DEPARTMENT OF MINES AND RESOURCES
MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH
BUREAU OF MINES

Physical and Chemical Survey Report No.137

Study of Coal From Tantalus Butte Mine, Yukon Territory

Operated by

Yukon Coal Co. Ltd., Carmacks, Y.T.

by

E. Swartzman

Fuel Research Laboratories
Ottawa Canada

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Approved by:
R.E. Gilmore,
Chief, Division of Fuels.

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INTRODUCTION.

The following report deals with a study of the physical and chemical properties of a bulk sample of unmodified mine run coal as well as of a channel sample of coal taken from the Tantalus Butte mine at Carmacks, Yukon Territory.

This is the first investigation of this nature conducted on Tantalus Butte coal and was done in order to supply certain basic information on the quality of the coal which would aid in planning mine development preparation and utilization.

Acknowledgement is due Mr. A. Ignatieff who collected the samples of coal and followed the study very closely, and to Mr. J.H.H. Nicolls under whose direction a major portion of the chemical analyses were conducted.

II.

DESCRIPTION OF THE MINE.

The Tantalus Butte mine which was first visited by A. Ignatieff, Mining Engineer with the Bureau of Mines, in October 1947, was described by him in Report F.R.L. No. 81[(1)].

The mine, owned and operated by the Yukon Coal Company Ltd., is situated about 2 miles west of Carmacks, on the Lewes River, some 100 miles N.W. of Whitehorse in the Yukon. The mine is entered by a tunnel some 350 feet above the level of the Lewes River. The tunnel, as shown in the sketch of the mine workings, goes in about 100 feet in drift followed by a crosscut about 130 feet long to the coal, the entry or top level being developed from here for a distance of some 550 feet. The coal seam, prior to 1947, had been worked above the main existing entry to a point some 200 feet from the crosscut by the room and pillar method, but due to the fact that entry pillars had been robbed and caving resulted it was considered inadvisable to continue operation from this level. Thus, on the recommendation of W.J. Dick, Consulting Engineer, development for mining of the seam below the present level was inaugurated. A short distance in from the crosscut, mentioned above, a slope and counter slope, with "raise" crosscuts at 50 foot centres, were driven down towards the proposed lower level. In July 1948 the main slope was down almost 500 feet, the No.6 crosscut was nearly half way to the counter slope location and the counter slope was developed down to the No.5 crosscut or "raise".

The coal seam which strikes about 355° and dips at the entry horizon about 50° to the west, is, on the average, about 9 feet in thickness. The coal appears to be clean looking "in situ", with only a few thin bone partings, and seems to be naturally friable.

No cutters are employed in mining, the coal being merely drilled and shot down out of the solid, a system which apparently results in the production of a large quantity of slack. The coal is hand loaded into 1000 pound capacity wooden end-dump cars. At the surface the coal is dumped into a roughly constructed chute, where it slides over a 1/2 inch stationary screen which only partly removes the 0 - 1/2 in. size, the coarser sizes segregating to the top of the coal stream. At the bottom of the chute the coal is bagged in 120 to 130 lb. sacks, the coarser coal being designated as of "domestic" quality, while the small coal and damp coal from the slope

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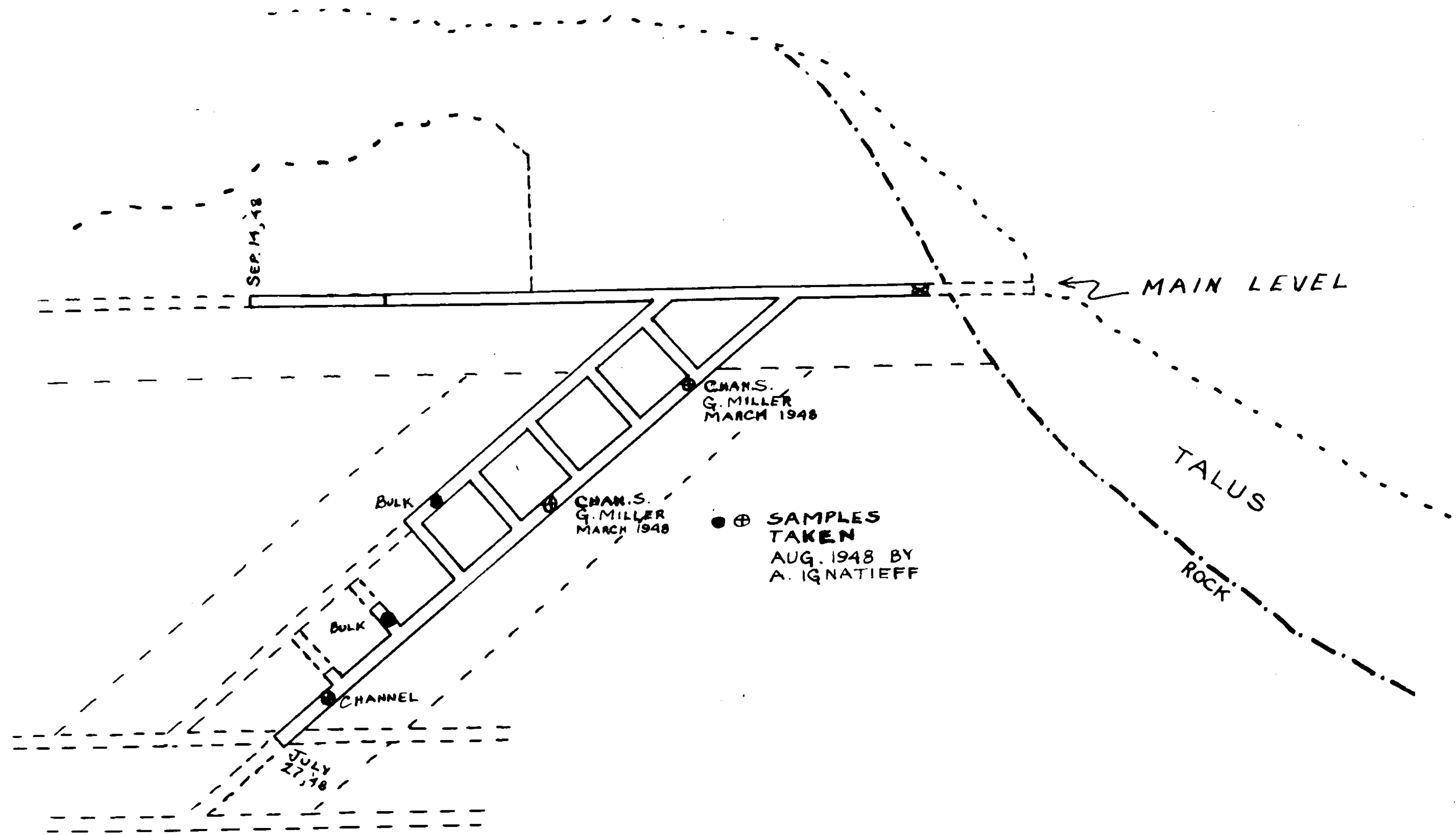
(1) F.R.L. No. 81 - "Report on Examination of Tantalus Butte Mine, Carmacks, Y.T." by A. Ignatieff, October, 1947.



