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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

REPORT OF INVESTIGATIONS

WASHABILITY CHARACTERISTICS AND WASHING OF COALS FROM THE MATANUSKA FIELD OF ALASKA

The work upon which this report was based was done under a cooperative agreement between the Bureau of Mines, United States Department of the Interior, and the College of Mines, University of Washington

BY

M. R. GEER AND H. F. YANCEY

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WASHABILITY CHARACTERISTICS AND WASHING OF COALS FROM THE MATANUSKA FIELD OF ALASKA[1]

By M. R. Geer[2] and H. F. Yancey[3]

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ILLUSTRATIONS

2/ Associate mining engineer, Northwest Experiment Station, Bureau of Mines, Seattle, Wash.

3/ Supervising engineer, Northwest Experiment Station, Bureau of Mines, Seattle, Wash.

INTRODUCTION

With the advent of war in 1941, military operations in Alaska were enlarged on such a scale that the demand for coal in the Territory more than doubled. Coal was needed urgently for heating forts and other military establishments, for use on large construction projects, and for handling the greatly increased volume of traffic on the Alaska Railroad. The additional tonnage required, estimated at perhaps 250,000 tons per year, probably could have been supplied by the United States, but shipping space between Pacific Coast ports and Alaska was already overburdened with military supplies and construction materials. Moreover, although of only secondary importance in wartime, the cost of coal shipped into the Territory is reported to have been as high as $40 per ton. The alternative to importing coal was, of course, to increase the production of the Alaska mines.

Production of coal in Alaska reached 350,000 tons in 1944, or more than double the prewar output. The responsibility for increasing coal production was assumed largely by the Army. A Coal Commission attached to the Alaska Department arranged financial assistance for some mining operations, aided the operators in procuring equipment for mechanization, and provided most of the labor necessary to operate the mines. The Bureau of Mines contributed to the program in several ways. First, exploration by the Bureau in the Moose Creek district revealed a substantial tonnage of coal of better grade than any currently mined in the Territory,[4] and drilling in the Broad Pass district, where a mine to supply coal for the Army had been started, revealed that the reserves were far less than had been supposed; this operation was abandoned. Second, coal-preparation practices were studied, and recommendations for improvements made, at two of the operating mines at which the quality of the coal makes preparation a factor of vital importance. Some of the information obtained in these studies forms the basis for the present report.

The two coals dealt with in this report are from the Evan Jones and Eska mines, both of which operate in the Eska Creek district of the Matanuska field. Located about 70 miles north of Anchorage, both mines are served by a branch line of the Alaska Railroad, and both have produced about 6,000 tons of washed coal per month under wartime demand. The coal is high-volatile B bituminous in rank. Production of the Eska mine, which is owned and operated by the Government, is used entirely as railroad fuel by the Alaska Railroad, also a Government operation. Coal from the Evan Jones mine is used for steam raising at Fort Richardson, and for domestic and commercial heating in Anchorage.

Object and Scope

The washability data presented in this report were obtained in the course of a general coal-preparation study rather than a detailed washability examination. Consequently, the information is somewhat less detailed and complete than most washability studies published by the Bureau of Mines. However, the

4/ Apell, G. A., Moose Creek District of Matanuska Coal Fields, Alaska: Bureau of Mines Rept. of Investigations 3784, 1944, 36 pp.

data are sufficiently complete to show accurately the general character of these coals and the quality of products obtainable from them by washing.

In addition to the washability data, the report contains detailed information on the washing of Eska coal in a modern Baum-type jig and some information on washing the Evan Jones coal in a manually controlled Forrester-type jig.

The report is published primarily, of course, for use by those interested in coals from the Eska Creek district. The correlation between washability data and washery performance will be found useful, however, by those concerned with washing unusually dirty coals from other localities.

Acknowledgments

This work was undertaken in cooperation with the College of Mines of the University of Washington. The cooperation of Harry L. Fiedler, formerly superintendent of the Evan Jones Coal Co., Herbert Tomlinson, superintendent of the Eska mine, and Maurice L. Sharp, formerly chief coal sampler and analyst of the Alaska Railroad, is gratefully acknowledged.

COAL FROM THE ESKA MINE

At the time of this investigation, production of the Eska mine was from the Eska, Shaw, and Martin beds. The accompanying tabulations show sections of these beds, measured in the areas now being mined, and proximate analyses of face samples. The coal is high-volatile B bituminous in rank, contains relatively large amounts of shale, bone, and bony coal, and very little clay, and is low in sulfur content. The coal is more friable than the associated shale and bone, and consequently tends to be concentrated in the finer sizes of the run-of-mine product. The following screen analysis, representing raw coal crushed to approximately 3 inches top size, shows that material coarser than 1 inch contains about twice as much ash as the material finer than 20-mesh.

Screen analysis of crushed raw coal

Size, inches, and mesh, square hole	Weight, percent	Ash, percent 1/
Over 1	28.7	54.4
1 to 3/8	29.1	43.4
3/8 to 20	35.4	28.7
Under 20	6.8	28.3
Total	100.0	40.3

1/ Moisture-free basis.

Sections of beds worked in Eska mine

Shaw bed

	Feet	Inches
Hangingwall, bone		
Coal	2	10
Bone	1	7
Coal		4-1/2
Shale		1
Coal		6
Shale		1/2
Coal		3-1/2
Bone		1/2
Coal		3
Bone and coal	1	8
Footwall, sandstone		
Total thickness	7	8

Eska bed

	Feet	Inches
Hangingwall, shale		
Shale		1/2
Coal		4
Shale		1/2
Coal	2	9
Bone and shale	1	4
Footwall, bone		
Total thickness	4	6

Martin bed

	Feet	Inches
Hangingwall, shale		
Coal	3	3
Shale	1	1
Coal	1	4
Footwall, bone		
Total thickness	5	8

Analyses of face samples from Eska mine, as-received basis[1/]

	Upper Shaw bed	Martin bed	Eska bed
Moisture, percent	4.3	5.6	4.94
Volatile matter, percent	41.4	39.3	38.03
Fixed carbon, percent	41.8	40.7	39.55
Ash, percent	12.5	14.4	17.48
Sulfur, percent	.4	.3	.37
B.t.u. per pound	11,945	11,660	11,146

1/ Tuck, Ralph, The Eska Creek Coal Deposits, Matanuska Valley, Alaska: Geol. Survey Bull. 880-D, 1937, 29 pp.

As this investigation dealt principally with jig operation, the washability study was made on the jig feed rather than on run-of-mine coal. The jig feed constituted the run-of-mine coal crushed to about 3-inch round-hole top size in a single-roll crusher. The coal was sampled over a full shift of washery operation on each of three successive days, about 500 pounds being collected each day. Upon receipt of the three samples at the Bureau of Mines Experiment Station in Seattle, Wash., each was examined separately. As there was no significant difference between the three lots of raw coal, the data for only one of the samples are given in this report.

The coal was screened at 1-inch and 3/8-inch (both square-hole openings) to correspond with screening practice at the washery; an additional separation at 20-mesh was necessary to facilitate float-and-sink testing. The four individual size fractions thus obtained were then separated at 1.30, 1.40,

