures D 271–33.[10]

The ash fusion data were obtained according to A.S.T.M. specifications D 271–33[11] (modified 1938) in a Barrett ash fusion furnace. The ash analyses were made in accordance with procedures outlined by Hillebrand and Lundell[12] and Washington[13] for the analysis of silicate rocks.

Ash fusion values, together with values for ash, sulfur, and weight per cent are given in tables 2 to 13 and figures 2 to 11.

A graph, on which the ash softening temperatures of the individual sizes are plotted, aids in comparing these values for the different sizes in the same mine, and the curves formed by connecting the points make it possible to place the mines in characteristic groups.

The graphs showing the effect of sizing upon ash softening temperatures for the coals from the ten mines may be divided into four groups each of which contains two or more similar curves. In Group 1, which includes coals from mines C and E (fig. 2), the highest ash softening temperatures are in the minus 48-mesh size. In Group 2, representing coals from mines I and A (fig. 3), the lowest softening temperatures occur in the ⅜-inch to 10-mesh size, followed by an increase of 100° to 150° F. in the 10- to 48-mesh size, and a drop to a lower softening temperature for the minus 48-mesh dust. In Group 3 for coals from mines G and H (fig. 4), the ash softening temperature is rather uniform for all sizes except the 10- to 48-mesh size which is consistently lowest. In Group 4, representing coals from mines B, D, F, and J (fig. 5), the highest softening temperatures are in the ¾ to ⅜-inch size. Curves D, F, and J show the lowest ash softening temperature in the 10- to 48-mesh size with a slightly higher softening temperature in the ash from the minus 48-mesh coal. In curve B no such reversal is shown.

The number of mines represented is too small to be conclusive, but there appears to be a relationship between the geographical location of the mines and the groupings indicated above. Mines C and E of Group 1 are in No. 5 coal in the western part of the coal basin (fig. 1). Mines G and H of Group 3 are in No. 6 coal in the Belleville district of southwestern Illinois. Mines B, D, F, and J of Group 4 are in the Grape Creek No. 2, the No. 5 and the No. 6 coals, all near the center or east of the center of the coal basin. Only Group 2 embraces two widely separated mines, Mine A in No. 1 coal in northern Illinois and Mine I in No. 6 coal in Williamson county.

Coals E and I were selected for an exhaustive study of ash composition in relation to ash fusion characteristics because of the extremes of sulfur content. Coal from Mine E has 5.3 per cent sulfur in 1¼ to 0-inch screenings and screenings from Mine I have 1.9 per cent sulfur.

Samples of each of the five sizes of coals from Mine E and Mine I were separated by heavy solutions into 1.30, 1.35, 1.40, 1.50 and 1.70 float, and 1.70 sink fractions. Chemical analyses of the ashes of the 1¼ to 0-inch samples of these two coals appear in table 14, and

[10]Standard Methods of Laboratory Sampling and Analysis of Coal and Coke: A.S.T.M. Standards on Coal and Coke, D 271–33, pp. 17 and 21, 1936.

[11]Idem. p. 27. (Revised 1938).

[12]Hillebrand, W. F., and Lundell, G. E. F., Applied inorganic analysis, John Wiley and Sons, Inc., 1929.

[13]Washington, H. S., The chemical analysis of rocks, John Wiley and Sons, Inc., 1930.

ash fusion determinations, ash, sulfur, and weight per cent values appear in tables 12 and 13. Table 14 shows the coal from Mine E to be higher in ash and sulfur than that from Mine I. The composition of the two ashes varies also, the SiO_2 and Al_2O_3 are lower in coal ash E and the Fe_2O_3, CaO, and SO_3 are considerably higher.

These closely sized fractions of narrow specific gravity limits cover a wide range of ash softening temperatures but the curves (figs. 6 and 7) show the ash softening temperatures to be quite different for the two coals. In general the lowest ash softening temperatures for coal E are in the fractions of low specific gravity and with the exception of the ⅜-inch to 10-mesh, the highest ash softening temperatures are in the 1.70 sink fractions. The coal I curves show low ash-softening temperatures in both the low and high specific gravity fractions and high ash-softening temperatures at intermediate specific gravities.

For coal I the ash softening temperature of the ¾ to ⅜-inch screenings floating at 1.40 specific gravity is 2547° F. (table 13) and of the 1.70 sink fraction it is 2019° F, a range of 528° between the maximum and minimum softening temperatures in one size. The difference in softening temperature between the 1.50 (2518° F.) and the 1.70 (2048° F.) float fractions in the 1¼ to ¾-inch size is 470°. For coal E the 1¼ to ¾-inch screenings show a range of 622° in the ash softening temperatures of the 1.50 specific gravity float (1971° F.) and the 1.70 sink (2593° F.) fractions (see table 12).

The head sample, or 1¼ to 0-inch screenings, for Mine I has a lower ash softening temperature than do most of the sizes prepared from it.

All ash softening temperatures of float-and-sink fractions derived from Mine E head sample are higher than the softening temperature of the head sample. Data for these two coals indicate that sizing and close gravity separation yield products which have higher ash softening temperatures than the original coal although each coal has individual characteristics.

Tables 2 to 11 and figures 8 to 11 present ash fusion data for size and cumulative gravity samples studied. The composite samples were made up according to weight per cent values obtained by gravity separations of each size. This makes it possible to determine how softening temperature is affected by adding high-ash coal to low-ash coal or by washing at any given specific gravity.

The ash softening temperatures of four of the high specific gravity fractions of coal E are considerably above the softening temperatures of the ash of the fractions of low specific gravity (fig. 6). It is apparent from an examination of the increment curves for this coal (fig. 9) that the addition of increments of high softening temperature ash does not always raise the softening temperature of the composite, rather it tends to lower it. In the curve showing softening temperatures of the individual fractions, of the ¾ to ⅜-inch size (fig. 6), fractions having specific gravities above 1.30 have higher softening temperatures than does the fraction floating at 1.30 specific gravity, yet when these fractions are combined in the proportion in which they occur in the coal, the effect of each added increment is to lower the softening temperature. The cumulative curve for the minus 48-mesh fraction (fig. 9) roughly follows the curve of individual softening temperatures (fig. 6) in the first five increments added but on the addition of the 1.70 sink fraction, which has a softening temperature 175° higher than that of the nearest increment (table 12), the softening temperature of the composite is lowered 128° (table 6).

Although the cumulative curves for coal from Mine I (fig. 10) conform in a general way to the curves of softening temperature for individual fractions (fig. 7), both high and low points are modified.

At 1.50 specific gravity, the washing gravity of most Illinois coals, the majority of sizes from all mines except B and F have higher ash softening temperatures than the 1¼ to 0-inch head sample (figs. 8-11). However, it does not follow that if these sizes were combined and washed the fusion temperature would be higher than in the unwashed screenings. It might be higher or it might be lower.

The cumulative ash softening curves for coal from Mines G and H (fig. 10) are similar, and the curves for the various sizes occupy the same relative positions.

These relations are not apparent for the coals of the other eight mines (figs. 8, 9, 10 and 11).

Sulfur values for all samples are listed (tables 2 to 13), but no definite relationship between these values and ash softening temperature values is apparent. Undoubtedly any such relationship depends on the nature and quantity of other minerals in the coal. These relationships will be discussed in a later publication.

CONCLUSIONS

(1) On the basis of sizing the ten coals studied may be divided into four groups within which the ash fusion relationships are similar.

(2) With the possible exception of coals from mines G and H whose ash fusion relationships are similar, no groupings similar to those derived from sizing appear possible on the basis of cumulative specific gravity separations.

(3) The greatest difference in ash softening temperature was obtained in sized coals of narrow specific gravity range. This may explain clinkering difficulties experienced with stoker coals when changes are made in sizing or in washing procedure.

(4) The effect, in general, of combining portions of narrow specific gravity range is to lower high softening temperature values and to raise low softening temperature values of the component portions.

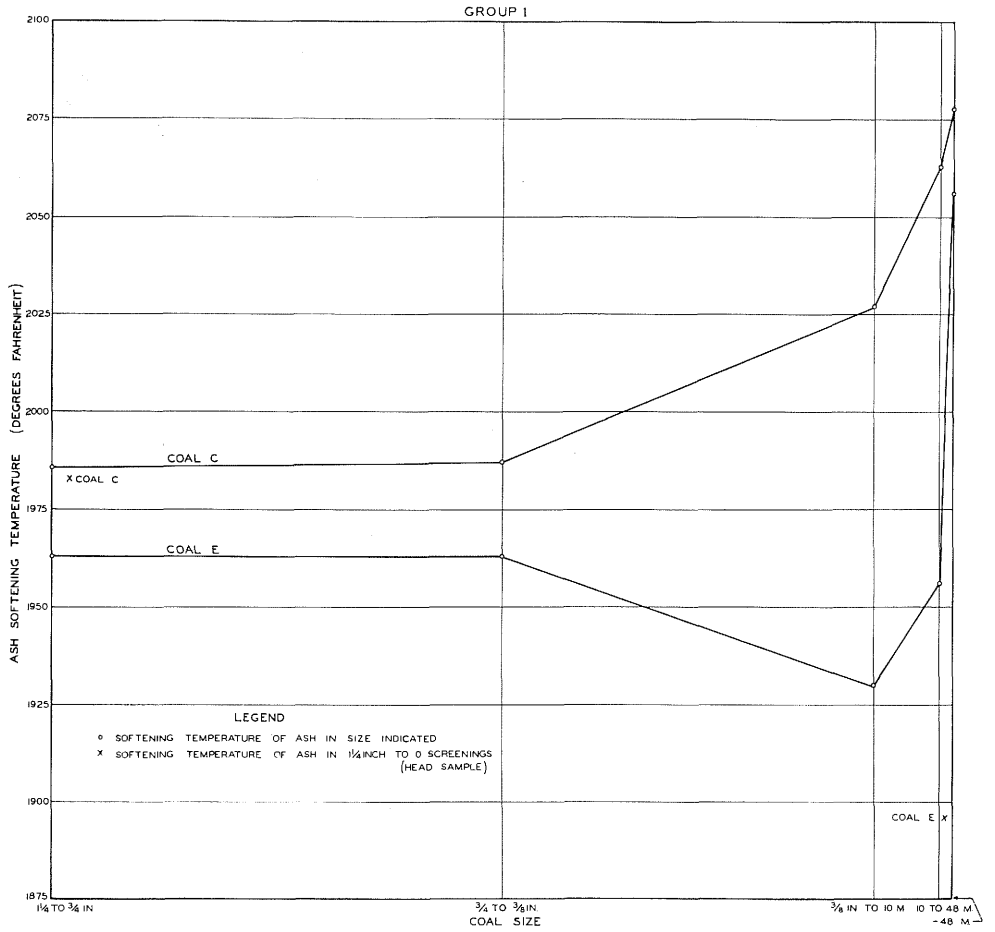

FIG. 2.—Relationship of ash softening temperature to size, coals C and E.