SKETCH SHOWING LOCATION of SAMPLES TANTALUS BUTTE Y.T.

Scale: 1in = 100 feet

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Fuels Div.
28 Oct. '48

which cannot be readily rescreened are designated as "Steam" coal.

III.

THE SAMPLES COLLECTED.

The samples for this study were collected at Tantalus Butte mine by A. Ignatieff on July 22 and 23, 1948. These included four separate mine run samples, detailed below, as well as a channel sample.

Mine Run Samples

In view of the fact that it was noted that there appeared to be a difference in physical quality between the coal being mined in the counter off No. 5 raise and that being mined in No. 6 raise, the coal samples from these two sections of the mine were segregated. In addition as there also appeared to be a difference in the size distribution of the coal coming from the same section on the two different sampling days, the two daily samples from each raise were also kept separate. Thus four samples in all, of mine run coal, were collected as follows:-

1. From No. 5 raise on July 22, 1948.
2. From No. 5 raise on July 23, 1948.
3. From No. 6 raise on July 22, 1948.
4. From No. 6 raise on July 23, 1948.

It should be noted here that the coal coming from No. 6 raise was in the immediate vicinity of a local downthrow fault, and it was suspected that it might be contaminated.

The samples were collected at the surface from the mine cars. Five cubic feet, or approximately 275 pounds of coal was taken from every second car of coal brought to the surface during the sampling period which extended over a complete working shift. Each car of coal contained approximately 600 pounds of coal and four cars were sampled on each day from each raise. Thus each of the above gross samples weighing approximately 1000 pounds was representative of about 2400 pounds of mined coal, which was half the total output of the shift.

Each of the above gross samples was coned and quartered, and one half was loaded into wooden boxes for shipment to Ottawa. The weights of the reduced samples on arrival at the Fuel Research Laboratories were as follows:-

1. No. 5 raise (July 22) ...... 456.75 lbs.
2. No. 5 raise (July 23) ...... 442.00 lbs.
3. No. 6 raise (July 22) ...... 425.75 lbs.
4. No. 6 raise (July 23) ...... 437.25 lbs.

In addition to the above, special samples from No. 5 and No.6 raises were packed in a sealed container for determining the total as mined moisture content.

It should be noted that although the four mine run samples were kept separate until examined for their size distribution by screening, subsequently the separate screened sizes of the four samples were mixed in the proportion as received to make up composite samples of the screen sizes for further examination.

Channel Sample

One channel sample was taken at a point 455 feet down the main slope. The coal seam at this point was 10.5 feet in thickness. As it was noted that the top three feet of the seam appeared to be somewhat different physically than the rest of the seam the channel was split in two sections as follows from hanging to foot wall:-

(a) 3 feet - rather friable coal (168.5 lbs.)
(b) 7.5 feet - somewhat tougher coal which came down lumpier. (700 lbs.)

IV.

TEST METHODS FOR ASSESSING THE PHYSICAL AND CHEMICAL PROPERTIES OF THE COAL

A. Physical Properties of the Coal

1. Screen Analysis

Each of the four individual mine run samples as well as the two sections of the channel sample were hand screened using a series of standard round-hole screens with openings from 10 inches down to 1/32 inch. The results of these tests are presented in Tables I and XXII. The individual screened sizes from each of the mine run samples were then mixed in the proportion as received for preparation of bulk samples for subsequent physical and chemical testing. The screen analysis of the composite of the four samples is presented in Table II.

2. Bulk Density and Apparent Specific Gravity

The bulk density (weight per cubic foot) and the apparent specific gravity were determined on various screened sizes of the composited mine run samples as well as upon the individual mine run samples and the sectional channel samples by standard methods. These data are presented in Tables I and II for the mine run samples and in Table XXII for the channel samples.

3. Resistance to Handling or Friability

The relative resistance of the coal to handling or conversely its friability, was determined by two A.S.T.M. methods. The "size stability" of the larger pieces, namely, the 2-3 inch and the 4-6 inch sizes from the composite mine run as well as from the bottom section of the channel sample was determined by the tentaive Drop-Shatter Test, A.S.T.M. Designation D:440-37 T. The "friability" of both sections of the channel sample was determined by the standard "Tumbler Test for Coal", A.S.T.M. Designation :D441-45. By means of this test the "size stability" of a smaller size, namely 1 to 1½ in. square-hole screened material, is determined. The results of the Drop-Shatter tests on the Mine Run Composite Sample are shown in Table III, and on the bottom section of the Channel sample in Table XXIII, whereas the data on the Tumbler Tests of both sections of the channel sample are given in Table XXIV.

4. Grindability

The grindability or the ease of pulverizability of the coals were determined by the A.S.T.M. Tentative method of "Test for Grindability of Coal by the Hardgrove Machine Method", A.S.T.M. Designation: D409-37 T. The method evaluates the relative grindability of a coal in comparison with a certain easily ground coal* designated as having a 100 grindability index. For comparison, four samples of varying size consist, prepared from the Composite Mine Run were tested. The results are shown in Table IV.

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* Low volatile run-of-mine bituminous coal from Jerome Mine, Upper Kittanning Bed, Somerset Co., Pa.

5. Crushing Characteristics

A crushing test was conducted on the plus 4 inch coal separated from the Mine Run samples using a special double-roll coke cutter with the rolls set at 1½ inches. The results of the test are shown in Table V.

B. Chemical Properties of the Coal and Ash

The various composited screened sizes and mixtures obtained from the Mine Run samples, as well as the individual mine run samples and the Sectional Channel samples were subjected to one or more of the following standard analyses for assessing their so-called chemical properties.

1. Proximate Analysis

Moisture, volatile matter, fixed carbon and ash, conducted on all the samples.

2. Sulphur Content

Conducted on all the samples.

3. Calorific Value

Determined for certain individual screened sizes, all the mine run samples, as well as for certain mixed sizes of the mine run composite, and for the channel samples.

All the above analyses for the mine run samples are shown in Tables VI and VII, whereas these data for the channel samples are presented in Table XXV.

4. Ultimate Analysis

Determined only on the two sections of the channel sample and shown in Table XX. Values for the Mine Run Composite sample were calculated from these analyses and are presented in Table VIII.

5. Fusibility of Ash

This included the determination of the initial, softening and fluid temperatures of the ashes of all the screened sizes of the Mine Run Composite and the channel samples. The results for the Mine Run samples are given in Table IX, and those for the channel samples in Table XXV.

6. Chemical Analyses of the Ash

The chemical analyses of the ash of the composite mine run sample are shown in Table X. These analyses were conducted by the Mineral Dressing Division of the Bureau of Mines under the supervision of Mr. J.A. Fournier.

C. Coking Properties

The physico-chemical phenomenon of coking is evaluated by means of several rigidly standardized physical tests which determine certain phenomena accompanying, or as a result of, thermal decomposition.