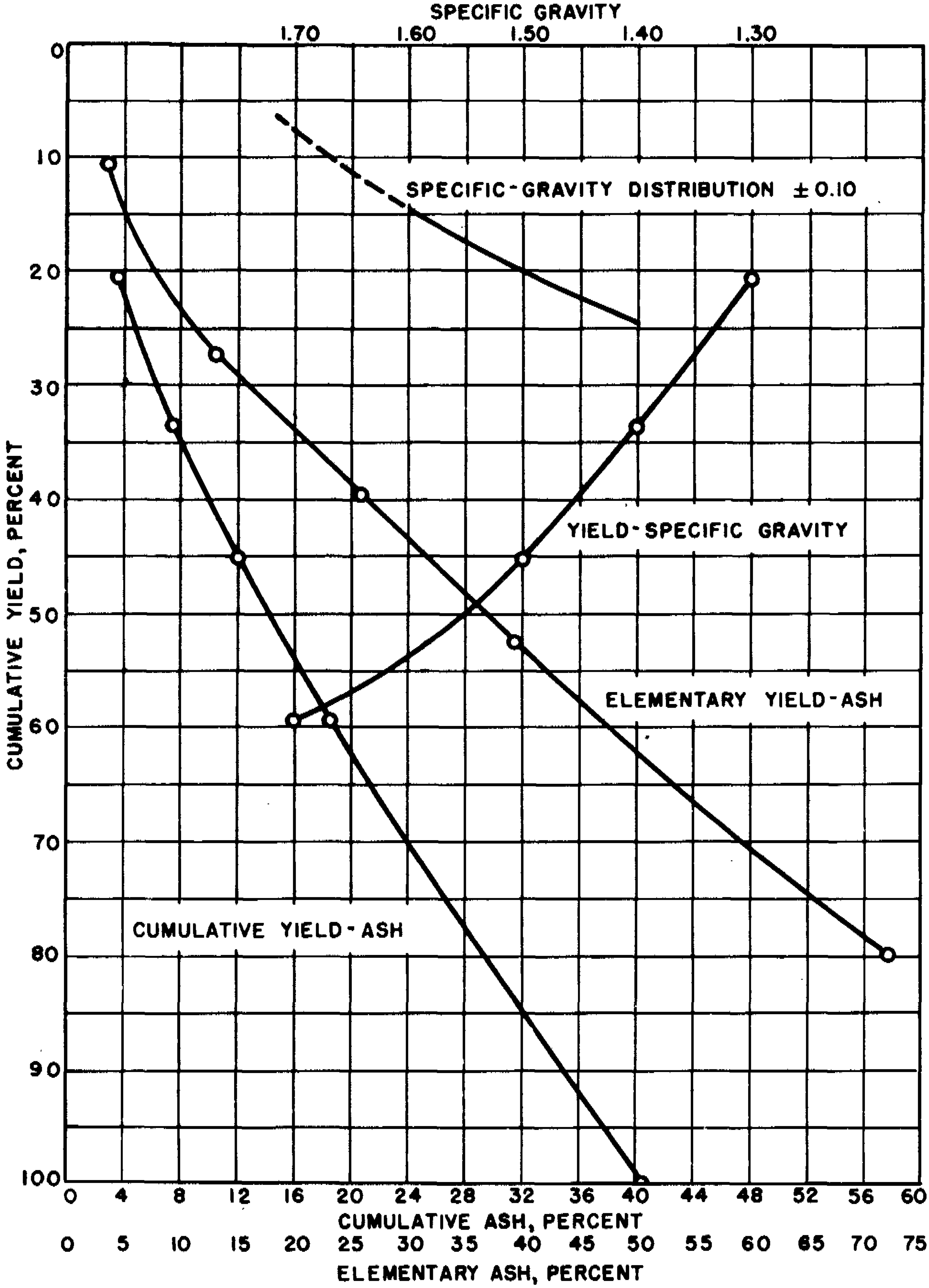

FIGURE 1.- Washability curves for Eska coal -- all sizes combined.

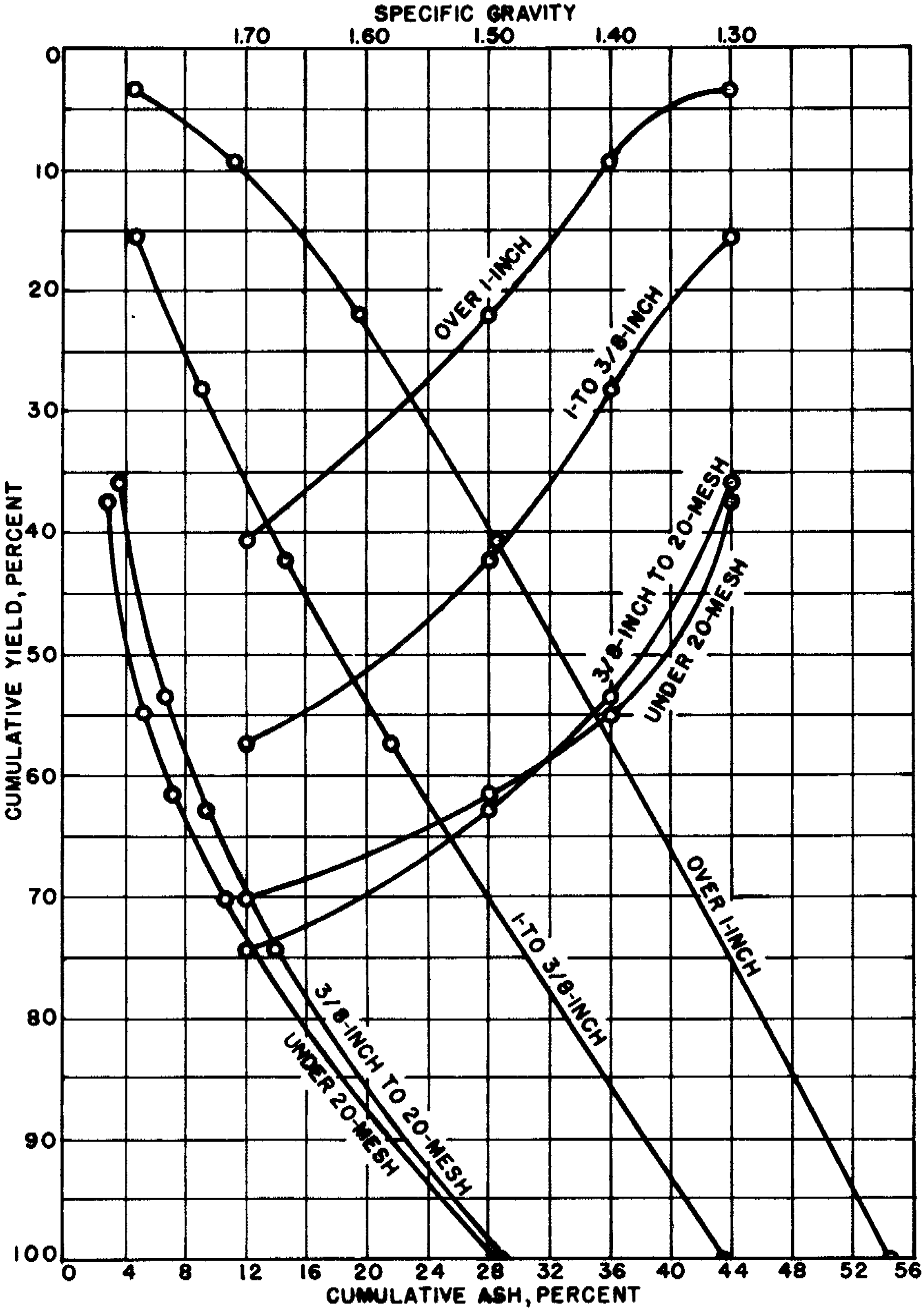

FIGURE 2.- Yield-ash and yield-specific-gravity curves for various sizes of Eska coal.

1.50, and 1.70 specific gravities. Aqueous solutions of zinc chloride were used for the sizes coarser than 20-mesh, while mixtures of benzol, carbon tetrachloride, and bromoform were employed for the finer material.