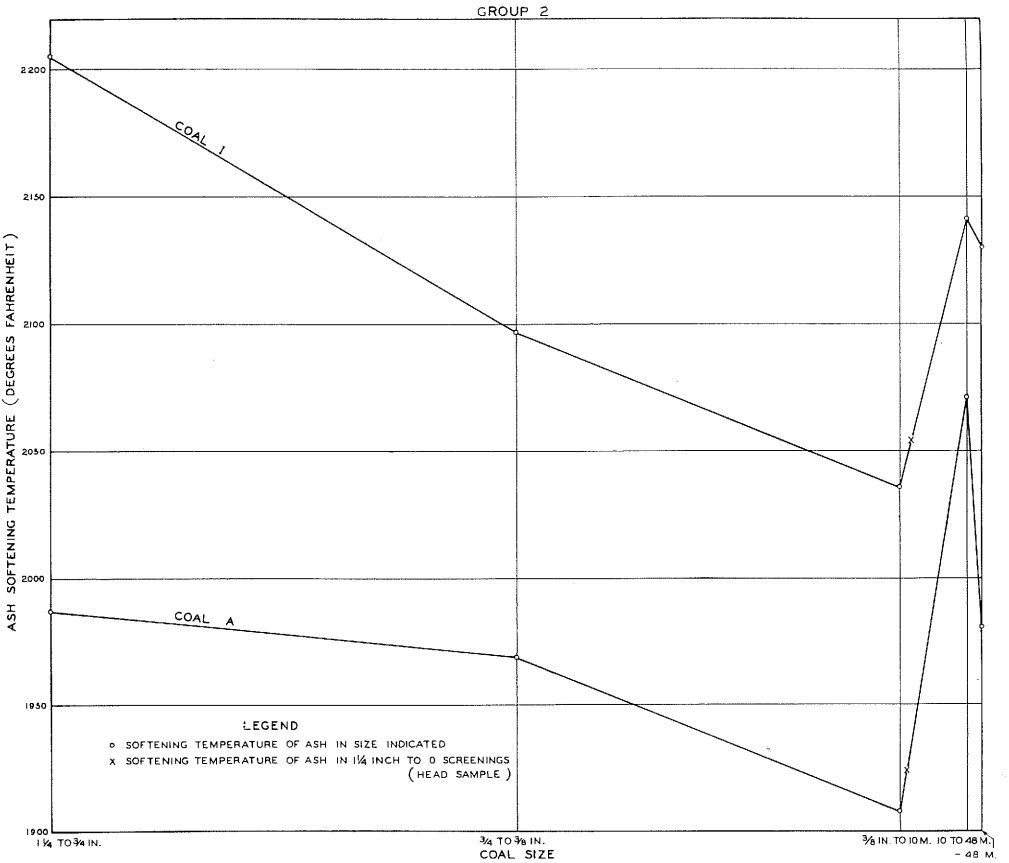

FIG. 3.—Relationship of ash softening temperature to size, coals I and A.

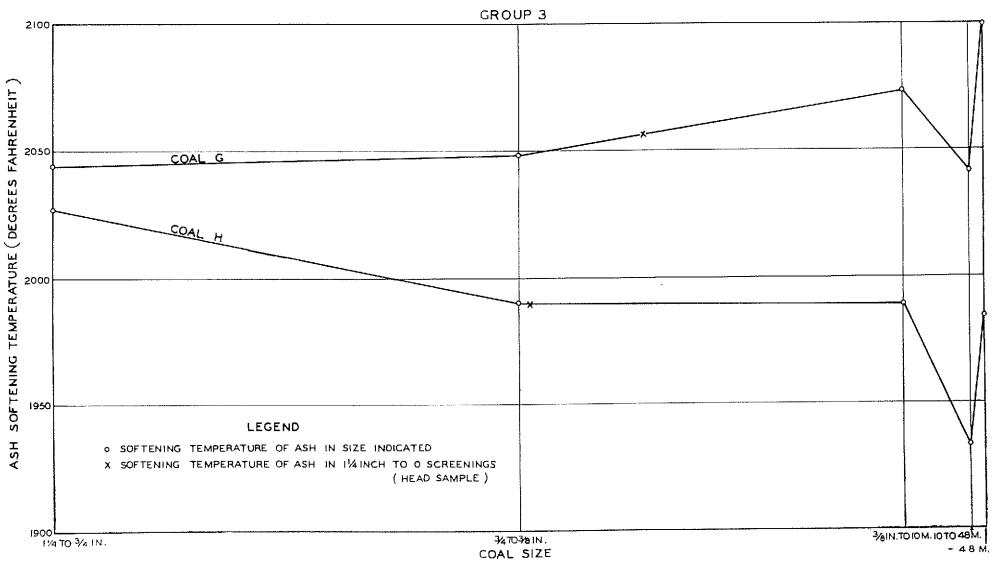

FIG. 4.—Relationship of ash softening temperature to size, coals G and H.

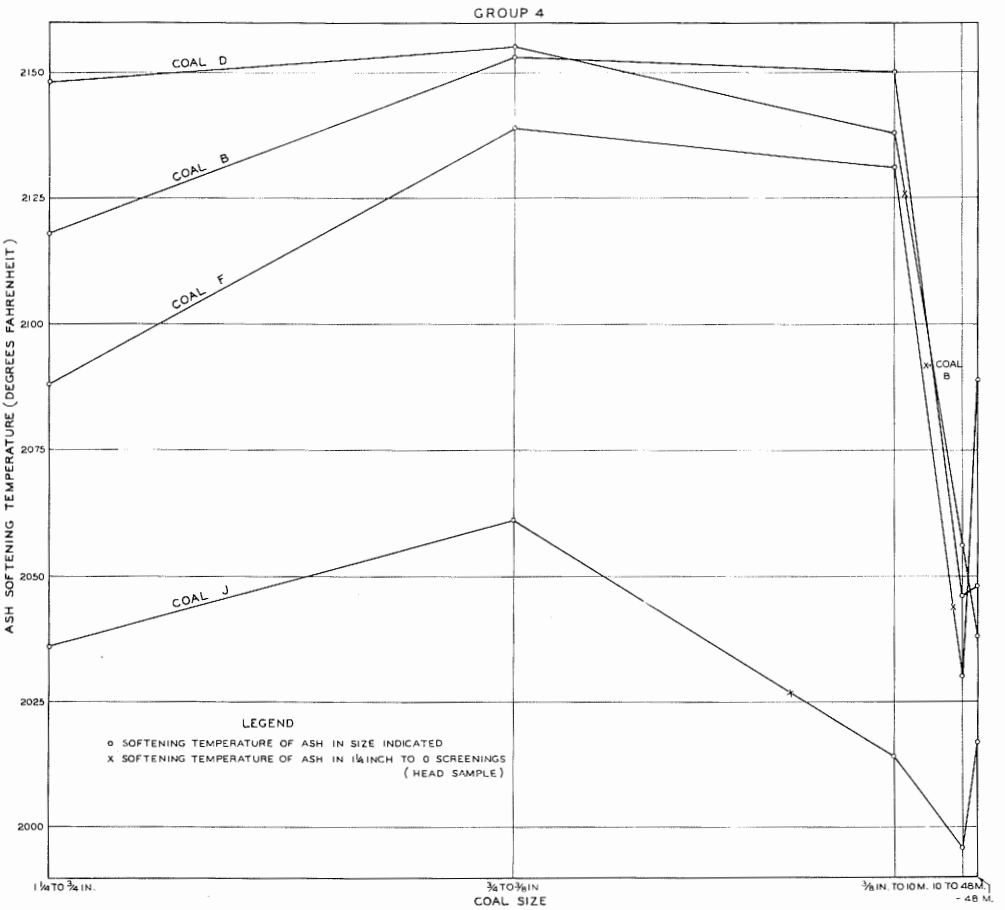

FIG. 5.—Relationship of ash softening temperature to size, coals B, D, F, and J.

TABLE 2.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine A

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1155	100.0	19.6	6.1	1880	1924	1960
1¼″ to ¾″	C–1156	25.0	17.2	6.1	1965	1987	2026
¾″ to ⅜″	C–1157	25.5	17.7	6.2	1902	1969	1984
⅜″ to 10 mesh	C–1158	31.8	19.5	6.2	1879	1908	1974
10 to 48 mesh	C–1159	12.5	25.5	6.2	1913	2071	2111
Minus 48 mesh	C–1160	5.2	29.9	7.1	1913	1981	2017
1¼″ to ¾″							
Sized sample[3]	C–1156	100.0	17.2	6.1	1965	1987	2026
1.30 Float	C–1350	39.9	6.8	3.6	1724	1927	2152
1.35	C–1838	66.7	8.5	4.1	1805	1883	2024
1.40	C–1839	79.3	9.6	4.4	1791	1904	2170
1.50	C–1840	87.4	11.0	4.6	1816	1927	2187
1.70	C–1841	92.2	12.4	4.8	1829	1913	2252
Composite head	C–1842	100.0	.....	.....	1849	1920	2242
¾″ to ⅜″							
Sized sample[3]	C–1157	100.0	17.7	6.2	1902	1969	1984
1.30 F	C–1356	40.7	5.7	3.4	1756	2025	2134
1.35	C–1843	66.0	7.7	4.0	1811	1907	2151
1.40	C–1844	77.6	9.0	4.3	1809	1931	2211
1.50	C–1845	85.9	10.6	4.6	1805	1968	2214
1.70	C–1846	90.1	11.9	4.8	1820	1920	1998
Composite head	C–1847	100.0	.....	.....	1846	1932	2161
⅜″ to 10 mesh							
Sized sample[3]	C–1158	100.0	19.5	6.2	1879	1908	1974
1.30 F	C–1396	26.5	4.1	3.2	1686	1876	2200
1.35	C–1848	54.6	5.3	3.5	1750	1869	2249
1.40	C–1849	66.4	6.5	3.8	1722	1875	[4]
1.50	C–1850	77.5	8.1	4.2	1768	1862	2118
1.70	C–1851	84.8	10.0	4.6	1695	1897	2218
Composite head	C–1852	100.0	.....	.....	1738	1869	2114
10 to 48 mesh							
Sized sample[3]	C–1159	100.0	25.5	6.2	1913	2071	2111
1.30 F	C–1402	10.2	2.6	3.0	1722	1885	2182
1.35	C–1853	42.5	3.6	3.2	1668	1893	2234
1.40	C–1854	53.2	4.7	3.5	1628	1901	2196
1.50	C–1855	64.7	6.4	3.8	1744	1898	2209
1.70	C–1856	72.6	8.5	4.2	1731	1893	2218
Composite head	C–1857	100.0	.....	.....	1791	2011	2057
Minus 48 mesh							
Sized sample[3]	C–1160	100.0	29.9	7.1	1913	1981	2017
1.30 F	C–1475	0.25	3.6	3.1	[5]	[5]	[5]
1.35	C–1858	8.9	2.8	3.0	1934	2000	2180
1.40	C–1859	19.1	4.0	3.2	1872	2065	2309
1.50	C–1860	31.9	6.4	3.5	1943	2073	2242
1.70	C–1861	68.6	15.0	4.6	1937	2056	2203
Composite head	C–1862	100.0	.....	.....	1880	2001	2074