1. Swelling Properties

The free swelling properties of a bituminous coking coal are determined by two methods at these laboratories as follows:-

(a) F.R.L. Swelling Index Test

This test consists of determining the volatile matter evolved and the percentage swelling of the resultant coke button produced at a temperature of 600°C. From these data the "swelling index" is calculated, and by the aid of a coke classification chart the coal is located in a particular group. The various groups are arbitrarily delimited according to the known physical properties of the cokes made from the coals within these groups.

(b) A.S.T.M. Free Swelling Index Test

This index is determined by the tentative method, A.S.T.M. Designation: D720 - 43T. The test consists of obtaining a coke button from 1 gram of coal under very rigid conditions of testing and determining the approximate free swelling under these conditions by comparing the button with a set of standard profiles with index numbers from 1 to 9 in increasing order of volume.

The results of these tests for mixed sizes prepared from the composite mine run coal are shown in Table XII.

D. Laboratory Washing Tests

Washing tests were conducted by the use of the float-and-sink method, washability curves being constructed from the data obtained to indicate the theoretical ash and sulphur contents and yields of both clean coal and refuse obtainable at a given gravity.

The data obtained as a result of these tests on the Plus 4 inch coal crushed to pass 4 in., the 1½ - 4 in., 1/8 - 1½ in. and 48 mesh - 1/8 in. sizes prepared from the Mine Run Composite coal are shown in Tables XIII to XX inclusive.

In addition to the usual washability curves the "specific gravity distribution" curve suggested by B.M. Bird was also plotted and used to indicate the degree of difficulty of wet washing as shown in the following table:-

±.10 Curve	Degree of Difficulty of Wet Washing	Preparation
Per Cent		
2 - 7	Simple	Almost any Process: high tonnage
7 -10	Moderately difficult....	Efficient process: high tonnage
10 - 15	Difficult	Efficient process: medium tonnage
15 - 20	Very difficult	Very efficient process; low tonnage
Above 25	Formidable	Limited to a few exceptionally efficient processes

For the ordinary wet washing of a coal, 10 per cent on the curve is used, and the specific gravity representing this point is selected as indicating simple to moderately difficult washing. When applying the float-and-sink data to a dry cleaning study of a coal, 3 per cent on the specific gravity distribution curve is recommended.

Curves showing the ash reduction which is possible under varying conditions of washing the various sizes prepared from the Mine Run coal are presented in Figures I to IV.

E. Petrographic Constitution

As this coal appeared to consist mainly of "Dull" coal with some fusain, only this latter was determined.

Fusain or mineral charcoal is a more or less inert petrographic constituent, but when present in relatively large quantities is associated with tendency of a coal to spontaneous combustion. It was determined by a modified form of the Heathcoat method. This method takes advantage of the fact that in bituminous and higher rank coals, the fusain is more resistant to oxidation than the other coal constituents. Hence after oxidizing the ulmic materials to an alkali-soluble product, the more resistant of fusain is collected by centrifuging followed by filtration.

The fusain content of various mixtures of sizes prepared from the Composite Mine Run sample are shown in Table XI.

F. General Burning and Clinkering Properties

The general burning and clinkering characteristics of the coals were studied by means of a simple furnace test which allowed for the collection of devolatilized coal, ash and clinker which could be evaluated for comparative purposes. The results of these burning tests conducted on mine run coal crushed to pass 1/2 in. and on 0 - 1½ in. slack prepared from the mine run coal are shown in Table XXI.

V.

DETAILS OF RESULTS

1. Mine Run Samples

The data, discussed in Chapter IV, obtained for the Mine Run samples of coal, is presented in the following series of tables.

A. Physical Properties of Coal

Table I - Screen Analyses of Individual Mine Run Samples from No. 5 and No. 6 Raises.
Table II - Screen Analysis, Specific Gravity and Bulk Density of the Composite Mine Run.
Table III - Size Stability (Drop-Shatter Method) of Larger pieces from Composite Mine Run.
Table IV - Grindability (Hardgrove Method) of Mixed Sizes from Composite Mine Run.
Table V - Crushing Test on Plus 4 in. Lump from Composite Mine Run.

B. Chemical Properties of Coal and Ash

Table VI - Chemical Properties of Individual Mine Run Samples from No. 5 and No. 6 Raises.
Table VII - Chemical Analyses of Various Sizes from the Composite Mine Run.
Table VIII - Ultimate Analyses of the Composite Mine Run.
Table IX - Fusibility of Ash of Various Sizes from the Composite Mine Run.
Table X - Chemical Analysis of Ash from Composite Mine Run.

C. Coking Properties

Table XII - Free Swelling Properties of Mixed Sizes from Composite Mine Run.

D. Laboratory Washing Tests.

Table XIII to Table XVI - Float and Sink Data on Plus 4 in. crushed lump, 1½ - 4 in., 1/8 - 1½ in., and 48 mesh - 1/8 in. sizes prepared from Composite Mine Run.

Tables XVII - XX - Proximate Analyses of Float and Sink Fractions for the various sizes tested.

E. Determination of Fusain

Table XI - Fusain Content of Mixed Sizes from Composite Mine Run.

F. General Burning and Clinkering Properties

Table XXI - Results of Burning and Clinkering Tests on two samples of coal.
(a) The Composite Mine Run crushed to pass 1/2 in. No other size was available because all the coal was crushed for sampling.
(b) A sample of 1½ in. slack prepared from a subsequent sample of Mine Run Coal (No. A562) specially shipped for more extensive combustion tests.

TABLE I

SCREEN ANALYSES OF MINE RUN SAMPLES TAKEN AT DIFFERENT LOCATIONS.*

Sample Location	No.5 Raise				No.6 Raise			
Date sampled	July 22/48		July 23/48		July 22/48		July 23/48	
	% Wt.	% Com.	% Wt.	% Com.	% Wt.	% Com.	% Wt.	% Com.
8 - 10 in.	1.6	1.6						
7 - 8 in.	0.0	1.6						
6 - 7 in.	0.0	1.6	0.7	0.7	0.7	0.5	5.4	5.4
5 - 6 in.	3.3	4.9	4.7	5.4	0.0	0.5	5.5	10.9
4 - 5 in.	2.8	7.7	4.4	9.8	1.9	2.4	4.5	15.4
3 - 4 in.	2.4	10.1	2.9	12.7	1.4	3.8	3.2	18.6
2½ - 3 in.	2.0	12.1	2.2	14.9	0.4	4.2	2.8	21.4
2 - 2½ in.	2.8	14.9	3.7	18.6	0.8	5.0	1.5	22.9
1½ - 2 in.	4.2	19.1	4.6	23.2	1.5	6.5	2.7	25.6
1¼ - 1½ in.	2.6	21.7	3.3	26.5	1.2	7.7	1.8	27.4
1 - 1¼ in.	3.6	25.3	4.3	30.8	1.6	9.3	2.3	29.7
3/4 - 1 in.	5.9	31.2	6.3	37.1	2.7	12.0	3.2	32.9
1/2 - 3/4 in.	9.2	40.4	9.8	46.9	5.8	17.8	5.7	38.6
3/8 - 1/2 in.	5.9	46.3	6.7	53.6	3.9	21.7	3.5	42.1
1/4 - 1/2 in.	8.1	54.4	7.4	61.0	7.2	28.9	5.7	47.8
1/8 - 1/4 in.	14.0	68.4	12.4	73.4	14.8	43.7	11.5	59.3
1/16 - 1/8 in.	8.0	76.4	7.9	81.3	9.8	53.5	7.0	66.3
1/32 - 1/16 in.	8.7	85.1	6.2	87.5	14.5	68.0	10.6	76.9
0 - 1/32 in.	14.9	100.0	12.5	100.0	32.0	100.0	23.1	100.0
Av. Particle Size in.	1.025		1.141		0.449		1.342	
Bulk Density lb/cu.ft.	57.8		57.4		56.9		67.5	

* Screen analysis in Table I is a composite of the above four samples.