Specific-Gravity Analyses

Table 1 gives the specific-gravity analyses of the individual sizes of raw coal, and figures 1 and 2 show the usual graphical presentation of the washability data. A detailed explanation of the interpretation of such washability curves is given in a Bureau of Mines report devoted to the subject.5/

TABLE 1. - Specific-gravity analyses of various sizes of raw coal - Eska mine

Size	Specific gravity	Weight, percent	Ash, percent1/	Cumulative Weight, percent	Cumulative Ash, percent1/
Over 1-inch	Under 1.30	3.2	4.6	3.2	4.6
Weight, 28.7 percent	1.30 to 1.40	6.1	14.6	9.3	11.2
	1.40 to 1.50	12.8	25.9	22.1	19.7
	1.50 to 1.70	18.7	38.8	40.8	28.5
	Over 1.70	59.2	72.2	100.0	54.4
1- to 3/8-inch	Under 1.30	15.3	4.7	15.3	4.7
Weight, 29.1 percent	1.30 to 1.40	13.0	14.1	28.3	9.0
	1.40 to 1.50	13.8	26.5	42.1	14.7
	1.50 to 1.70	15.3	40.1	57.4	21.5
	Over 1.70	42.6	72.9	100.0	43.4
3/8-inch to 20-mesh	Under 1.30	35.9	3.6	35.9	3.6
Weight, 35.4 percent	1.30 to 1.40	17.7	12.7	53.6	6.6
	1.40 to 1.50	9.3	25.3	62.9	9.4
	1.50 to 1.70	11.5	39.4	74.4	14.0
	Over 1.70	25.6	71.2	100.0	28.7
Under 20-mesh	Under 1.30	37.4	2.9	37.4	2.9
Weight, 6.8 percent	1.30 to 1.40	17.6	9.9	55.0	5.1
	1.40 to 1.50	6.7	24.1	61.7	7.2
	1.50 to 1.70	8.4	36.2	70.1	10.7
	Over 1.70	29.9	69.7	100.0	28.3
Composite, all sizes	Under 1.30	20.7	3.8	20.7	3.8
	1.30 to 1.40	13.0	13.1	33.7	7.4
	1.40 to 1.50	11.4	25.9	45.1	12.1
	1.50 to 1.70	14.5	39.3	59.6	18.7
	Over 1.70	40.4	72.1	100.0	40.3

1/ Moisture-free basis.

5/ Coe, G. D., An Explanation of Washability Curves for the Interpretation of Float-and-Sink Data on Coal: Bureau of Mines Inf. Circ. 7045, 1939, 10 pp.

The most outstanding feature of the washability data is the unusually high proportion of heavy impurity associated with this coal. Considering all sizes together, 40 percent of the raw coal is impurity heavier than 1.70 specific gravity. The proportion of material of intermediate density also is unusually high; about 25 percent of the raw coal occurs between 1.40 and 1.70 specific gravity.

The individual size fractions of the coal differ widely in character. In passing through the primary crusher, as well as by the breakage incident to mining, the coal tends to be reduced to finer size than the more resistant shale and bone. The result is a concentration of the clean coal in the finer sizes and of shale and bone in the coarser sizes. Inspection of the yield-ash curves in figure 2 shows that the amount of coal available at, for example, 12 percent ash, varies from only 10 percent in the 1-inch material to over 70 percent in the material finer than 3/8 inch.

Actually, the material coarser than 1 inch contains little more coal than the refuse discarded at some washeries. Coal containing so much impurity could not be mined in most localities in the United States, owing to the cost of mining and treating so much unsalable material. Only in an area like Alaska, where competing fuels are costly, could a coal of this character be utilized.

Results Obtained in Washing

With coals of ordinary specific-gravity composition, the correlation between washability characteristics and washery performance is sufficiently well-established to permit fairly accurate prediction of the results obtainable in washing. The literature contains virtually no information, however, on the results obtainable in washing a material containing such a high proportion of impurity as that present in the Eska coal. Consequently, a detailed evaluation of the performance of the Eska washery is included in this report. This correlation between washability characteristics and washing results will be found useful by those concerned with washing unusually dirty coals mined in other localities.

The Eska coal is washed in a single-compartment, 3-cell, Baum-type jig having a washing compartment 4 feet wide by 9 feet 6 inches long. The plant is the type commonly sold as a unit washery; jig, settling tank, recirculating pump, and accessory piping form an integrated unit. Material treated in the jig ranges up to 60 tons per hour, a feed rate unquestionably in excess of the optimum tonnage for coal of this character. Figure 3 shows the flow sheet of the Eska washery.

Three test runs were made with the jig, the only variable being the specific gravity at which the separation between coal and refuse was made, that is, the proportion of refuse removed. Each test lasted for a full shift of washery operation, and samples of the feed, washed coal, and refuse were collected during the entire period. Examination of these samples in the laboratory followed the procedure already described for the raw coal.

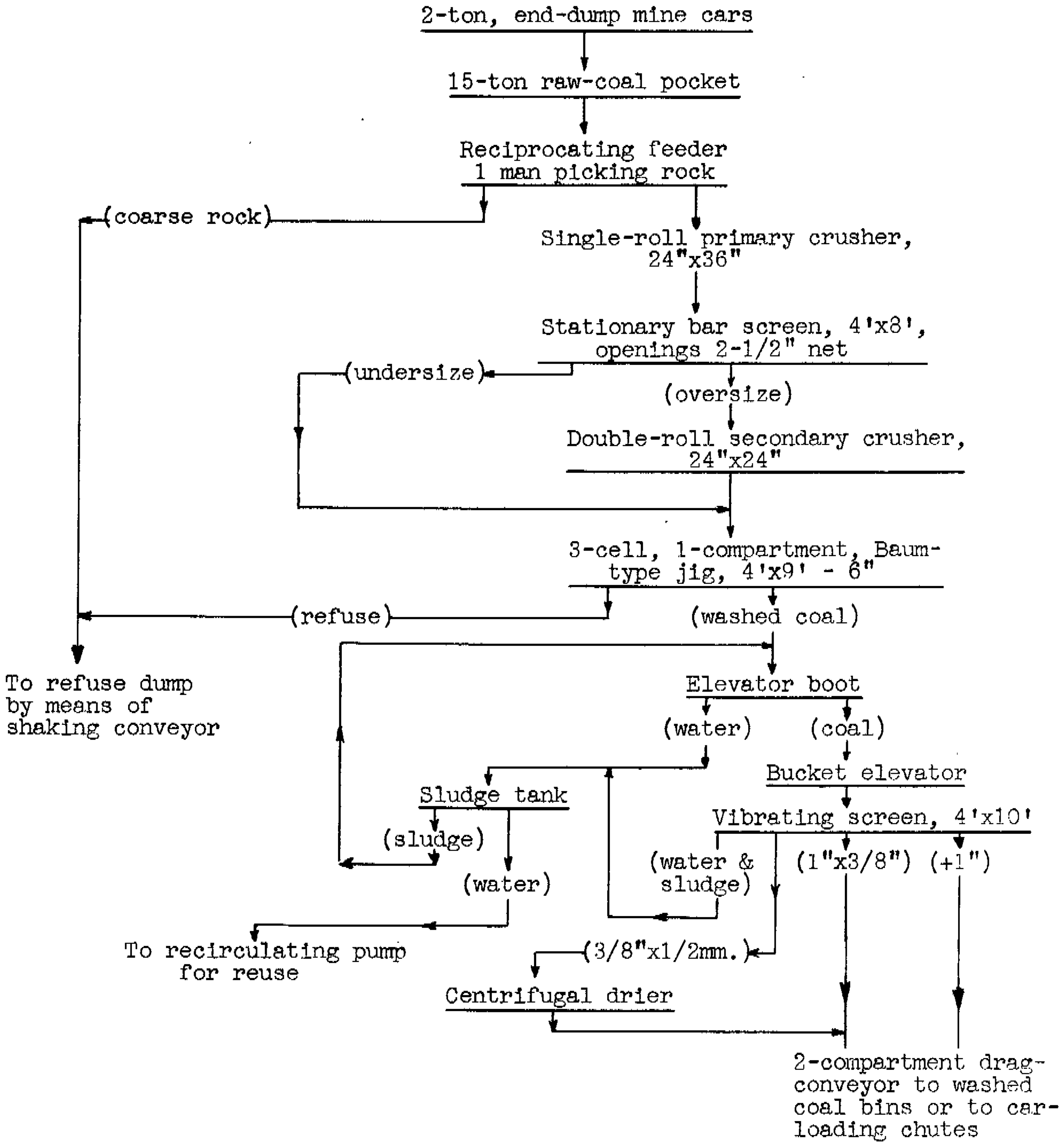

FIGURE 3.- Flow sheet of Eska washery.