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Out of range. [5]Insufficient sample.

TABLE 3.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine B

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C– 993	100.0	19.4	2.2	2030	2092	2316
1¼″ to ¾″	C– 994	20.3	11.0	1.7	2053	2118	2373
¾″ to ⅜″	C– 995	29.4	14.3	1.8	2077	2153	2187
⅜″ to 10 mesh	C– 996	31.0	19.7	2.0	2077	2150	2365
10 to 48 mesh	C– 997	13.6	30.5	2.9	1958	2046	2139
Minus 48 mesh	C– 998	5.7	36.5	4.0	1947	2048	2091
1¼″ to ¾″							
Sized sample[3]	C– 994	100.0	11.0	1.7	2053	2118	2373
1.30 Float	C–1067	75.6	3.8	1.0	1821	2073	2514
1.35	C–1705	86.7	4.6	1.2	1803	2069	2543
1.40	C–1706	89.4	5.0	1.2	1803	2089	2419
1.50	C–1707	91.8	5.5	1.3	1819	2098	2144
1.70	C–1708	93.4	6.1	1.3	1875	2076	2458
Composite head	C–1709	100.0	.....	.....	1919	2120	2514
¾″ to ⅜″							
Sized sample[3]	C– 995	100.0	14.3	1.8	2077	2153	2187
1.30 F	C–1072	74.1	3.9	1.0	1811	2065	2428
1.35	C–1710	81.7	4.5	1.1	1809	2041	[4]
1.40	C–1711	84.0	4.8	1.2	1835	2066	2428
1.50	C–1712	86.1	5.3	1.2	1823	2048	2090
1.70	C–1713	88.3	6.1	1.4	1835	2058	2371
Composite head	C–1714	100.0	.....	.....	1929	2126	2390
⅜″ to 10 mesh							
Sized sample[3]	C– 996	100.0	19.7	2.0	2077	2150	2365
1.30 F	C–1000	68.9	3.3	1.0	1753	1987	2380
1.35	C–1715	72.8	3.6	1.1	1687	1925	2349
1.40	C–1716	75.3	3.9	1.1	1721	1974	2335
1.50	C–1717	77.8	4.6	1.2	1756	1979	2346
1.70	C–1718	80.1	5.3	1.3	1776	1998	2335
Composite head	C–1719	100.0	.....	.....	1807	2021	2338
10 to 48 mesh							
Sized sample[3]	C– 997	100.0	30.5	2.9	1958	2046	2139
1.30 F	C–1034	47.0	2.5	0.90	1753	1980	2344
1.35	C–1720	58.0	2.9	0.95	1753	2007	2399
1.40	C–1721	62.2	3.5	1.0	1768	2044	2061
1.50	C–1722	65.0	4.0	1.1	1768	2044	2394
1.70	C–1723	68.0	5.4	1.3	1842	2053	2370
Composite head	C–1724	100.0	.....	.....	1921	2025	2313
Minus 48 mesh							
Sized sample[3]	C– 998	100.0	36.5	4.0	1947	2048	2091
1.30 F	C–1522	4.0	2.1	0.96	1930	2140	2469
1.35	C–1725	12.0	2.6	0.89	2008	2175	2432
1.40	C–1726	28.0	4.1	0.92	1990	2200	2432
1.50	C–1727	48.0	7.0	1.1	1915	2175	2400
1.70	C–1728	54.0	7.9	1.1	1882	2175	2424
Composite head	C–1729	100.0	.....	.....	2030	2124	2337

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Out of range.

TABLE 4.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine C

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1149	100.0	16.5	3.3	1885	1983	2040
1¼″ to ¾″	C–1150	34.7	14.3	3.5	1943	1986	2068
¾″ to ⅜″	C–1151	28.8	14.6	3.3	1950	1987	2227
⅜″ to 10 mesh	C–1152	23.5	16.3	3.2	1964	2027	2263
10 to 48 mesh	C–1153	9.3	18.9	2.9	1981	2063	2080
Minus 48 mesh	C–1154	3.7	22.9	2.7	2034	2077	2089
1¼″ to ¾″							
Sized sample[3]	C–1150	100.0	14.3	3.5	1943	1986	2068
1.30 Float	C–1528	20.4	7.9	2.7	1793	2143	2428
1.35	C–1730	68.9	10.9	2.7	1939	2106	2367
1.40	C–1731	85.6	12.2	2.9	1877	2030	2277
1.50	C–1732	92.8	13.2	3.1	1876	1944	2151
1.70	C–1733	95.9	13.9	3.2	1862	1971	2201
Composite head	C–1734	100.0	.....	.....	1862	1925	2181
¾″ to ⅜″							
Sized sample[3]	C–1151	100.0	14.6	3.3	1950	1987	2227
1.30 F	C–1534	26.7	7.6	2.4	1891	2148	2452
1.35	C–1735	73.0	10.7	2.6	1891	2068	2388
1.40	C–1736	85.3	11.9	2.8	1913	2014	2290
1.50	C–1737	91.1	12.8	2.9	1918	2011	2134
1.70	C–1738	94.3	13.6	3.0	1927	1968	2016
Composite head	C–1739	100.0	.....	.....	1936	1970	2167
⅜″ to 10 mesh							
Sized sample[3]	C–1152	100.0	16.3	3.2	1964	2027	2263
1.30 F	C–1412	21.6	5.7	2.4	1893	2136	2520
1.35	C–1740	57.1	7.1	2.4	1882	2132	2520
1.40	C–1741	76.4	8.5	2.5	1905	2097	2483
1.50	C–1742	85.9	9.6	2.7	1900	2069	2320
1.70	C–1743	90.7	10.6	2.8	1872	2011	2179
Composite head	C–1744	100.0	.....	.....	1917	1993	2038
10 to 48 mesh							
Sized sample[3]	C–1153	100.0	18.9	2.9	1981	2063	2080
1.30 F	C–1418	6.3	3.4	2.4	1814	2014	2488
1.35	C–1745	45.4	5.1	2.4	1814	2096	2593
1.40	C–1746	66.4	6.8	2.5	1865	2124	2572
1.50	C–1747	77.5	8.4	2.6	1867	2109	2536
1.70	C–1748	83.2	9.6	2.7	1926	2053	2564
Composite head	C–1749	100.0	.....	.....	1936	2045	2062
Minus 48 mesh							
Sized sample[3]	C–1154	100.0	22.9	2.7	2034	2077	2089
1.30 F	C–1521	0.24	2.7	2.5	[5]	[5]	[5]
1.35	C–1750	19.1	2.9	2.5	1830	2006	2457
1.40	C–1751	39.4	5.0	2.5	1866	2076	[4]
1.50	C–1752	58.3	7.4	2.5	1879	2090	[4]
1.70	C–1753	73.7	10.1	2.5	1913	2069	2431
Composite head	C–1754	100.0	.....	.....	1990	2047	2095

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Out of range. [5]Insufficient sample.

TABLE 5.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine D

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C– 975	100.0	14.6	2.3	2052	2126	2342
1¼″ to ¾″	C– 974	18.8	12.6	1.9	2068	2148	2452
¾″ to ⅜″	C– 976	24.1	13.6	2.0	2077	2155	2372
⅜″ to 10 mesh	C– 973	32.2	14.7	2.1	2068	2138	2193
10 to 48 mesh	C– 972	16.1	17.5	2.5	1948	2056	2243
Minus 48 mesh	C– 971	8.8	21.4	3.8	1939	2038	2119
1¼″ to ¾″							
Sized sample[3]	C– 974	100.0	12.6	1.9	2068	2148	2452
1.30 Float	C–1488	51.7	5.8	1.2	1801	2140	2511
1.35	C–1640	82.6	7.8	1.3	1882	2170	(4)
1.40	C–1641	86.2	8.2	1.4	1885	2163	2185
1.50	C–1642	89.8	8.9	1.4	1937	2177	2189
1.70	C–1643	94.0	10.2	1.5	1912	2173	(4)
Composite head	C–1644	100.0	.....	.....	1909	2177	(4)
¾″ to ⅜″							
Sized sample[3]	C– 976	100.0	13.6	2.0	2077	2155	2372
1.30 F	C–1495	46.9	5.2	1.1	1839	2183	2529
1.35	C–1645	71.7	7.0	1.3	1885	2168	(4)
1.40	C–1646	79.8	7.8	1.4	1909	2144	2223
1.50	C–1647	87.4	8.9	1.5	1933	2168	2192
1.70	C–1648	93.4	10.7	1.6	1946	2170	2194
Composite head	C–1649	100.0	.....	.....	1975	2165	2483
⅜″ to 10 mesh							
Sized sample[3]	C– 973	100.0	14.7	2.1	2068	2138	2193
1.30 F	C– 984	63.9	4.4	1.3	1767	2061	2111
1.35	C–1650	76.0	5.6	1.5	1850	2112	2218
1.40	C–1651	80.6	6.2	1.6	1816	2119	2181
1.50	C–1652	86.2	7.3	1.7	1847	2142	2218
1.70	C–1653	90.3	8.7	1.8	1897	2143	2213
Composite head	C–1654	100.0	.....	.....	1954	2145	2181
10 to 48 mesh							
Sized sample[3]	C– 972	100.0	17.5	2.5	1948	2056	2243
1.30 F	C– 978	58.6	3.7	1.3	1821	2022	2228
1.35	C–1655	67.6	4.5	1.4	1854	2058	(4)
1.40	C–1656	72.9	5.1	1.5	1864	2071	(4)
1.50	C–1657	79.2	6.2	1.6	1889	2065	2105
1.70	C–1658	84.9	8.0	1.7	1861	2088	2125
Composite head	C–1659	100.0	.....	.....	1945	2052	2213
Minus 48 mesh							
Sized sample[3]	C– 971	100.0	21.4	3.8	1939	2038	2119
1.30 F	C–1006	5.7	2.0	1.1	1710	1996	2355
1.35	C–1875	26.3	2.7	1.1	1840	2071	2345
1.40	C–1876	40.3	4.0	1.3	1991	2047	2329
1.50	C–1877	58.1	5.9	1.4	2041	2079	2362
1.70	C–1878	77.0	8.3	1.6	2041	2089	2448
Composite head	C–1879	100.0	.....	.....	1931	2144	2400