TABLE II

SCREEN ANALYSIS, SPECIFIC GRAVITY, AND BULK DENSITY
Composite Mine Run (1)

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs per cu.ft.	Ash %
Plus 8 in.	0.4	0.4	1.39 (Plus 8 – 4 in.)	51.5 (Plus 8 – 4 in.)	23.4 (Plus 8 – 4 in.)
4 - 8 in.	8.4	8.8			
3 - 4 in.	2.5	11.3	1.35	50.5	17.7 (4 – 2 in.)
2½ - 3 in.	1.9	13.2	1.43 (3 – 2 in.)	46.5 (3 – 2 in.)	
2 - 2½ in.	2.3	15.5			
1½ - 2 in.	3.3	18.8	1.38	46.5	20.2
1¼ - 1½ in.	2.2	21.0	1.38	44.9	19.7
1 - 1¼ in.	3.0	24.0	1.34	44.3	19.1
3/4- 1 in.	4.5	28.5	1.31	43.8	18.8
1/2- 3/4 in.	7.6	36.1	1.29	45.0	19.3
3/8- 1/2 in.	5.0	41.1	1.25	43.5	18.1
1/4- 3/8 in.	7.1	48.2	1.24	45.0	22.1
1/8- 1/4 in.	13.2	61.4	1.28	47.0	19.0
1/16- 1/8 in.	8.2	69.6	1.38 (1/8 – 0 in.)	42.6	19.0
1/32-1/16 in.	10.0	79.6		42.3	22.4
0 -1/32 in.	20.4	100.0		47.3	17.8
Mine Run		100.0		59.9	21.2
Plus 1 ½ in.		18.8			22.7
0 -1 ½ in.		81.2			19.4
1/4 -1 ½ in.		29.4			19.7
0 -1/4 in.		51.8		51.3	19.2

		As Received
Average Size of Run-of-Mine....................	in.	1.017

* All screens are round-hole screens.
(1)Composited from samples taken from No.5 and No. 6 Raises.

TABLE III

SIZE STABILITY OF LARGER PIECES OF COAL FROM COMPOSITE MINE RUN
(Drop-Shatter Test Method)

Screen Sizes	Screen Analyses Before and After Drop-Shatter Test					
	2 - 3 in. Size			4 - 6 in. Size		
	Before Test %	After 2 Drops %	After 4 Drops %	Before Test %	After 2 drops %	After 4 drops %
5 - 6 in.				50.0	26.5	10.1
4 - 5 in.				50.0	17.0	11.1
3 - 4 in.					13.5	8.0
2 - 3 in.	100.0	53.0	43.0		8.5	19.6
1½ - 2 in.		13.0	12.0		5.0	9.1
1 - 1½ in.		10.0	11.5		6.5	7.5
3/4 - 1 in.		3.0	6.0		3.5	4.0
1/2 - 3/4 in.		5.5	4.0		4.0	6.0
0 - 1/2 in.		15.5	23.5		15.5	24.6
Av'g Size in.	2.500	1.777	1.555	5.000	3.169	2.205
Size Stab'ty %		71.1	62.2		63.4	44.1

TABLE IV

GRINDABILITY

Screen Size of Coal Tested*	Hardgrove Index (New)	Ash %
Mine Run	75.4	21.2
Plus 1-½ in.	83.7	22.7
¼ - 1½ in.	71.9	19.7
0 - ¼ in.	101.7	19.2

* From Mine Run Composite

TABLE V

CRUSHING TEST ON PLUS 4 INCH LUMP
(Crusher set at 1½ inch)

	Plus 4 inch Lump Screen Analysis	
	Before Crushing %	After Crushing %
8 - 10 inch............	20.8	
7 - 8 "	0.0	
6 - 7 "	0.0	
5 - 6 "	42.8	
4 - 5 "	36.4	
3 - 4 "		8.5
2½ - 3 "		16.6
2 - 2½ "		18.4
1½ - 2 "		12.7
1¼ - 1½ "		4.8
1 - 1¼ "		5.7
3/4- 1 "		5.7
1/2- 3/4"		5.9
3/8- 1/2"		3.5
1/4- 3/8"		3.5
1/8- 1/4"		4.4
0 - 1/8"		10.3
Av'g. particle size...in.	5.864	1.652
Size Reduction.........%		28.2

* From Mine Run Composite.

TABLE VI

CHEMICAL PROPERTIES OF MINE RUN SAMPLES TAKEN AT DIFFERENT LOCATIONS

Sample Location.	No.5 Raise				No.6 Raise			
Date Sampled	July 22/48		July 23/48		July 22/48		July 23/48	
	AR*	DB*	AR*	DB*	AR*	DB*	AR*	DB*
Proximate Analysis								
Moisture.........%	4.9		4.9		4.6		4.6	
Ash..............%	12.2	12.9	12.8	13.4	23.9	25.0	28.3	29.6
Volatile Matter..%	33.6	35.3	33.7	35.5	28.8	30.2	27.8	29.1
Fixed Carbon.....%	49.3	57.8	48.6	51.1	42.7	44.8	39.3	41.3
Sulphur..........%	0.4	0.5	0.5	0.5	0.3	0.4	-	-
Calorific Value ... .B.t.u./lb	11,725	12340	11625	12230	9875	10355	-	-
Coking Properties (by volatile button at 950°C.)....	Poor		Poor		Poor		Poor	
Calorific Value - Mineral. Matter free basis ......B.t.u./lb.	14,380		14,354		14,299		-	

* A.R. = As received basis
D.B. = Dry basis.