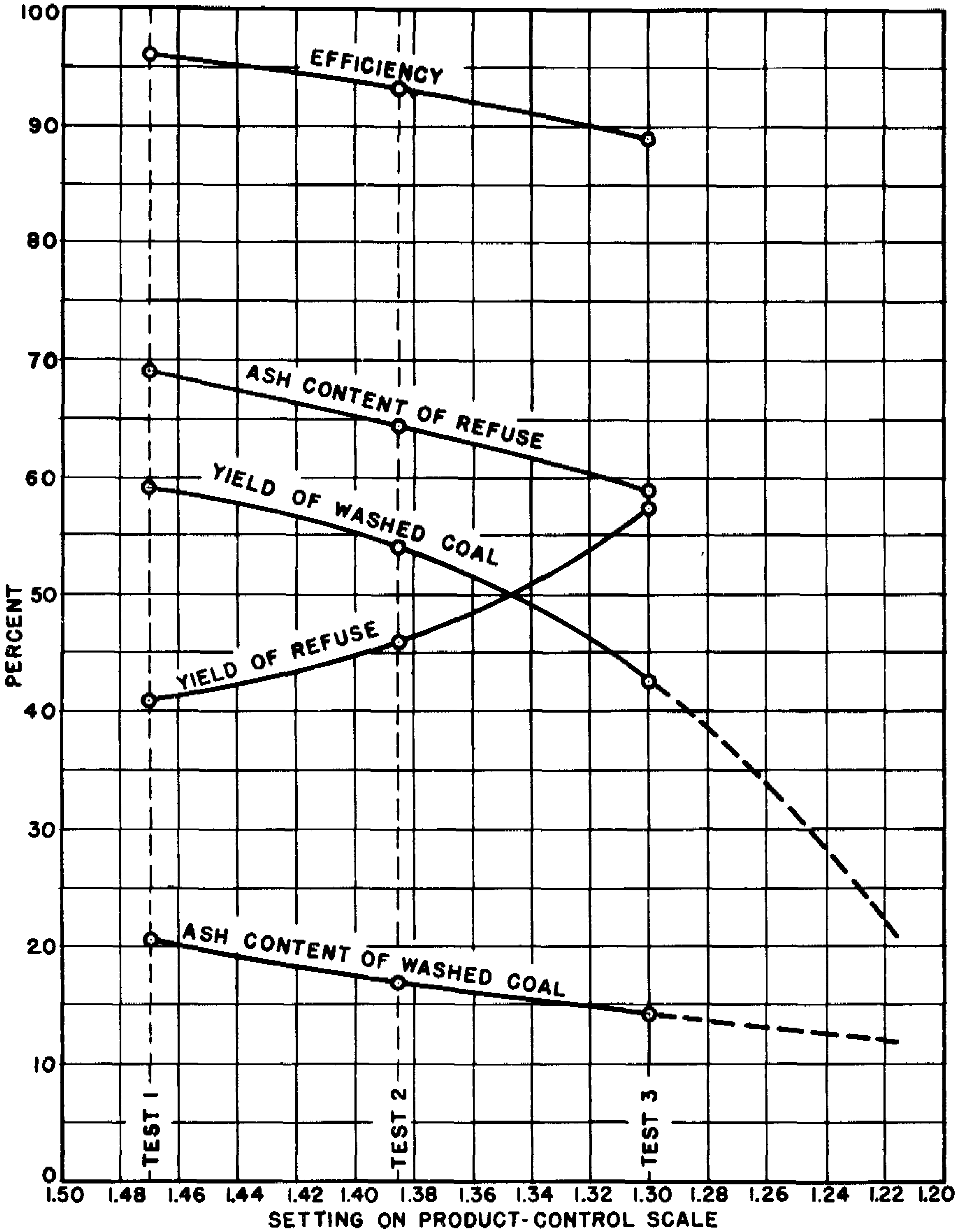

FIGURE 4.- Yield, ash content, and efficiency in relation to settings on product-control scale of jig.

Tables 2 and 3 give specific-gravity analyses of the washed coal and refuse produced in test 1; the corresponding data for the feed already have been presented in table 1. Space does not permit presenting complete data for the other two tests, but the essential information is summarized in table 4 and figure 4. The yields shown in the table were calculated from the ash contents of the feed, washed coal, and refuse by means of an ash balance, as it was not possible to weigh the washery products. The efficiency of washing, as the term is used in this report, may be defined as the ratio, expressed in percentage, of the yield of washed coal to the yield of float coal in the feed at the ash content of the washed coal; the yield of float coal in the feed is determined from the yield-ash curves of figures 1 and 2.

TABLE 2. - Specific-gravity analyses of washed coal - Eska mine

Size	Specific gravity	Weight, percent	Ash, percent 1/	Cumulative 2/ Weight, percent	Cumulative 2/ Ash, percent 1/
Over 1-inch	Under 1.30	9.5	4.6	9.5	4.6
Weight, 16.6 percent	1.30 to 1.40	17.9	14.6	27.4	11.1
	1.40 to 1.50	36.5	26.0	63.9	19.6
	1.50 to 1.70	36.1	36.9	100.0	25.9
	Over 1.70	.0	-	100.0	25.9
1- to 3/8-inch	Under 1.30	25.9	4.7	25.9	4.7
Weight, 29.1 percent	1.30 to 1.40	22.0	14.1	47.9	9.0
Ash, 23.1 percent 1/	1.40 to 1.50	23.0	26.6	70.9	14.7
	1.50 to 1.70	22.4	39.5	93.3	20.7
	Over 1.70	6.7	56.7	100.0	23.1
3/8-inch to 20-mesh	Under 1.30	46.3	3.6	46.3	3.6
Weight, 45.1 percent	1.30 to 1.40	22.6	12.7	68.9	6.6
Ash, 16.4 percent 1/	1.40 to 1.50	11.5	25.3	80.4	9.3
	1.50 to 1.70	12.7	39.1	93.1	13.3
	Over 1.70	6.9	58.1	100.0	16.4
Under 20-mesh	Under 1.30	44.4	2.9	44.4	2.9
Weight, 9.2 percent	1.30 to 1.40	19.2	10.0	63.6	5.0
Ash, 21.4 percent 1/	1.40 to 1.50	7.8	24.0	71.4	7.1
	1.50 to 1.70	8.5	36.2	79.9	10.2
	Over 1.70	20.1	65.8	100.0	21.4
Composite, all sizes	Under 1.30	34.1	3.8	34.1	3.8
	1.30 to 1.40	21.3	13.2	55.4	7.4
	1.40 to 1.50	18.7	25.9	74.1	12.1
	1.50 to 1.70	19.0	38.4	93.1	17.5
	Over 1.70	6.9	59.8	100.0	20.4

1/ Moisture-free basis.
2/ Cumulative ash percentage adjusted to equal head ash percentage; average difference between unadjusted cumulative ash and head ash, 0.5 percent, maximum difference, 0.8 percent.

TABLE 3. - Specific-gravity analyses of refuse - Eska mine

Size	Specific gravity	Weight, percent	Ash, percent[1]	Cumulative[2] Weight, percent	Cumulative[2] Ash, percent[1]
Over 1-inch	Under 1.30	0.0	-	0.0	-
Weight, 46.1 percent	1.30 to 1.40	.0	-	.0	-
	1.40 to 1.50	.5	19.9	.5	19.9
	1.50 to 1.70	9.6	42.6	10.1	41.5
	Over 1.70	89.9	72.2	100.0	69.1
	Under 1.30	.0	-	.0	-
1- to 3/8-inch	1.30 to 1.40	.0	-	.0	-
Weight, 29.1 percent	1.40 to 1.50	.4	20.6	.4	20.6
Ash, 72.8 percent[1]	1.50 to 1.70	5.1	44.0	5.5	42.3
	Over 1.70	94.5	74.6	100.0	72.8
3/8-inch to 20-mesh	Under 1.30	4.2	3.5	4.2	3.5
Weight, 21.4 percent	1.30 to 1.40	3.0	13.2	7.2	7.5
Ash, 65.8 percent[1]	1.40 to 1.50	2.5	25.5	9.7	12.2
	1.50 to 1.70	7.9	40.9	17.6	25.1
	Over 1.70	82.4	74.5	100.0	65.8
Under 20-mesh	Under 1.30	9.5	3.2	9.5	3.2
Weight, 3.4 percent	1.30 to 1.40	11.3	9.4	20.8	6.6
Ash, 55.7 percent[1]	1.40 to 1.50	2.9	25.5	23.7	8.9
	1.50 to 1.70	8.0	36.2	31.7	15.8
	Over 1.70	68.3	74.2	100.0	55.7
Composite, all sizes	Under 1.30	1.2	3.4	1.2	3.4
	1.30 to 1.40	1.0	11.8	2.2	7.2
	1.40 to 1.50	1.0	23.6	3.2	12.3
	1.50 to 1.70	7.9	42.3	11.1	33.7
	Over 1.70	88.9	73.4	100.0	69.0

1/ Moisture-free basis.
2/ Cumulative ash percentage adjusted to equal head ash percentage; average difference between unadjusted cumulative ash and head ash, 0.1 percent; maximum difference, 0.1 percent.