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Out of range.

TABLE 6.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine E

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1085	100.0	13.8	5.3	1885	1896	2036
1¼″ to ¾″	C–1086	29.5	12.8	5.2	1918	1963	2036
¾″ to ⅜″	C–1087	28.6	14.1	5.5	1930	1963	2033
⅜″ to 10 mesh	C–1088	26.6	13.8	5.3	1909	1930	1980
10 to 48 mesh	C–1089	10.7	17.3	5.4	1911	1956	1970
Minus 48 mesh	C–1090	4.6	20.2	5.0	1983	2056	2075
1¼″ to ¾″							
Sized sample[3]	C–1086	100.0	12.8	5.2	1918	1963	2036
1.30 Float	C–1219	42.8	7.0	3.5	1712	2019	[4]
1.35	C–1755	71.9	9.0	3.8	1735	1984	2299
1.40	C–1756	86.1	10.2	4.1	1773	1964	2470
1.50	C–1757	93.9	11.2	4.4	1769	1925	2131
1.70	C–1758	97.7	12.0	4.7	1782	1906	2442
Composite head	C–1759	100.0	.....	.....	1807	1918	2288
¾″ to ⅜″							
Sized sample[3]	C–1087	100.0	14.1	5.5	1930	1963	2033
1.30 F	C–1225	38.7	6.2	3.4	1678	1951	2509
1.35	C–1760	68.8	8.3	3.7	1705	1940	2454
1.40	C–1761	83.3	9.6	4.0	1729	1907	2460
1.50	C–1762	92.3	10.8	4.4	1737	1878	2392
1.70	C–1763	96.3	11.7	4.6	1737	1858	2376
Composite head	C–1764	100.0	.....	.....	1756	1849	2138
⅜″ to 10 mesh							
Sized sample[3]	C–1088	100.0	13.8	5.3	1909	1930	1980
1.30 F	C–1198	61.9	6.5	3.5	1829	1984	2434
1.35	C–1765	68.7	6.8	3.6	1771	2008	2481
1.40	C–1766	75.8	7.3	3.7	1726	2017	2317
1.50	C–1767	87.5	8.8	4.0	1756	1999	2280
1.70	C–1768	92.4	9.9	4.2	1771	1968	2188
Composite head	C–1769	100.0	.....	.....	1784	1883	2153
10 to 48 mesh							
Sized sample[3]	C–1089	100.0	17.3	5.4	1911	1956	1970
1.30 F	C–1192	34.4	3.5	3.2	1844	1985	2492
1.35	C–1770	54.4	4.3	3.2	1844	1999	2484
1.40	C–1771	65.9	5.4	3.3	1844	2008	2398
1.50	C–1772	78.8	7.1	3.6	1844	1992	2249
1.70	C–1773	84.8	8.5	3.8	1854	1948	2226
Composite head	C–1774	100.0	.....	.....	1854	1920	1933
Minus 48 mesh							
Sized sample[3]	C–1090	100.0	20.2	5.0	1983	2056	2075
1.30 F	C–1508	1.5	2.2	3.1	1747	1918	2183
1.35	C–1880	17.3	2.5	3.0	1702	1957	2238
1.40	C–1881	41.0	4.1	3.1	1729	2033	2547
1.50	C–1882	63.3	6.4	3.0	1729	2040	2518
1.70	C–1883	78.1	8.7	3.1	1920	2139	2445
Composite head	C–1884	100.0	.....	.....	1839	2011	2171

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Out of range.

TABLE 7.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine F

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1120	100.0	17.8	4.7	1900	2044	2316
1¼″ to ¾″	C–1121	28.3	14.2	4.7	1898	2088	2453
¾″ to ⅜″	C–1122	28.7	17.0	4.8	1898	2139	2458
⅜″ to 10 mesh	C–1123	27.3	18.7	4.7	1972	2131	2458
10 to 48 mesh	C–1124	10.2	25.3	4.7	1927	2030	2262
Minus 48 mesh	C–1125	5.5	21.1	3.5	1943	2089	2262
1¼″ to ¾″							
Sized sample[3]	C–1121	100.0	14.2	4.7	1898	2088	2453
1.30 Float	C–1296	37.9	4.8	3.6	1633	1912	2347
1.35	C–1818	67.9	6.9	3.6	1659	1939	2424
1.40	C–1819	78.6	7.8	3.8	1670	1936	2363
1.50	C–1820	85.4	8.8	3.9	1659	1958	2334
1.70	C–1821	88.9	9.8	4.1	1677	1958	2381
Composite head	C–1822	100.0	.....	.....	1689	1980	2363
¾″ to ⅜″							
Sized sample[3]	C–1122	100.0	17.0	4.8	1898	2139	2458
1.30 F	C–1302	35.5	4.4	3.5	1691	2026	2322
1.35	C–1823	65.2	6.7	3.6	1711	2018	2344
1.40	C–1824	77.0	7.8	3.7	1696	2051	2367
1.50	C–1825	84.8	8.9	3.9	1736	2058	2404
1.70	C–1826	88.2	9.9	4.1	1714	2035	2446
Composite head	C–1827	100.0	.....	.....	1748	2058	2518
⅜″ to 10 mesh							
Sized sample [3]	C–1123	100.0	18.7	4.7	1972	2131	2458
1.30 F	C–1207	35.9	4.5	3.4	1819	1953	2020
1.35	C–1828	60.9	5.7	3.5	1780	1947	2211
1.40	C–1829	72.2	6.7	3.6	1780	1942	2263
1.50	C–1830	80.2	7.8	3.7	1811	1999	2330
1.70	C–1831	85.2	9.2	3.9	1802	2027	2312
Composite head	C–1832	100.0	.....	.....	1820	2027	2385
10 to 48 mesh							
Sized sample[3]	C–1124	100.0	25.3	4.7	1927	2030	2262
1.30 F	C–1213	29.8	4.1	3.3	1715	1906	1936
1.35	C–1833	50.2	5.4	3.4	1711	1962	2053
1.40	C–1834	61.0	6.5	3.5	1674	1910	2260
1.50	C–1835	71.0	7.8	3.6	1682	1877	2312
1.70	C–1836	78.2	9.8	3.7	1764	1938	2322
Composite head	C–1837	100.0	.....	.....	1743	2028	2305
Minus 48 mesh							
Sized sample[3]	C–1125	100.0	21.1	3.5	1943	2089	2262
1.30 F	PA–6A[4]	0.86	2.1	3.1	(5)	(5)	(5)
1.35	C–1905	4.5	3.0	3.1	1678	1909	2236
1.40	C–1906	14.4	4.9	3.1	1703	2005	2331
1.50	C–1907	33.7	7.1	2.9	1674	1980	2247
1.70	C–1908	82.2	10.6	2.6	1775	2091	2386
Composite head	C–1909	100.0	.....	.....	1678	2056	2355

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample. [4]Sample number. [5]Insufficient sample.

TABLE 8.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine G

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1179	100.0	18.1	4.6	1944	2056	2157
1¼″ to ¾″	C–1180	29.0	15.5	4.7	1930	2044	2305
¾″ to ⅜″	C–1181	26.5	16.9	4.7	1900	2048	2233
⅜″ to 10 mesh	C–1182	26.0	19.3	4.5	1902	2073	2354
10 to 48 mesh	C–1183	12.5	25.8	4.2	1939	2041	2372
Minus 48 mesh	C–1184	6.0	25.2	3.4	1966	2099	2459
1¼″ to ¾″							
Sized sample[3]	C–1180	100.0	15.5	4.7	1930	2044	2305
1.30 Float	C–1308	33.0	5.6	3.2	1862	2081	2536
1.35	C–1600	69.1	7.9	3.3	1829	2108	2460
1.40	C–1601	81.8	9.0	3.4	1863	2078	2480
1.50	C–1602	88.8	10.0	3.6	1820	2074	2469
1.70	C–1603	91.4	10.6	3.7	1876	2065	2413
Composite head	C–1604	100.0	.....	.....	1876	2030	2384
¾″ to ⅜″							
Sized sample[3]	C–1181	100.0	16.9	4.7	1900	2048	2233
1.30 F	C–1314	33.1	4.5	3.1	1832	2050	2629
1.35	C–1605	69.4	7.3	3.2	1876	2081	2389
1.40	C–1606	80.0	8.4	3.3	1881	2068	2312
1.50	C–1607	86.8	9.5	3.5	1885	2058	2336
1.70	C–1608	90.3	10.4	3.6	1849	2041	2232
Composite head	C–1609	100.0	.....	.....	1888	2017	2204
⅜″ to 10 mesh							
Sized sample[3]	C–1182	100.0	19.3	4.5	1902	2073	2354
1.30 F	C–1384	50.0	5.2	3.3	1848	2025	2240
1.35	C–1610	66.8	6.5	3.4	1897	2065	2281
1.40	C–1611	74.4	7.3	3.5	1910	2065	2344
1.50	C–1612	81.0	8.3	3.6	1927	2065	2293
1.70	C–1613	85.6	9.5	3.8	1927	2043	2256
Composite head	C–1614	100.0	.....	.....	1930	2046	2220
10 to 48 mesh							
Sized sample[3]	C–1183	100.0	25.8	4.2	1939	2041	2372
1.30 F	C–1390	30.0	3.2	3.2	1848	1984	2141
1.35	C–1615	51.6	4.8	3.3	1860	2028	2264
1.40	C–1616	61.0	5.9	3.4	1860	2055	2271
1.50	C–1617	69.6	7.4	3.5	1882	2056	2247
1.70	C–1618	76.1	9.2	3.6	1920	2051	2229
Composite head	C–1619	100.0	.....	.....	1963	2025	2251
Minus 48 mesh							
Sized sample[3]	C–1184	100.0	25.2	3.4	1966	2099	2459
1.30 F	C–1433	2.3	1.4	3.1	1934	1973	2180
1.35	C–1885	16.7	2.9	3.1	1766	1990	2405
1.40	C–1886	26.7	4.2	3.1	1751	2002	2397
1.50	C–1887	43.0	6.6	3.1	1712	2032	2406
1.70	C–1888	69.3	10.0	2.7	1727	2085	2420
Composite head	C–1889	100.0	.....	.....	1920	2109	2200

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample.