TABLE VII

CHEMICAL ANALYSES OF COAL SIZES FROM MINE RUN COMPOSITE PROXIMATE, SULPHUR, AND CALORIFIC VALUE

Screen Sizes	Moisture (as rec'd) %	Dry Basis Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value BTU/Lb
Plus 4in.	2.0	23.4	34.1	42.5	0.4	9615
2 - 4 in.	2.1	17.7	34.1	48.2	0.4	-
1½ - 2 in.	2.1	20.2	34.5	45.3	0.4	-
1¼ - 1½ in.	2.2	19.7	33.6	46.7	0.4	-
1 - 1¼ in.	2.2	19.1	34.1	46.8	0.4	-
3/4 - 1 in.	2.1	18.8	33.1	48.1	0.4	-
1/2 - 3/4 in.	2.3	19.3	32.9	47.8	0.4	-
3/8 - 1/2 in.	2.2	18.1	33.2	48.7	0.4	-
1/4 - 3/8 in.	2.4	22.1	31.3	46.6	0.4	-
1/8 - 1/4 in.	2.5	19.0	32.4	48.6	0.4	-
1/16 - 1/8 in.	2.2	19.0	32.6	48.4	0.4	-
1/32 - 1/16 in.	2.2	22.4	31.0	46.6	0.4	-
0 - 1/32 in.	2.6	17.8	32.0	50.2	0.4	11,465
Mine Run	2.7	21.2	32.2	46.6	0.4	10,980
Plus 1½ in.	2.1	22.7	34.1	43.2	0.4	10,065
1/4 - 1½ in.	2.2	19.7	32.1	48.2	0.4	11,175
0 - 1/4 in.	2.3	19.2	32.0	48.8	0.4	11,310

TABLE VIII

ULTIMATE ANALYSES*

Sample	Mine Run Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
Dry Basis	65.1	4.2	0.4	0.8	8.3	21.2	
As Rec'd	61.9	4.0	0.4	0.8	7.8	20.2	4.9

*Calculated from channel sample analyses.

TABLE IX

FUSIBILITY OF ASH[1]

Screen Sizes	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F	Ash %
Plus 4 in.	2310	2410	2450	140	100	40	23.4
2 - 4 in.	2130	2190	2230	100	60	40	17.7
1½ - 2 in.	2280	2350	2400	120	70	50	20.2
1¼ - 1½ in.	2080	2200	2280	200	120	80	19.7
1 - 1¼ in.	2120	2160	2200	80	40	40	19.1
3/4 - 1 in.	2140	2180	2200	60	40	20	18.8
1/2 - 3/4 in.	2180	2220	2260	80	40	40	19.3
3/8 - 1/2 in.	2170	2230	2270	100	60	40	18;1
1/4 - 3/8 in.	2170	2220	2290	120	50	70	22.1
1/8 - 1/4 in.	2200	2260	2310	110	60	50	19.0
1/16 - 1/8 in.	2220	2290	2460	240	70	170	19.0
1/32 - 1/16 in.	2240	2300	2450	210	60	150	22.4
0 - 1/32 in.	2220	2280	2350	130	60	70	17.8
Mine Run	2200	2250	2300	100	50	50	21.2
Plus 1½ in.	2230	2350	2450	220	120	100	22.7
1/4 - 1½ in.	2200	2300	2340	140	100	40	19.7
0 - 1/4 in.*	2200	2330	2420	220	130	90	19.2

* Calculated.
(1) Composite Mine Run Sizes.

TABLE X

CHEMICAL ANALYSIS OF ASH

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run[1]	48.4	4.2	20.0	16.7	5.4	0.1	0.2	0.9	0.1	1.0	3.3	100.3

TABLE XI

FUSAIN CONTENT

Sizes Tested*	Fusain % of Pure Coal
Mine Run	2.52
Plus $1\frac{1}{2}$ in. Lump	0.73
0 - 1/4 in. Fines	4.02

* From Mine Run Composite

TABLE XII

FREE SWELLING PROPERTIES

Sizes Tested*	FREE SWELLING PROPERTIES			
	F.R.L. Swelling Index			A.S.T.M. Free Swelling Index
	Vol.at 600°C. (D.B.)	Swelling %	Swelling Index	
Mine Run	24.4	10	41	1
Plus $1\frac{1}{2}$ in. Lump	22.1	- 5	-21	-
1/4 - $1\frac{1}{2}$ in.	24.4	-15	-61	-
0 - 1/4 in. Fines	21.0	15	71	-

* From Mine Run Composite

TABLE XIII (See Fig. I)

Float and Sink Data on Plus 4 in. (Crushed to pass 4 in.)

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks		±.10 Specific Gravity Distribution	
				Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
		%	%	%	%	%	%	%	
	Floats 1.30	1.5	3.9	1.5	3.9	100.0	21.3	1.40	58.5
Sinks 1.30	" 1.40	25.6	7.3	27.1	7.1	98.5	21.6	1.45	52.6
" 1.40	" 1.50	19.3	15.4	46.4	10.6	72.9	26.6	1.55	35.8
" 1.50	1.60 1.60	14.8	22.0	61.2	13.3	53.6	30.7	1.65	19.0
" 1.60		38.8	34.0	100.0	21.3	38.8	34.0	1.75	10.5
Curve No.	4		2	1,2,4	1	3	3	5	5

TABLE XIV (See Fig. II)

Float and Sink Data on 1½-4 in.

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks		±.10 Specific Gravity Distribution	
				Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
		%	%	%	%	%	%		
	Floats 1.33	5.7	4.8	5.7	4.8	100.0	18.5	1.40	70.4
Sinks 1.33	" 1.40	38.1	9.6	43.8	9.0	94.3	19.3	1.45	64.2
" 1.40	" 1.50	23.0	14.1	66.8	10.7	56.2	26.0	1.55	25.7
" 1.50	" 1.60	11.0	21.2	77.8	12.2	33.2	34.2	1.65	11.2
" 1.60	"	22.2	40.6	100.0	18.5	22.2	40.6	1.75	5.8
Curve No.	4		2	1,2,4	1	3	3	5	5

TABLE XV (See Fig. III)

Float and Sink Data on 1/8-1½ in.

-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.33	10.1	5.4	10.1	5.4	100.0	25.2	1.40	69.8
Sinks 1.33 " 1.40	22.0	9.2	32.1	8.0	89.9	27.4	1.45	57.4
" 1.40 " 1.50	24.8	15.2	56.9	11.1	67.9	33.4	1.55	31.0
" 1.50 " 1.60	11.9	26.8	68.8	13.8	43.1	43.8	1.65	14.1
" 1.60	31.2	50.3	100.0	25.2	31.2	50.3	1.75	8.0
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE XVI (See Fig. IV)

Float and Sink Data on 48 mesh - 1/8 in.

-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.30	5.9	4.3	5.9	4.3	100.0	25.8	1.40	70.4
Sinks 1.30 " 1.40	39.5	9.3	45.4	8.7	94.1	27.2	1.45	54.0
" 1.40 " 1.50	19.0	18.0	64.4	11.4	54.6	40.1	1.55	19.9
" 1.50 " 1.60	7.2	32.6	71.6	13.5	35.6	51.9	1.65	10.5
" 1.60	28.4	56.8	100.0	25.8	28.4	56.8	1.75	7.3
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE XVII

Chemical Analysis of Float and Sink Portions
Plus 4 in. (Crushed to pass 4 in.)