In test 1 the ash content was reduced from 40.3 percent in the feed to 20.4 percent in the washed coal by rejecting a refuse product amounting to 40.9 percent of the feed and containing 69.0 percent ash. The efficiency of the separation was 96.1 percent; that is, the jig recovered 96.1 percent of the coal of 20.4 percent ash present in the feed. The separation was made at a point corresponding to about 1.82 specific gravity. Considerable material heavier than 1.70 specific gravity remained in the washed coal, particularly in the finer sizes. Very little low-density coal was lost in the refuse.

Tests 2 and 3 were made at successively lower specific gravities, 1.66 and 1.55 respectively, by rejecting larger percentages of refuse. The washed coals produced were substantially lower in ash content; and, of course, more coal was lost in the refuse.

TABLE 4. - Ash content, yield, and efficiency, by particle size - Eska mine

Size, inches and mesh, square hole	Feed, weight, percent	Ash, percent[1]			Yield, percent		Efficiency, percent
		Feed	Washed coal	Refuse	Float coal	Washed coal	
Test No. 1							
Over 1	28.7	54.4	25.9	69.1	35.2	34.2	97.2
1 to 3/8	29.1	43.4	23.1	72.8	60.4	59.1	97.8
3/8 to 20	35.4	28.7	16.4	65.8	79.3	75.3	95.0
Under 20	6.8	28.3	21.4	55.7	89.4	80.0	89.5
Weighted average	100.0	40.3	20.4	69.0	61.8	59.1	96.1
Test No. 2							
Over 1	26.9	53.7	20.4	64.9	27.6	25.1	90.9
1 to 3/8	29.5	41.2	18.4	66.7	55.2	52.8	95.7
3/8 to 20	35.6	28.0	14.2	62.8	76.2	71.6	94.0
Under 20	8.0	27.1	19.9	53.5	89.0	78.4	88.1
Weighted average	100.0	38.8	16.9	64.6	58.0	54.1	93.2
Test No. 3							
Over 1	28.6	51.5	16.9	59.3	21.6	18.4	85.2
1 to 3/8	29.0	43.3	15.6	61.1	42.6	39.3	92.3
3/8 to 20	35.0	30.6	12.0	58.0	65.8	59.7	90.7
Under 20	7.4	26.0	16.6	48.4	84.5	69.8	82.6
Weighted average	100.0	39.9	14.1	59.1	47.8	42.7	89.0

1/ Moisture-free basis.

The efficiencies obtained in this series of tests, namely, from 96 to 89 percent, are lower than those that can be attained in washing ordinary coals. Although Coe[6] states that an efficiency of 95 percent is average performance on coals that are not too difficult to wash, efficiencies of 98 or 99 percent are not uncommon under favorable circumstances.

The efficiency obtainable in washing is influenced largely by the amount of intermediate-density or "bony" material present in the raw coal. The index frequently used to indicate how difficult a coal is to wash with high efficiency is the percentage of material occurring between ± 0.10 unit of specific gravity of the point at which the separation between clean coal and refuse is made. The ± 0.10 index is shown in figure 1 for the feed of test 1, and in the following tabulation it is compared with efficiency values for the three tests.

6/ Work cited in footnote 5.

Relation of efficiency and ± 0.10 values

	Test		
	1	2	3
Ash in washed coal, percent	20.4	16.9	14.1
Yield of washed coal, percent	59.1	54.1	42.7
Specific gravity of separation	1.82	1.66	1.55
±0.10 value, unadjusted	3.0	11.8	17.3
±0.10 value, adjusted1/	4.7	17.4	25.9
Efficiency, percent	96.1	93.2	89.0

1/ Adjusted to eliminate influence of material heavier than 2.00 specific gravity by dividing by yield of float coal at 2.00 specific gravity.

On the basis of ± 0.10 value, test 1 should have given an efficiency of at least 98 percent, because a ± 0.10 value of only 4.7 percent generally denotes a separation that can be made at high efficiency. Tests 2 and 3 were made at lower specific gravities and consequently would not be expected to give as high efficiencies; however, the efficiency of 89 percent obtained in test 3 seems unduely low even for a ± 0.10 value of 25.9 percent.

One factor having a bearing on these low efficiencies, although the magnitude of its influence is difficult to assess, is the fact that the jig was treating up to 1.58 tons per hour per square foot of bed area. This throughput is about 50 percent greater than that generally used in Baum-type jigs treating coals that are substantially easier to wash.

A factor that probably had a much greater influence on efficiency is the unusually large amount of refuse removed by the jig. In test 1, 40.9 percent of the feed was rejected as refuse, and the corresponding amounts for tests 2 and 3 were 45.9 and 57.3 percent, respectively. With such a high proportion of the feed withdrawn as refuse, the chances for mechanical entrapment of coal in the refuse product are increased materially.

The refuse produced in test 1 contained about 9 percent of coal equal in ash content to the washed coal produced during that test, namely, 20.4 percent; the corresponding percentage of coal contained in the refuse of test 3 was only about 7 percent. However, with the larger amount of refuse produced in test 3, the total loss of coal was actually greater, as indicated by the lower efficiency. Thus, the proportion of refuse rejected in a cleaning operation has an important bearing on the efficiency of the operation, and, other factors being equal, coals containing a high proportion of impurity cannot be washed with as high efficiency as that obtainable in treating cleaner coals.

COAL FROM THE EVAN JONES MINE

Production of the Evan Jones mine at the time of this investigation was from the No. 5 and No. 8 beds. Sections of these beds, measured in the area being developed at that time, are shown in table 5. Analyses of face samples from the two beds, reported in Bulletin 880-D of the Geological Survey, are shown in the following tabulation.

Analyses of face samples, as-received basis

	No. 5 bed	No. 8 bed
Moisture, percent	3.5	5.2
Volatile matter, percent	36.8	34.7
Fixed carbon, percent	38.4	41.4
Ash, percent	21.3	18.7
Sulfur, percent	.2	.4
B.t.u. per pound	10,450	10,860

Although analyses of face samples of the two beds do not differ greatly, the sections indicate that No. 5 bed contains a far greater proportion of bony coal - the intermediate density material that renders a coal difficult to wash. Moreover, the experience in washing the two coals has demonstrated that the No. 5 coal is the more troublesome. This circumstance, coupled with the fact that the greater part of the production, both present and future, is from the No. 5 bed, indicated that the washability examination should be limited to this coal.

The run-of-mine coal from the No. 5 bed was sampled over a full shift of mine operation. To enhance the accuracy of sampling, the coal was sampled in two sizes, over and under 3-inch round-hole, thus obviating the problem of securing the proper proportion of coarse and fine material. The sample of 3-inch lump weighed 1,600 pounds, and that of the 3-inch slack weighed 1,900 pounds. A larger quantity of slack coal was needed for laboratory tests.

A screen analysis of the coal, with ash contents of the individual size fractions, is shown in the following tabulation:

Screen analysis and ash contents of raw coal

Screen size, inches, round-hole and mesh	Weight, percent of minus 3-inch coal	Ash,1/ percent, moisture-free basis
Over 3	-	42.0
3 to 1-1/2	17.5	39.3
1-1/2 to 3/4	19.3	33.3
3/4 to 3/8	18.2	27.6
3/8 to 3/16	15.4	23.4
3/16 to 10	12.9	20.9
10 to 20	6.7	20.4
Under 20	10.0	21.7

1/ Moisture-free basis.

This coal, like that from the Eska mine, is more friable than the associated bone and shale and therefore tends to concentrate in the finer sizes. Conversely, the coarser material contains more impurity. The material coarser than 3 inches, for example, contains 42 percent ash as compared with about 21 percent ash in material finer than 3/16 inch.