TABLE 9.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine H

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1186	100.0	16.3	4.6	1928	1990	2118
1¼″ to ¾″	C–1187	33.0	15.4	4.7	1966	2027	2272
¾″ to ⅜″	C–1188	23.5	15.5	4.9	1947	1990	2255
⅜″ to 10 mesh	C–1189	26.7	15.0	4.7	1916	1989	.....
10 to 48 mesh	C–1190	11.8	17.3	4.2	1902	1933	.....
Minus 48 mesh	C–1191	5.0	20.4	3.7	1914	1984	2017
1¼″ to ¾″							
Sized sample[3]	C–1187	100.0	15.4	4.7	1966	2027	2272
1.30 Float	C–1263	36.4	5.1	2.9	1847	2045	2319
1.35	C–1580	63.7	7.2	3.0	1877	2084	2366
1.40	C–1581	77.8	8.6	3.1	1877	2112	2379
1.50	C–1582	86.6	9.9	3.3	1877	2090	2366
1.70	C–1583	89.9	10.7	3.4	1847	2057	2319
Composite head	C–1584	100.0	.....	.....	1886	2037	2319
¾″ to ⅜″							
Sized sample[3]	C–1188	100.0	15.5	4.9	1947	1990	2255
1.30 F	C–1269	42.8	5.1	2.8	1858	2038	2291
1.35	C–1585	67.8	6.9	2.9	1886	2068	2388
1.40	C–1586	78.3	8.0	3.0	1867	2068	2380
1.50	C–1587	86.0	9.2	3.2	1774	2068	2319
1.70	C–1588	90.2	10.3	3.3	1861	2062	2391
Composite head	C–1589	100.0	.....	.....	1880	2032	2228
⅜″ to 10 mesh							
Sized sample[3]	C–1189	100.0	15.0	4.7	1916	1989	.....
1.30 F	C–1281	65.3	5.5	2.9	1774	2022	2389
1.35	C–1590	75.3	6.4	3.0	1867	2019	2391
1.40	C–1591	80.1	7.0	3.1	1867	2044	2232
1.50	C–1592	85.1	7.9	3.2	1900	2047	2290
1.70	C–1593	89.7	9.1	3.3	1870	2046	2334
Composite head	C–1594	100.0	.....	.....	1932	2030	2273
10 to 48 mesh							
Sized sample[3]	C–1190	100.0	17.3	4.2	1902	1933	.....
1.30 F	C–1287	43.7	3.6	2.8	1763	1898	2383
1.35	C–1595	61.3	4.6	2.9	1813	1959	2288
1.40	C–1596	71.7	5.6	2.9	1754	2008	2184
1.50	C–1597	78.9	6.7	3.0	1722	2030	2193
1.70	C–1598	85.3	8.3	3.2	1898	1994	2383
Composite head	C–1599	100.0	.....	.....	1898	1950	1966
Minus 48 mesh							
Sized sample[3]	C–1191	100.0	20.4	3.7	1914	1984	2017
1.30 F	C–1515	5.1	3.3	2.6	1694	1911	2074
1.35	C–1890	33.1	3.6	2.5	1729	1848	2358
1.40	C–1891	45.2	4.5	2.6	1752	1888	2358
1.50	C–1892	59.9	5.9	2.6	1737	1934	2415
1.70	C–1893	77.7	7.5	2.5	1794	1996	2399
Composite head	C–1894	100.0	.....	.....	1839	1986	2377

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample.

TABLE 10. ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine I

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1689	100.0	10.4	1.9	1921	2054	2260
1¼″ to ¾″	C–1163	28.6	9.8	1.7	2081	2205	2451
¾″ to ⅜″	C–1164	25.6	9.9	1.9	1953	2097	2450
⅜″ to 10 mesh	C–1165	27.0	10.8	2.2	1887	2036	2311
10 to 48 mesh	C–1166	12.9	14.4	2.3	2014	2141	2411
Minus 48 mesh	C–1167	5.9	14.6	2.2	2008	2130	2381
1¼″ to ¾″							
Sized sample[3]	C–1163	100.0	9.8	1.7	2081	2205	2451
1.30 Float	C–1245	54.1	4.4	1.3	1856	2122	2460
1.35	C–1660	86.4	6.0	1.4	1856	2180	2452
1.40	C–1661	92.1	6.5	1.4	1876	2200	2526
1.50	C–1662	96.1	7.2	1.5	1891	2304	2544
1.70	C–1663	97.4	7.5	1.5	1911	2255	2534
Composite head	C–1664	100.0	.....	.....	1864	2179	2453
¾″ to ⅜″							
Sized sample[3]	C–1164	100.0	9.9	1.9	1953	2097	2450
1.30 F	C–1257	53.6	3.7	1.3	1829	2064	2421
1.35	C–1665	83.8	5.5	1.4	1867	2134	2400
1.40	C–1666	89.4	6.1	1.4	1867	2169	2441
1.50	C–1667	93.3	6.7	1.4	1908	2174	2451
1.70	C–1668	95.8	7.4	1.5	1913	2134	2416
Composite head	C–1669	100.0	.....	.....	1936	2114	2379
⅜″ to 10 mesh							
Sized sample[3]	C–1165	100.0	10.8	2.2	1887	2036	2311
1.30 F	C–1502	77.7	4.6	1.4	1865	2093	2312
1.35	C–1670	86.4	5.3	1.5	1874	2143	2382
1.40	C–1671	89.4	5.7	1.5	1903	2156	2381
1.50	C–1672	92.1	6.2	1.5	1909	2113	2390
1.70	C–1673	94.2	6.8	1.5	1856	2125	2335
Composite head	C–1674	100.0	.....	.....	1934	2078	2259
10 to 48 mesh							
Sized sample[3]	C–1166	100.0	14.4	2.3	2014	2141	2411
1.30 F	C–1239	69.3	3.5	1.1	1855	2058	2268
1.35	C–1675	76.5	4.1	1.2	1898	2091	2230
1.40	C–1676	80.3	4.6	1.2	1898	2116	2307
1.50	C–1677	84.9	5.3	1.2	1862	2126	2405
1.70	C–1678	88.1	6.2	1.3	1862	2132	2383
Composite head	C–1679	100.0	.....	.....	1942	2098	2277
Minus 48 mesh							
Sized sample[3]	C–1167	100.0	14.6	2.2	2008	2130	2381
1.30 F	C–1427	17.9	1.7	0.89	1856	2025	2192
1.35	C–1680	31.5	2.6	0.97	1856	2048	2264
1.40	C–1681	45.4	3.8	1.0	1896	2085	2294
1.50	C–1682	57.6	4.8	0.99	1927	2106	2278
1.70	C–1683	87.3	6.7	0.98	1956	2177	2508
Composite head	C–1684	100.0	.....	.....	1991	2119	2281

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample.

TABLE 11.—ASH FUSION DATA FOR SIZED AND CUMULATIVE GRAVITY SAMPLES

Mine J

Sample	Lab. No.	WEIGHT[1] Per cent	Ash[2]	Sulfur[2]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1172	100.0	11.8	3.0	1928	2028	2193
1¼″ to ¾″	C–1174	30.7	9.7	2.8	1893	2036	2385
¾″ to ⅜″	C–1175	26.0	10.2	2.7	1876	2072	2376
⅜″ to 10 mesh	C–1176	25.4	11.7	2.9	1915	2022	2214
10 to 48 mesh	C–1177	12.3	18.5	3.3	1931	1996	2061
Minus 48 mesh	C–1178	5.6	16.8	3.7	1945	2017	2138
1¼″ to ¾″							
Sized sample[3]	C–1174	100.0	9.7	2.8	1893	2036	2385
1.30 Float	C–1336	50.5	5.3	1.5	1849	2155	2529
1.35	C–1620	86.3	7.0	1.7	1902	2118	2496
1.40	C–1621	92.1	7.4	1.9	1919	2068	2100
1.50	C–1622	95.0	7.8	2.0	1919	2075	2148
1.70	C–1623	96.5	8.1	2.2	1832	2065	2151
Composite head	C–1624	100.0	.....	.....	1833	2047	2107
¾″ to ⅜″							
Sized sample[3]	C–1175	100.0	10.2	2.7	1876	2061	2376
1.30 F	C–1342	50.1	4.8	1.5	1877	2120	2539
1.35	C–1625	85.4	6.5	1.7	1832	2118	2157
1.40	C–1626	91.0	6.9	1.8	1822	2077	2088
1.50	C–1627	93.9	7.3	2.0	1822	2054	2073
1.70	C–1628	95.2	7.6	2.1	1859	2080	2464
Composite head	C–1629	100.0	.....	.....	1900	2059	2415
⅜″ to 10 mesh							
Sized sample[3]	C–1176	100.0	11.7	2.9	1915	2014	2230
1.30 F	C–1372	59.0	4.5	1.5	1869	2080	2424
1.35	C–1630	82.6	5.9	1.7	1902	2127	2452
1.40	C–1631	87.5	6.3	1,8	1881	2127	2469
1.50	C–1632	90.4	6.6	1.9	1923	2086	2468
1.70	C–1633	92.3	7.0	2.1	1858	2047	2412
Composite head	C–1634	100.0	.....	.....	1942	2046	2219
10 to 48 mesh							
Sized sample[3]	C–1177	100.0	18.5	3.3	1931	1996	2061
1.30 F	C–1378	50.1	3.2	1.4	1824	2013	2244
1.35	C–1635	68.3	4.6	1.5	1869	2064	2416
1.40	C–1636	73.9	5.1	1.6	1878	2068	2418
1.50	C–1637	79.4	5.9	1.7	1898	2078	2424
1.70	C–1638	82.5	6.5	1.9	1886	2070	2392
Composite head	C–1639	100.0	.....	.....	1912	1980	2039
Minus 48 mesh							
Sized sample[3]	C–1178	100.0	16.8	3.7	1945	2017	2138
1.30 F	C–1447	15.9	2.0	1.2	1936	2122	2358
1.35	C–1895	30.8	3.2	1.3	1703	1942	2345
1.40	C–1896	39.8	4.1	1.4	1683	1955	2354
1.50	C–1897	51.0	5.2	1.4	1678	1984	2342
1.70	C–1898	82.1	7.1	1.6	1753	2040	2304
Composite head	C–1899	100.0	.....	.....	1846	1948	2202