Specific Gravity		Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties
	Floats 1.30	4.0	41.4	54.6	Fair
Sinks 1.30	" 1.40	7.5	36.0	56.5	Poor
" 1.40	" 1.50	15.7	34.4	49.9	Poor
" 1.50	" 1.60	22.4	33.7	43.9	Strong Agglomerate
" 1.60		34.4	36.0	29.6	Non Agglomerate

TABLE XVIII

Chemical Analysis of Float and Sink Portions
1½-4 in. Sizes

Specific Gravity		Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties
	Floats 1.30	4.9	38.1	57.0	Poor
Sinks 1.30	" 1.40	9.8	35.9	54.3	Poor
" 1.40	" 1.50	14.4	33.6	52.0	Poor
" 1.50	" 1.60	21.7	34.8	43.5	Strong Agglomerate
" 1.60		41.1	32.7	26.2	Non Agglomerate

TABLE XIX

Chemical Analysis of Float and Sink Portions
1/8-1½ in. Sizes

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties
Floats 1.30	5.5	39.4	55.1	Fair
Sinks 1.30 " 1.40	9.5	33.5	57.0	Poor
" 1.40 " 1.50	15.5	31.2	53.3	Poor
" 1.50 " 1.60	27.4	30.2	42.4	Strong Agglomerate
" 1.60	51.0	25.3	23.7	Non Agglomerate

TABLE XX

Chemical Analysis of Float and Sink Portions
48 mesh-1/8 in. Sizes

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties
Floats 1.30	4.5	39.5	56.0	Fair
Sinks 1.30 " 1.40	9.5	32.3	58.2	Poor
" 1.40 " 1.50	18.4	29.1	52.5	Agglomerate
" 1.50 " 1.60	33.1	26.8	40.1	Non Agglomerate
" 1.60	57.5	21.2	21.3	Non Agglomerate

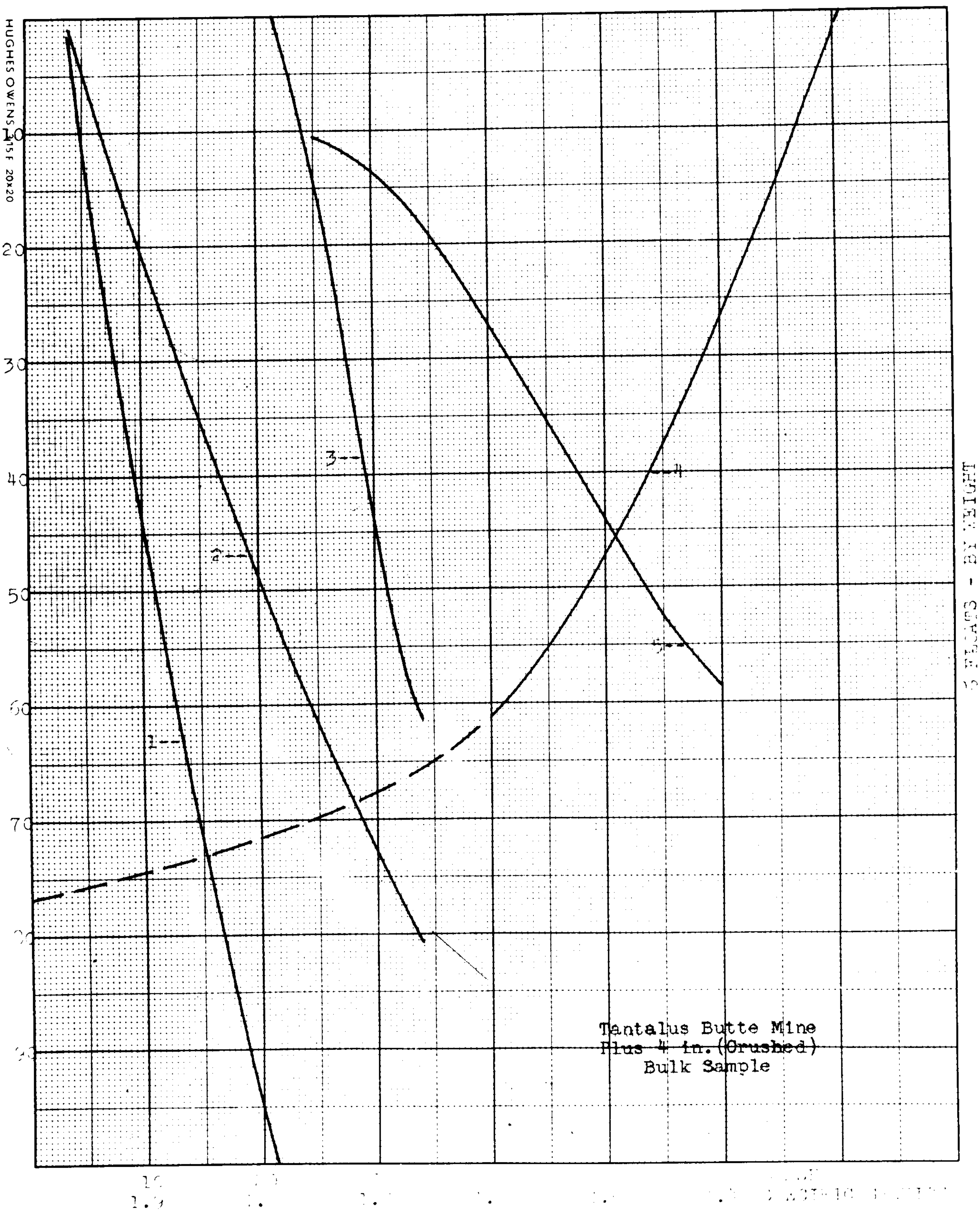

Fig. I - WASHABILITY CURVES FOR PLUS 4 in. (Crushed) - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5 - ±.10 Specific gravity distribution