TABLE 5. - Sections of Nos. 5 and 8 beds[1] - Evan Jones mine

No. 5 bed

Section	Feet	Inches
Hangingwall, sandstone		
Shale, carbonaceous.	6	
Coal		6
Shale (immediate roof)		2
Coal, bony	2	1
Bone		2
Coal, bony		7
Shale, brown		1
Coal		10
Shale, sandy		1
Coal, bony	3	4
Shale, sandy		3
Coal	1	6
Coal, bony		6
Shale, brown		3
Coal	1	2
Coal, bony		9
Bone (immediate floor)		
Footwall, sandstone		
Total thickness of bed	18	2/ 3

No. 8 bed

Section	Feet	Inches
Hangingwall, shale		
Alternating bands of bone, shale, and bony coal, bone predominating	5	11
Shale, sandy (immediate roof)		6
Coal, bony		9
Shale, sandy		6
Coal, bright	1	5
Bone		2
Coal, bright	2	5-1/2
Bone		1
Coal, bony		3
Bone		1-1/2
Coal, bony		1-1/2
Bone		1
Coal, bright		5-1/2
Shale, brown, soft..		2
Shale, brown		3
Coal, bony		2
Shale, (immediate floor)		
Shale, bone, and bony	9	6
Footwall, shale		
Total thickness of bed	22	11

Thickness between immediate walls	No. 5 bed	No. 8 bed
Coal	3 ft. 6 in.	4 ft. 4 in.
Bony coal	7 ft. 3 in.	1 ft. 3-1/2 in.
Impurity	0 ft. 10 in.	1 ft. 4-1/2 in.
Total thickness	11 ft. 7 in.	7 ft. 0 in.

1/ No. 5 bed measured in gangway at 19 chute; upper part of No. 8 bed measured in gangway 25 ft. inby 3 chute, remainder measured at rock tunnel.

2/ Does not include thickness of bone in the immediate floor.

Examination of 3-Inch Lump

The 3-inch lump contains such a high proportion of impurity that preparation of this material by hand-picking is unsatisfactory. This size of coal was examined, therefore, to determine what results might be expected from hand picking out the clean shale and crushing and washing the remainder of the material. The yield of coal obtainable by this procedure was determined in the

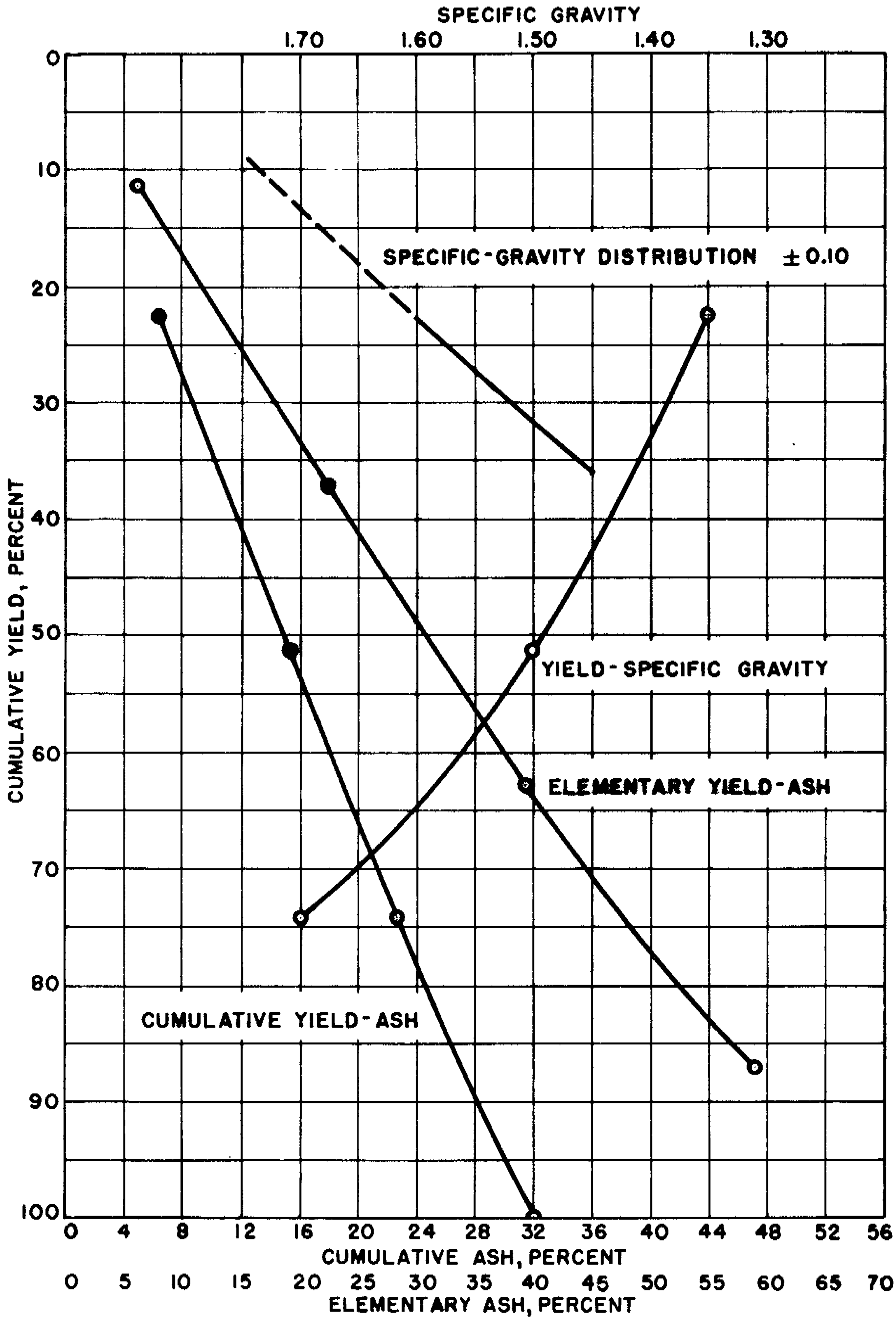

FIGURE 5.- Washability curves for 3-inch hand-picked lump crushed to pass 2 inches -- Evan Jones coal.

laboratory by picking out and discarding the shale, crushing the remaining coal-bone portion to pass a 2-inch round-hole screen, and testing the crushed material by the float-and-sink method. The following tabulation gives the results of the laboratory hand picking, and table 6 shows the results of the float-and-sink test on the coal and bone.

Results of hand-picking test

	Weight, percent	Ash, percent 1/
Coal-bone portion	79.6	34.6
Hand-picked rock	20.4	70.8
Composite, by calculation		42.0

1/ Moisture-free basis.

TABLE 6. - Specific-gravity analysis of 3-inch hand-picked lump crushed to pass 2-inch - Evan Jones mine

Size	Specific gravity	Weight, percent	Ash, percent 1/	Cumulative Weight, percent	Cumulative Ash, percent 1/
2-inch round-hole to	Under 1.35	21.2	6.7	21.2	6.7
20-mesh	1.35 to 1.50	29.8	22.4	51.0	15.9
Weight, 95.0 percent	1.50 to 1.70	23.1	39.6	74.1	23.3
	Over 1.70	25.9	58.7	100.0	32.4
Under 20-mesh	Under 1.35	49.2	3.3	49.2	3.3
Weight, 5.0 percent	1.35 to 1.50	15.5	19.8	64.7	7.3
Ash, 24.9 percent 1/	1.50 to 1.70	11.9	36.1	76.6	11.7
	Over 1.70	23.4	62.5	100.0	23.6
Composite, 2-inch	Under 1.35	22.5	6.3	22.5	6.3
round-hole to 0	1.35 to 1.50	29.1	22.3	51.6	15.3
Ash, 34.6 percent 1/	1.50 to 1.70	22.6	39.5	74.2	22.7
	Over 1.70	25.8	58.9	100.0	32.0

1/ Moisture-free basis.

Hand picking eliminated one-fifth of the original material as clean rock, leaving four-fifths for gravity treatment. As shown in table 6, 74.2 percent of the coal-bone portion is lighter than 1.70 specific gravity and contains 22.7 percent ash. The yield of coal containing 22.7 percent ash, in terms of the original raw lump, would be 59.1 percent (0.796 x 74.2). The shape of the washability curves for this material, shown in figure 5, indicates that it would be difficult material to wash and probably could not be separated efficiently at much lower than 1.70 specific gravity. Although this material would be difficult to wash, in comparison with ordinary coals, it would be less difficult to treat than the 3- to 3/4-inch coal currently handled by the washery.