[1]Individual values for sized samples; cumulative values for gravity samples.
[2]Dry basis. [3]Sub-head sample.

TABLE 12.—ASH FUSION DATA FOR SIZED AND INDIVIDUAL GRAVITY SAMPLES

Mine E

Sample	Lab. No.	WEIGHT Per cent	Ash[1]	Sulfur[1]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C–1085	100.0	13.8	5.3	1885	1896	2036
1¼″ to ¾″	C–1086	29.5	12.8	5.2	1918	1963	2036
¾″ to ⅜″	C–1087	28.6	14.1	5.5	1930	1963	2033
⅜″ to 10 mesh	C–1088	26.6	13.8	5.3	1909	1930	1980
10 to 48 mesh	C–1089	10.7	17.3	5.4	1911	1956	1970
Minus 48 mesh	C–1090	4.6	20.2	5.0	1983	2056	2075
1¼″ to ¾″							
Sized sample[2]	C–1086	100.0	12.8	5.2	1918	1963	2036
1.30 Float	C–1219	42.8	7.0	3.5	1712	2019	[3]
1.30–1.35	C–1220	29.1	12.0	4.2	1864	2003	2197
1.35–1.40	C–1221	14.2	16.3	5.8	1882	2142	2334
1.40–1.50	C–1222	7.8	22.1	7.1	1852	1971	2133
1.50–1.70	C–1223	3.8	31.0	11.6	2098	2164	2425
1.70 Sink	C–1224	2.3	51.2	25.0	1909	2593	2644
¾″ to ⅜″							
Sized sample[2]	C–1087	100.0	14.1	5.5	1930	1963	2033
1.30 F	C–1225	38.7	6.2	3.4	1678	1951	2509
1.30–1.35	C–1226	30.1	11.0	4.0	1947	2165	2432
1.35–1.40	C–1227	14.6	16.0	5.7	1903	2007	2271
1.40–1.50	C–1228	9.0	21.6	7.5	1925	2070	2405
1.50–1.70	C–1229	4.0	31.9	10.0	1893	2023	2259
1.70 S	C–1230	3.6	54.4	25.6	1882	2376	2471
⅜″ to 10 mesh							
Sized sample[2]	C–1088	100.0	13.8	5.3	1909	1930	1980
1.30 F	C–1198	61.9	6.5	3.5	1829	1984	2434
1.30–1.35	C–1199	6.8	9.2	3.9	1877	2003	2210
1.35–1.40	C–1200	7.1	12.8	4.6	1904	2037	2538
1.40–1.50	C–1201	11.7	18.1	6.1	1998	2085	2215
1.50–1.70	C–1202	4.8	29.4	8.5	1864	1942	1960
1.70 S	C–1203	7.7	60.3	15.5	1886	1959	1959
10 to 48 mesh							
Sized sample[2]	C–1089	100.0	17.3	5.4	1911	1956	1970
1.30 F	C–1192	34.4	3.5	3.2	1844	1985	2492
1.30–1.35	C–1193	20.0	5.7	3.3	2019	2149	2681
1.35–1.40	C–1194	11.5	10.4	3.9	1856	2110	2468
1.40–1.50	C–1195	12.9	15.8	4.9	1926	2082	2349
1.50–1.70	C–1196	6.0	27.5	7.1	1985	2102	2215
1.70 S	C–1197	15.2	61.7	12.7	2093	2395	2548
Minus 48 mesh							
Sized sample[2]	C–1090	100.0	20.2	5.0	1983	2056	2075
1.30 F	C–1508	1.5	2.2	3.1	1747	1918	2183
1.30–1.35	C–1509	15.8	2.5	3.0	1882	2118	2639
1.35–1.40	C–1510	23.7	5.2	3.1	1912	2044	2259
1.40–1.50	C–1511	22.4	10.7	2.9	1912	2125	2381
1.50–1.70	C–1512	14.7	18.8	3.2	1976	2150	2417
1.70 S	C–1513	21.9	58.6	11.6	2005	2325	2355

[1]Dry basis. [2]Sub-head sample. [3]Out of range.

TABLE 13.—ASH FUSION DATA FOR SIZED AND INDIVIDUAL GRAVITY SAMPLES

Mine I

Sample	Lab. No.	WEIGHT Per cent	Ash[1]	Sulfur[1]	Initial Deformation °F	Softening °F	Fluid °F
Head (1¼″ to 0)	C-1689	100.0	10.4	1.9	1921	2054	2260
1¼″ to ¾″	C-1163	28.6	9.8	1.7	2081	2205	2451
¾″ to ⅜″	C-1164	25.6	9.9	1.9	1953	2097	2450
⅜″ to 10 mesh	C-1165	27.0	10.8	2.2	1887	2036	2311
10 to 48 mesh	C-1166	12.9	14.4	2.3	2014	2141	2411
Minus 48 mesh	C-1167	5.9	14.6	2.2	2008	2130	2381
1¼″ to ¾″							
Sized sample[2]	C-1163	100.0	9.8	1.7	2081	2205	2451
1.30 Float	C-1245	54.1	4.4	1.3	1856	2122	2460
1.30–1.35	C-1246	32.2	8.7	1.6	1996	2311	2503
1.35–1.40	C-1247	5.7	14.9	1.7	1893	2309	2631
1.40–1.50	C-1248	4.0	21.1	2.1	2309	2518	2696
1.50–1.70	C-1249	1.3	34.3	3.5	1900	2048	2433
1.70 Sink	C-1250	2.7	67.5	10.3	2054	2139	2334
¾″ to ⅜″							
Sized sample[2]	C-1164	100.0	9.9	1.9	1953	2097	2450
1.30 F	C-1257	53.6	3.7	1.3	1829	2064	2421
1.30–1.35	C-1258	30.3	8.8	1.6	1890	2290	2554
1.35–1.40	C-1259	5.6	14.5	1.7	2039	2547	2736
1.40–1.50	C-1260	4.0	20.7	2.2	1920	2224	2437
1.50–1.70	C-1261	2.5	35.2	3.1	2054	2220	2408
1.70 S	C-1262	4.0	67.7	10.4	1878	2019	2370
⅜″ to 10 mesh							
Sized sample[2]	C-1165	100.0	10.8	2.2	1887	2036	2311
1.30 F	C-1502	77.7	4.6	1.4	1865	2093	2312
1.30–1.35	C-1503	8.7	11.8	1.8	1886	2268	2562
1.35–1.40	C-1504	3.0	16.5	2.0	1851	2289	2454
1.40–1.50	C-1505	2.7	22.3	2.0	1942	2151	2547
1.50–1.70	C-1506	2.1	35.2	2.9	1912	2186	2267
1.70 S	C-1507	5.8	67.9	12.1	1877	1994	2230
10 to 48 mesh							
Sized sample[2]	C-1166	100.0	14.4	2.3	2014	2141	2411
1.30 F	C-1239	69.3	3.5	1.1	1855	2058	2268
1.30–1.35	C-1240	7.2	10.1	1.5	1872	2230[3]	2587
1.35–1.40	C-1241	3.8	14.1	1.7	1924	2224	2431
1.40–1.50	C-1242	4.6	18.1	1.7	2053	2445	2575
1.50–1.70	C-1243	3.2	30.3	2.1	2021	2192	2448
1.70 S	C-1244	11.9	71.1	10.5	2035	2107	2361[3]
Minus 48 mesh							
Sized sample[2]	C-1167	100.0	14.6	2.2	2008	2130	2381
1.30 F	C-1427	17.9	1.7	0.89	1856	2025	2192
1.30–1.35	C-1428	13.7	3.8	1.1	2049	2153	2503
1.35–1.40	C-1429	13.9	6.4	1.1			
1.40–1.50	C-1430	12.2	8.6	0.90	1936	2125	2401
1.50–1.70	C-1431	29.7	10.4	0.92	1978	2178	2556
1.70 S	C-1432	12.6	62.5	9.3	1900	2043	2219

[1]Dry basis. [2]Sub-head sample. [3]Single determination.