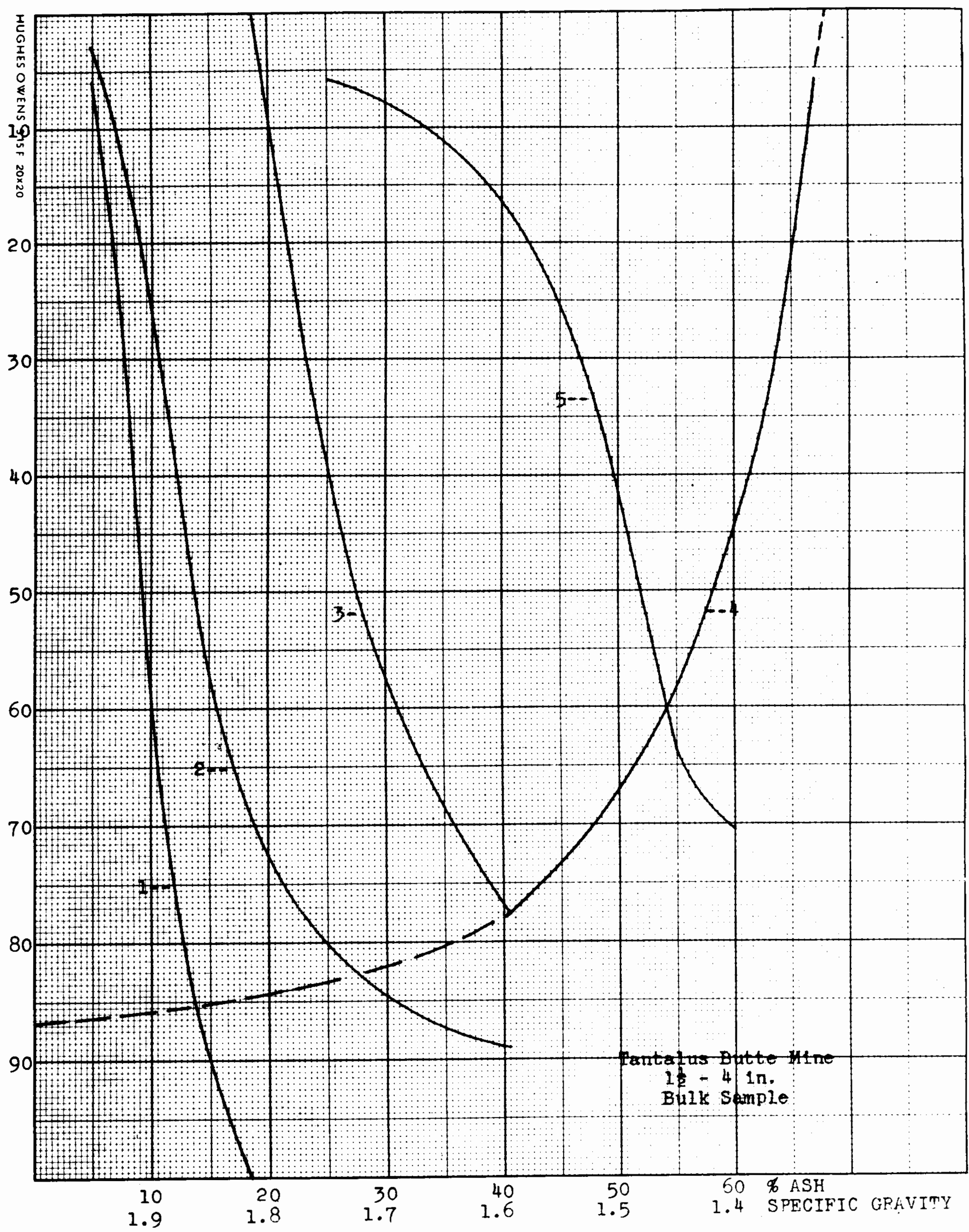

Fig. II - WASHABILITY CURVES FOR 1½ - 4 in. - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5 - ±.10 Specific gravity distribution

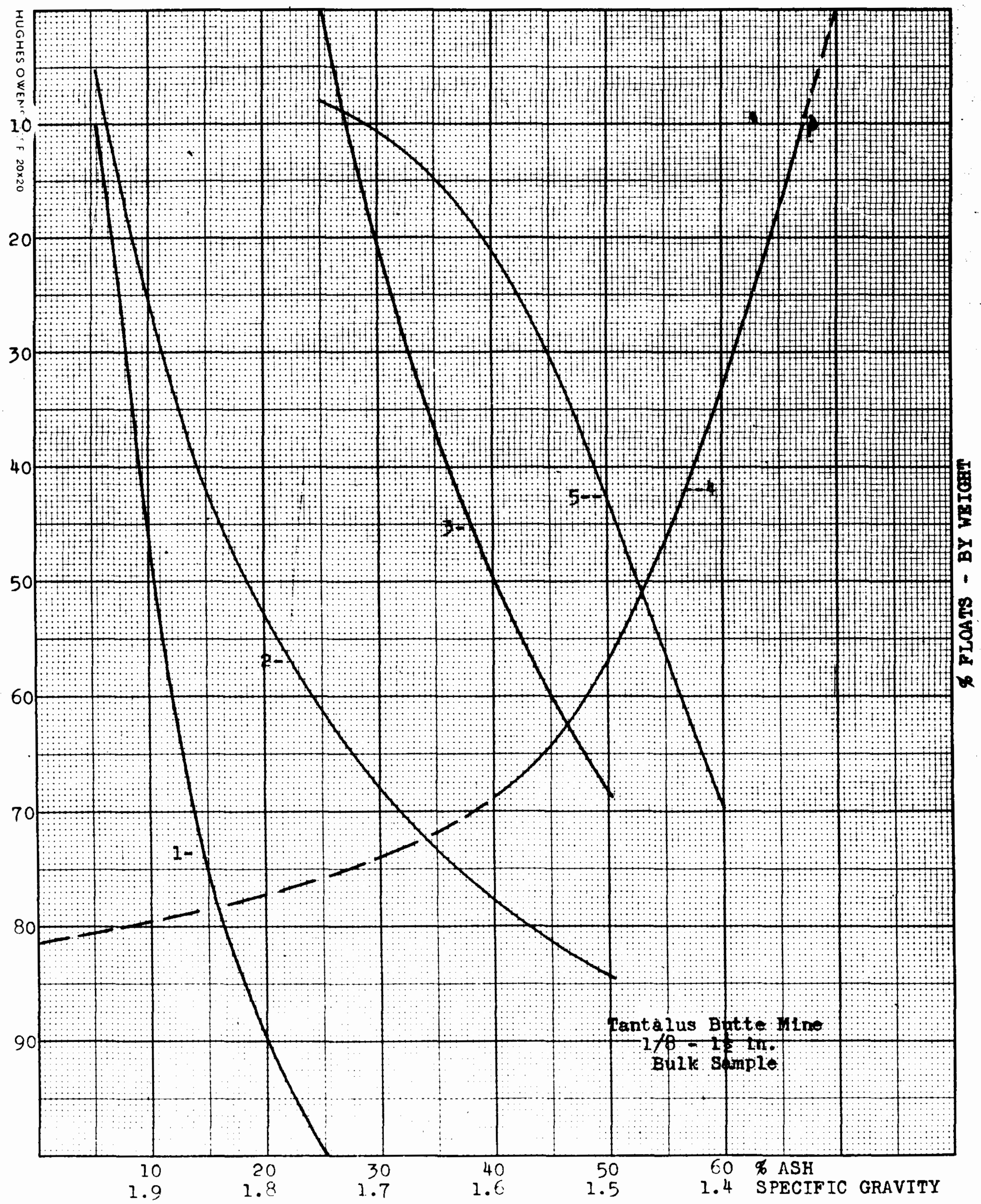

Fig. III - WASHABILITY CURVES FOR 1/8 - 1½ in. - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5.- ±.10 Specific gravity distribution