Examination of 3-Inch Slack

Table 7 and figures 6 and 7 show the specific-gravity analyses of the 3-inch slack and the 3- to 3/4-inch and 3/4-inch to 0 size fractions of this material. As these three sizes of coal were sampled separately and on different days, the weighed average of the data for the 3- to 3/4-inch and 3/4-inch to 0 material does not equal exactly the corresponding figures for the 3-inch slack. This discrepancy is small, however, considering the variability of the raw coal.

TABLE 7. - Specific-gravity analyses of various sizes of raw coal - Evan Jones mine

Size	Specific gravity	Weight, percent	Ash, percent[1]	Cumulative Weight, percent	Cumulative Ash, percent[1]
3-inch round-hole to 3/4-inch square-hole	Under 1.35	17.0	7.8	17.0	7.8
	1.35 to 1.50	29.5	21.9	46.5	16.7
	1.50 to 1.70	23.2	39.4	69.7	24.3
	Over 1.70	30.3	62.5	100.0	35.9
3/4-inch square-hole to 0	Under 1.35	44.5	5.2	44.5	5.2
	1.35 to 1.50	22.9	21.1	67.4	10.6
	1.50 to 1.70	14.6	38.8	82.0	15.6
	Over 1.70	18.0	62.5	100.0	24.1
3-inch round-hole to 0	Under 1.35	35.5	5.6	35.5	5.6
	1.35 to 1.50	25.8	21.0	61.3	12.1
	1.50 to 1.70	17.0	38.5	78.3	17.8
	Over 1.70	21.7	62.6	100.0	27.5

1/ Moisture-free basis.

This coal contains only about half as much heavy impurity as coal from the Eska mine, but the amount is greater than that found in most so-called "dirty" coals mined in the United States. The amount of intermediate-density material also is high, there being 17 percent of the 3-inch slack between 1.50 and 1.70 specific gravity. Containing such a high proportion of both bony material and heavy impurity, this coal is difficult to wash with high efficiency. The 3- to 3/4-inch size is particularly difficult to treat.

Considering the 3-inch slack as a whole, a separation at 1.70 specific gravity to remove only the heavy impurity would give a product of 17.8 percent ash at a float-and sink yield of 78.3 percent. Separations in the range between 1.70 and 1.50 specific gravity entail a loss in yield of 3 percent for each decrease of 1 percent in the ash content of the float product. This rapid decrease in yield with decrease in ash content is inherent in the specific-gravity composition of the coal and is not related to loss in yield due to inefficient washing; losses due to inefficient washing also increase with separations at lower specific gravities.

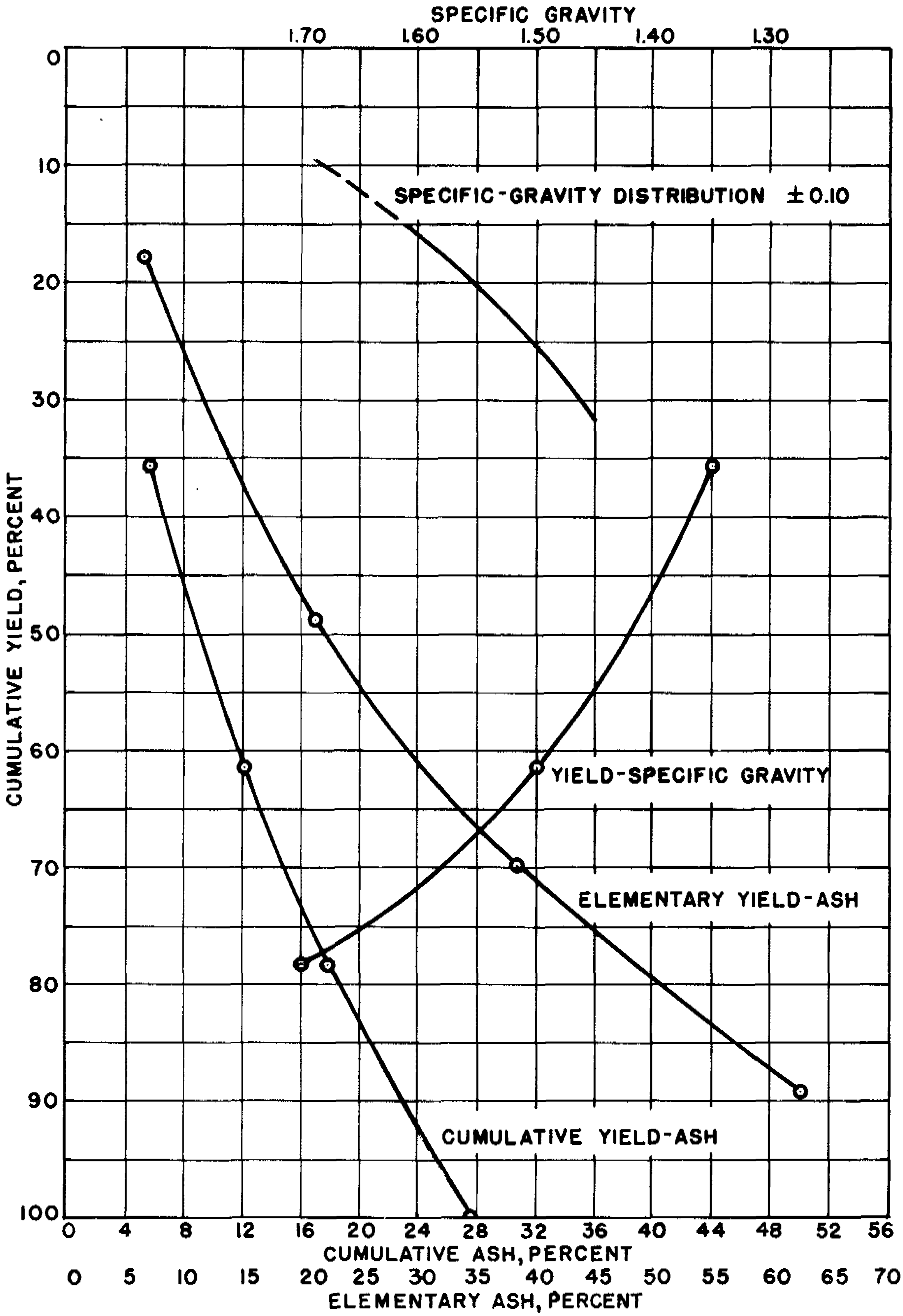

FIGURE 6.- Washability curves for 3-inch slack -- Evan Jones coal.