TABLE 14.—ASH ANALYSES OF SCREENING SAMPLES (1¼″ TO 0) FROM MINES E AND I

Ash Constituents	Mine E	Mine I
	Per cent	*Per cent*
SiO_2	40.15	46.94
TiO_2	.77	.93
Al_2O_3	11.81	20.19
Fe_2O_3	26.20	18.82
MgO	.88	1.24
CaO	8.37	4.62
Na_2O	.92	.50
K_2O	1.35	2.12
P_2O_5	.00	.00
Total sulfur as SO_3	9.09	4.69
Totals	99.54	100.05
Ash in coal (dry basis)	13.8	10.4
Sulfur in coal (dry basis)	5.3	1.9

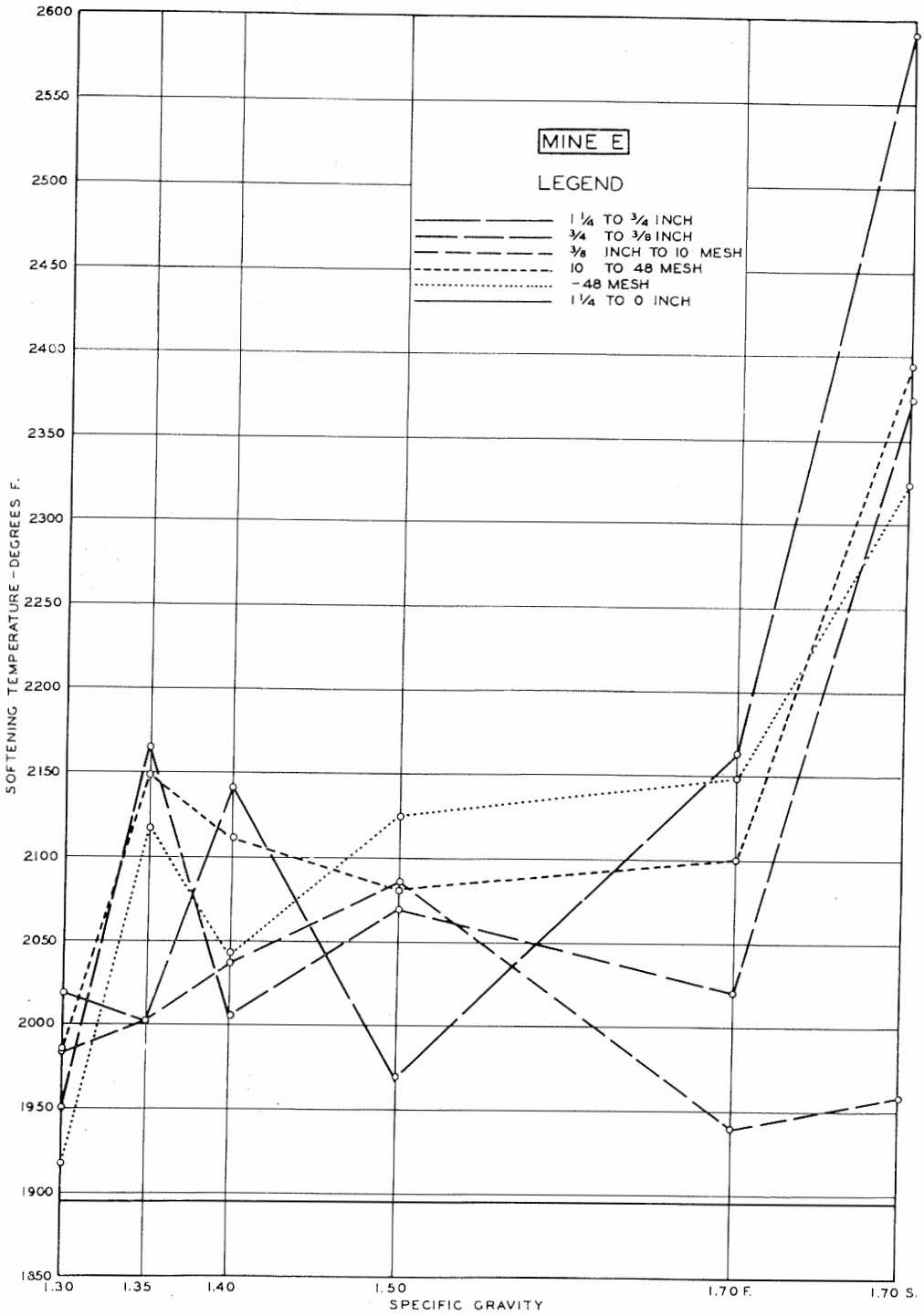

FIG. 6.—Relationship of ash softening temperature to specific gravity fractions of a narrow range, coal E.

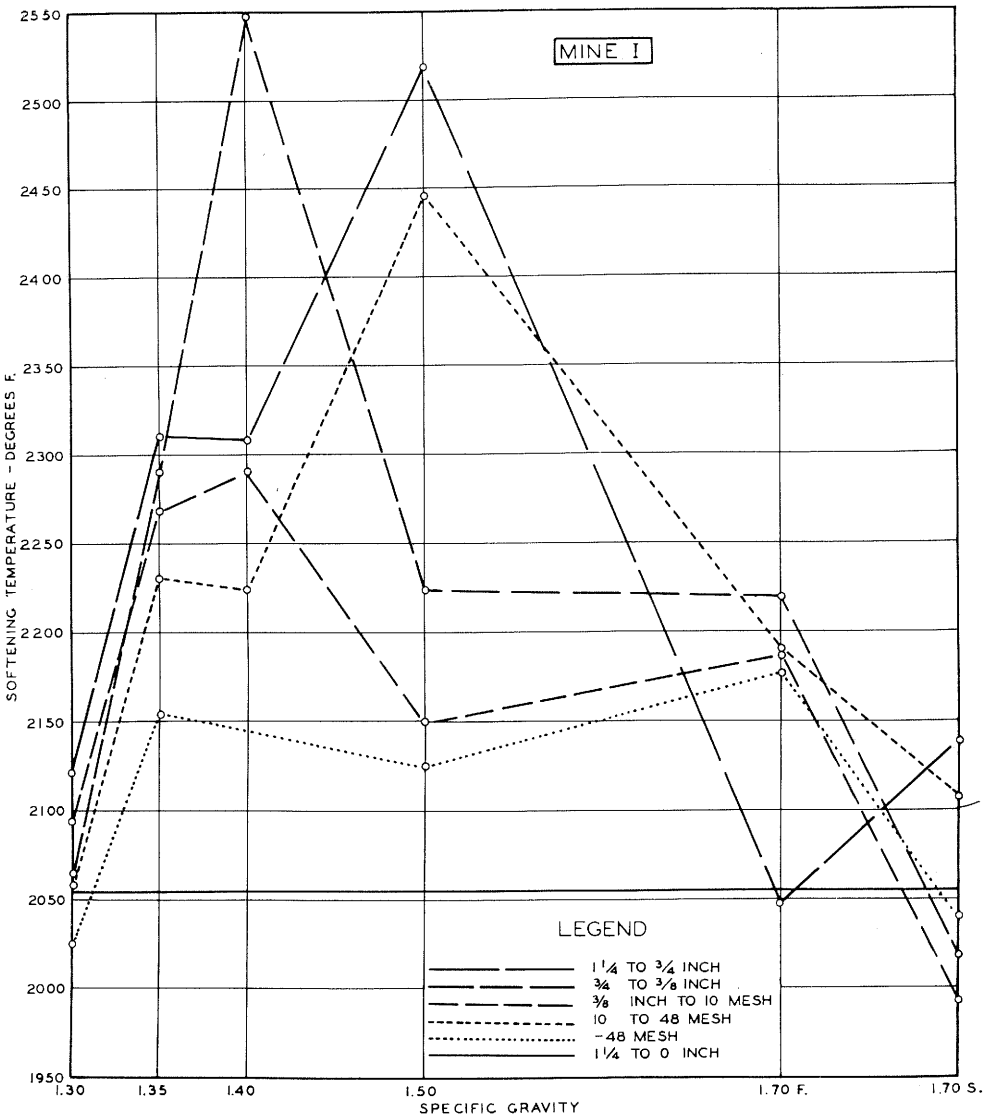

FIG. 7.—Relationship of ash softening temperature to specific gravity fractions of a narrow range, coal I.

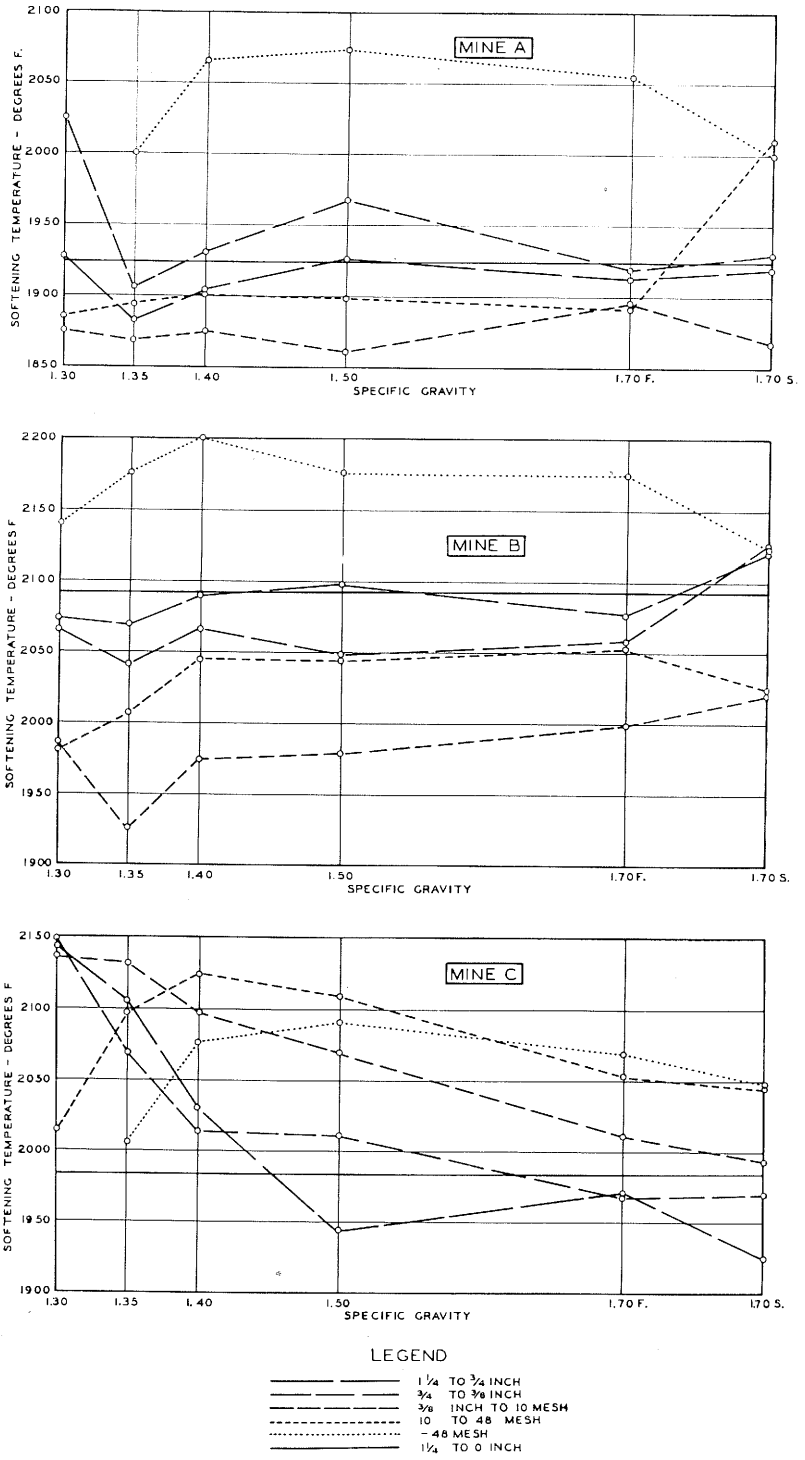

FIG. 8.—Relationship of ash softening temperature to cumulative specific gravity, coals A, B, and C.