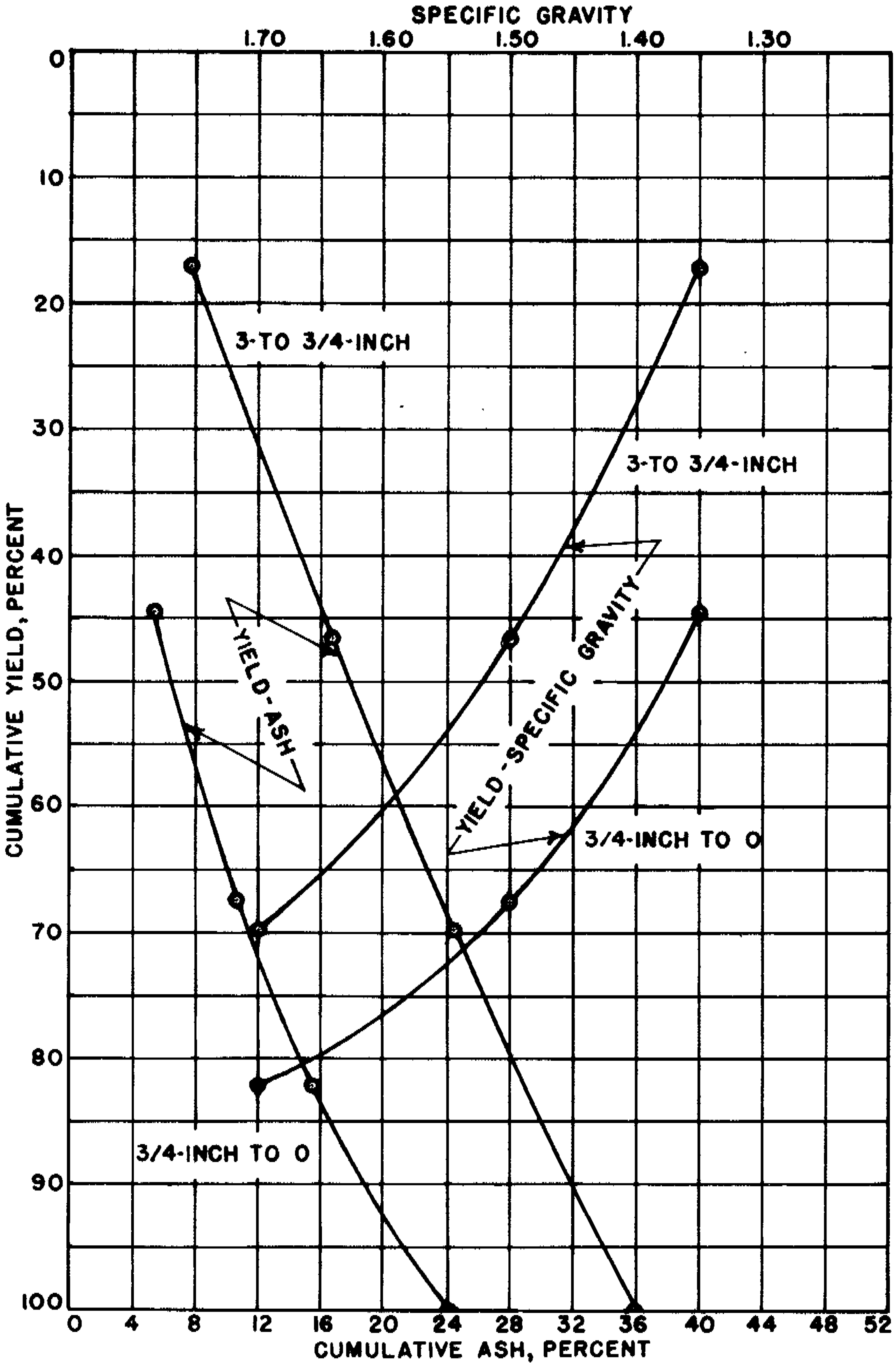

FIGURE 7.- Yield-ash and yield-specific-gravity curves for various sizes of Evan Jones coal.

With some coals containing a high proportion of intermediate-density material, the yield of clean coal obtainable is increased by crushing the raw coal before washing. In the crushing operation, particles of clean coal attached to particles of heavy impurity are freed for recovery in the washed product. To determine whether this was the case with the Evan Jones coal, a sample of the 3-inch slack was crushed to pass 3/4-inch and then tested at 1.70 specific gravity. The yield of float coal obtained was virtually the same as that in the uncrushed material. Apparently, the material of intermediate density is almost entirely bony coal rather than intergrown particles of coal and shale, therefore no advantage would accrue from crushing.

Results Obtained in Washing

In contrast to general washery practice, a single jig is employed at this mine to treat separately three different sizes of coal - 3 to 1-1/2-inch, 1-1/2- to 3/4-inch, and 3/4-inch to 0. The three sizes are accumulated in separate raw-coal bins as they are produced and then alternately washed in the jig; with this procedure the feed to the jig is changed every few hours. The jig is a 5- by 5-foot Forrester-type unit with a capacity of about 30 tons per hour. Refuse removal is controlled manually by the jig operator, who judges how frequently to open the refuse gate and how long to hold it open by visual inspection of the products, especially the refuse, and by the condition of the jig bed as determined by its "feel" or its appearance. A competent operator who has had ample experience with the particular coal being washed can effect a reasonably efficient separation between coal and impurity with this type of jig, but an inexperienced man cannot control properly the quality of the products.

The inadequacy of manuel control over jig operation is illustrated by the following tabulation, which shows how the quality of the jig products varies.

Ash contents[1] of raw coal, washed coal, and refuse

Product	Sample series 1	Sample series 2
3- to 3/4-inch size:		
Raw coal	35.5	34.2
Washed coal	19.2	22.5
Refuse	53.6	55.6
3/4-inch slack:		
Raw coal	22.4	25.0
Washed coal	14.4	19.2
Refuse	50.9	64.6

1/ Moisture-free basis.

Each of these series of samples was collected over a period of several hours of washery operation, therefore the results do not merely reflect variations between individual cars of raw coal. Considering the results obtained in washing the 3- to 3/4-inch size, for example, the cleaner of the two raw coals yielded the dirtier washed product. With the 3/4-inch slack, the washed coal ranged from 14 to 19 percent ash, and the corresponding variation in the refuse was from 51 to 65 percent ash.

This indication of the variability in jig performance is augmented by the record of the quality of coal shipped over a period of several months. As the following tabulation shows, this record also indicates marked fluctuations in the ash content of the washed coal, even though each analysis represents a composite of a number of cars of coal.

Ash content of washed-coal shipments[1]

	3/4-inch slack	3- to 3/4-inch
	September	
Number of cars..	79	26
High............	19.6	25.0
Low.............	13.5	17.1
Average.........	17.1	20.7
	October	
Number of cars..	53	35
High............	17.8	24.0
Low.............	14.8	18.3
Average.........	16.4	20.7
	November	
Number of cars..	73	35
High............	20.9	24.1
Low.............	16.3	17.1
Average.........	19.1	22.9

1/ Moisture-free basis.

In washing the 3- to 3/4-inch size, the average performance of the jig has been to produce a washed coal of 21 percent ash; this corresponds to a separation at about 1.60 specific gravity. Average performance with the 3/4-inch slack has been to yield a washed product of 18 percent ash, corresponding to a separation at over 1.70 specific gravity. The data available are not sufficient to permit accurate evaluation of the efficiency of the jig operation, but the ash contents of the refuse products indicate that the loss of coal may be higher than usual.

SUMMARY AND CONCLUSIONS

This report describes the washability characteristics and washing of coals from the Eska and Evan Jones mines - the principal producers in the Matanuska field of Alaska. Screen-sizing tests and specific-gravity analyses were made on both coals to evaluate their washability characteristics, and detailed washery-performance tests were made with the Eska coal.

The Eska coal contains 40 percent of impurity heavier than 1.70 specific gravity, and the Evan Jones coal about half that amount. Both coals contain, in addition, unusually large amounts of intermediate-density bony material. The shale and bone associated with both coals is more resistant to breakage than the clean coal and consequently tend to concentrate in the coarser sizes, with a corresponding concentration of the clean coal in the finer sizes. Considering all sizes together, a product of 18 to 19 percent ash is obtained by a separation at 1.70 specific gravity. Separation at a specific gravity of less than about 1.70 entails a large loss in yield for the increased reduction in ash content obtained, owing to the large proportion of bony material in the coal.

The Eska coal is washed in a modern Baum-type jig. The jig is able to make an efficient separation between coal and refuse in preparing a washed product of 20 percent ash, but separations at lower specific gravities to obtain cleaner washed coal can be made only at impared efficiency. The washing results indicate that in treating coals of this type the efficiency of the separation effected between coal and impurity is influenced by the amount of refuse material removed, as well as by the proportion of "near-gravity" material present in the coal.

The Evan Jones coal is washed in a manually controlled, Forrester-type jig. With this type of jig the quality of the products obtained is determined largely by the skill of the operator, and uniformity of operation is difficult to maintain. Samples of the washed coal collected on successive days varied from 14 to 19 percent ash. A similar variation in quality is evident in the record of shipments from this mine.

An important factor that must be considered in connection with the utilization of coals from this district is that their specific-gravity composition imposes a lower limit for the ash content to which they can be washed with a reasonable yield of washed coal. This factor is inherent in the character of the coal and, therefore, applies even when the coal is treated in modern, well operated, washing equipment. Washed coal having a minimum ash content of 14 percent can be produced, but only with a sharp sacrifice in yield. If coal of less than 18 percent ash is required, its enhanced value must justify the increased cost of preparing such a product.