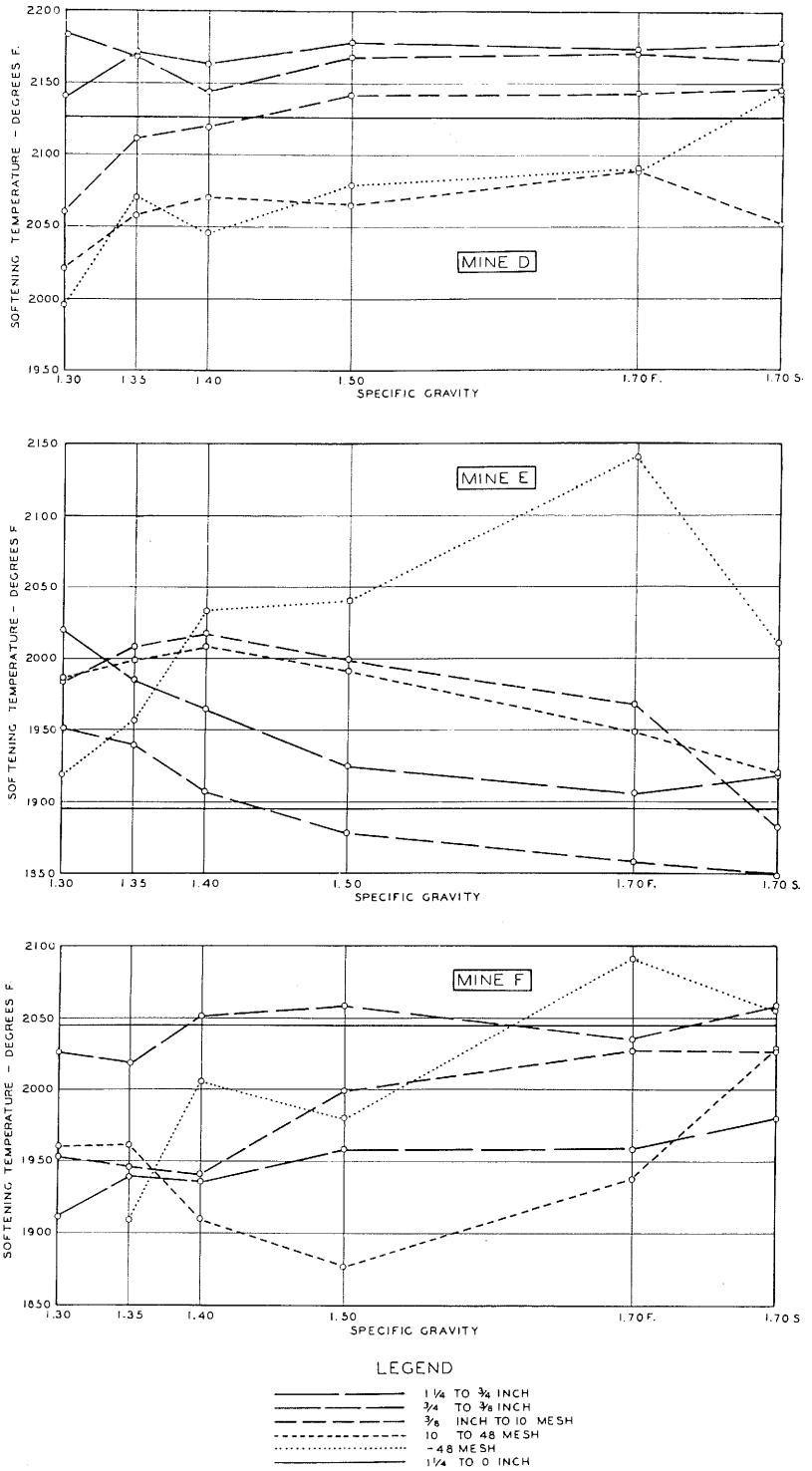

FIG. 9.—Relationship of ash softening temperature to cumulative specific gravity, coals D, E, and F.

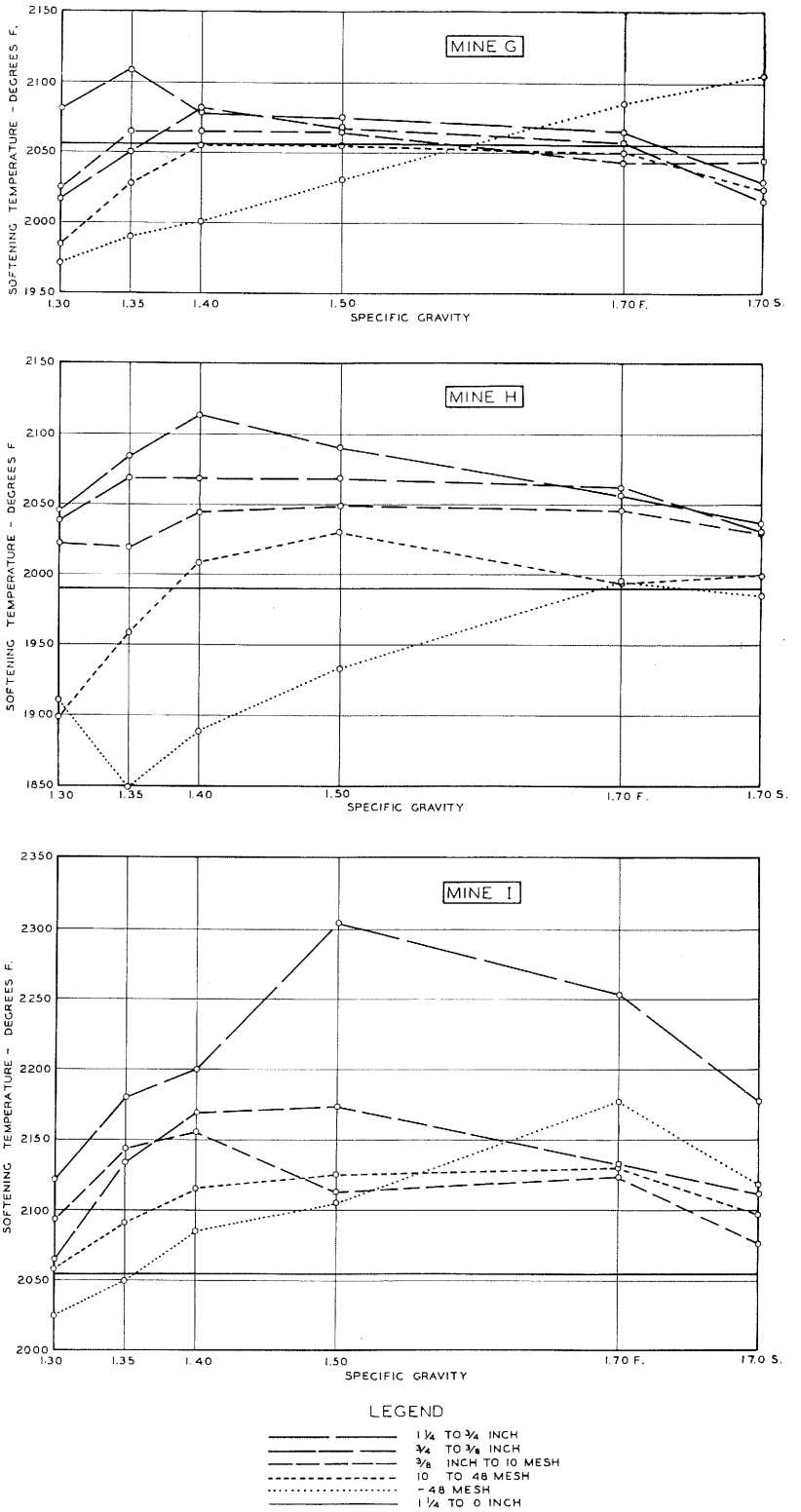

FIG. 10.—Relationship of ash softening temperature to cumulative specific gravity, coals G, H, and I.

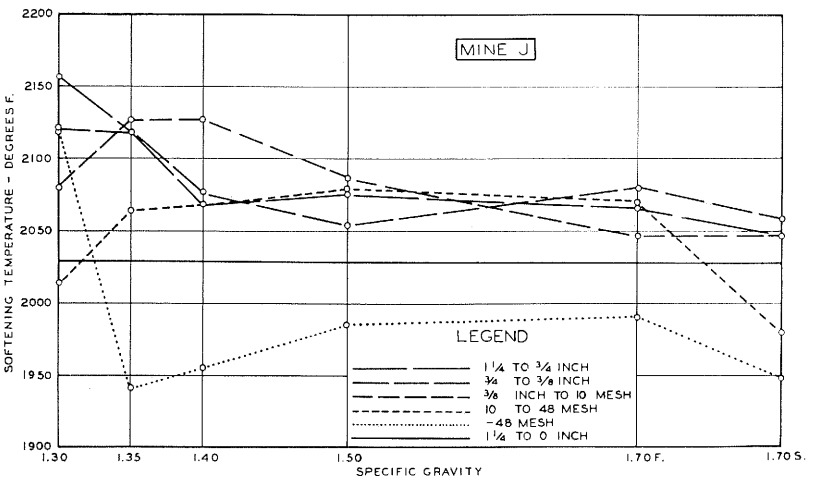

FIG. 11.—Relationship of ash softening temperature to cumulative specific gravity, coal J.