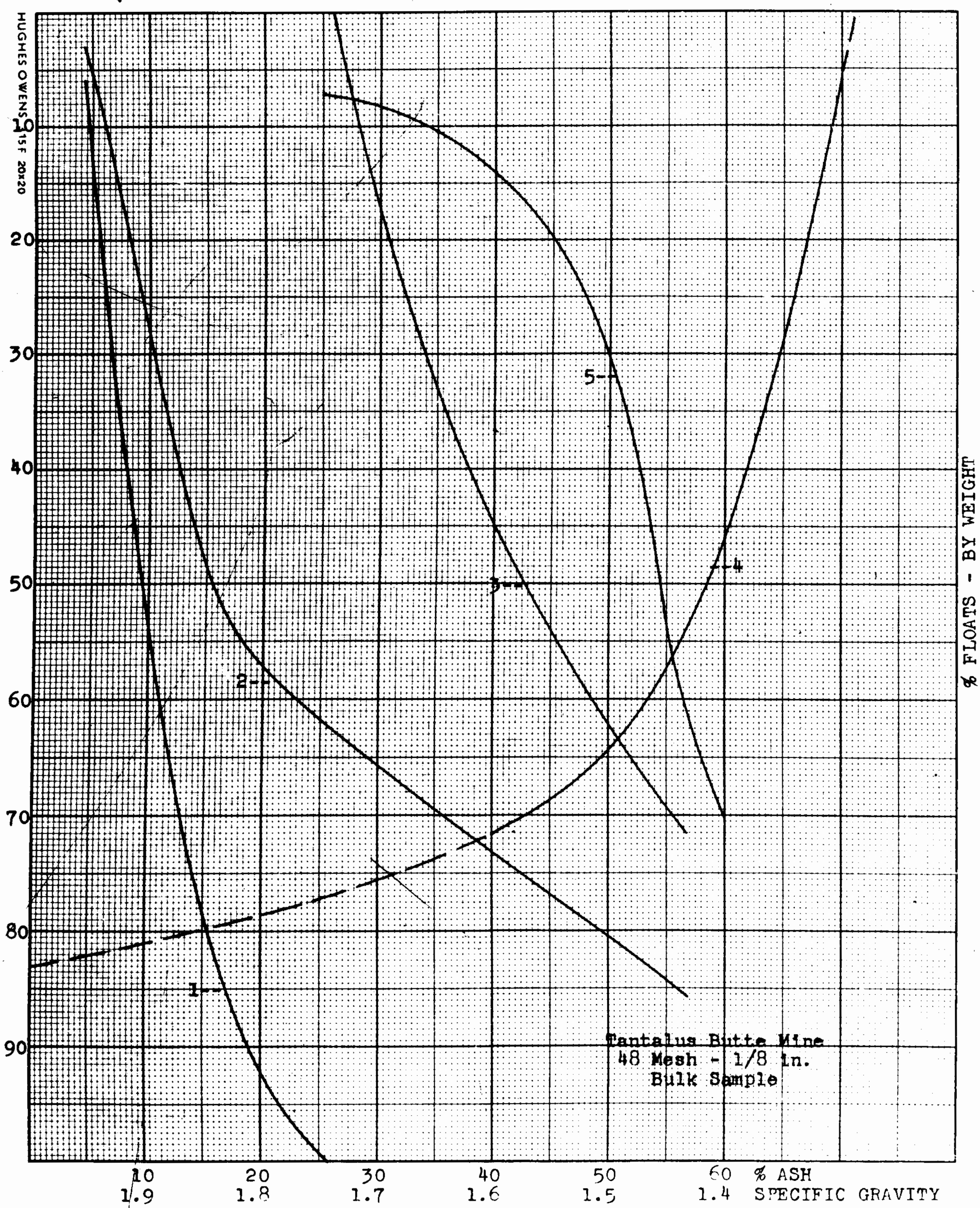

Fig. IV - WASHABILITY CURVES FOR 48 MESH - 1/8 in. - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5 - ±.10 Specific gravity distribution

TABLE XXI

Results of Burning and Clinkering Tests

	Mine Run Crushed to Pass ½ in.	1½ in. Slack from Mine Run(3)
Properties of Coal		
Proximate Analysis (Dry basis)		
Ash ....%	21.2	12.1
Volatile Matter ....%	32.2	33.4
Fixed Carbon ....%	46.6	54.5
Calorific Value.............B.T.U./lb.	10,980	12,070
Softening Temp. of Ash..............°F.	2250	2250
Caking Properties		
From button at 950° C.	Poor	Poor
F.R.L. Swelling Index	41	25
Burning and Clinkering Test Results		
Size of Coal Tested .... in.	0-1/2	0-1½
Weight of Coal burned ....lbs.	100	100
Burning Time......................hrs.	8.33	6.42
Residue on Grate		
+1/2 in. coke(1)..................gms.	227	0
+1/2 in. clinker..................gms.	3178	1589
-1/2 in. residue..................gms.	9988	7491
Clinker (+1/2 in.) as part of residue.(2)....................%	31.8	17.5
Quality of Clinker		
(a) Screen Analysis of +1/2" clinker		
Plus 4 in. (sq. mesh)...........%	17.6	45.2
2-4 in..........................%	28.5	4.8
1-2 in..........................%	28.5	28.1
1/2-1 in........................%	11.3	21.9
0-1/2 in........................%	14.1	0.0
Average particle size..........in.	2.399	4.321
(b) Tumbler Test.		
Size Stability..................%	50.4	51.9
Abradability (-1/16 in.)........%	12.1	15.2
(c) Apparent Specific Gravity	1.50	1.50

(1) There was no coke, only devolatilized and partially burned coal.
(2) Residue here equals +1/2 in. clinker plus -1/2 in. residue.
(3) This was prepared from a subsequent sample of mine run coal.

2. <u>Channel Samples</u>

The data, discussed in Chapeter IV, obtained for the two sections of the single channel sample collected at Tantalus Butte mine are presented in the following tables:-

Table XXII	-	Screen Analyses.
Table XXIII	-	Size Stability (Drop-Shatter Method) of the larger pieces.
Table XXIV	-	Friability (Tumbler Test) of the smaller pieces.
Table XXV	-	Chemical Properties.

TABLE XXII

SCREEN ANALYSES - CHANNEL SAMPLE

	Top 36" section % by Wt.	Bottom 90" Section % by Wt.	Composite Channel* % by Wt.
10 - 14 in.		14.0	10.0
8 - 10 in.		2.1	1.5
6 - 8 in.		5.5	3.9
4 - 6 in.	5.0	3.4	3.9
3 - 4 in.	3.8	4.0	3.0
2½ - 3 in.	5.2	3.0	3.6
2 - 2½ in.	4.5	4.0	4.2
1½ - 2 in.	6.8	5.2	5.7
1¼ - 1½ in.	3.4	2.2	2.5
1 - 1¼ in.	5.3	4.3	4.6
3/4 - 1 in.	6.7	5.0	5.5
1/2 - 3/4 in.	9.0	7.5	7.9
3/8 - 1/2 in.	6.5	4.9	5.3
1/4 - 3/8 in.	7.6	5.9	6.4
1/8 - 1/4 in.	11.7	9.3	10.0
1/16- 1/8 in.	7.8	4.8	5.7
1/32- 1/16 in.	6.7	5.3	5.7
0 - 1/32 in.	10.0	9.6	9.7
Av. Particle Size..........in.	1.067	3.184	2.579
Bulk Density ....lb./cu.ft.	58.1	59.1	--

* 28.6% top section and 71.4% bottom section.

TABLE XXIII

SIZE STABILITY OF LARGER PIECES FROM BOTTOM SECTION OF CHANNEL SAMPLE
(Drop-Shatter Test Method)

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test					
	2 - 3 in. Size			4 - 6 in. Size		
	Before Test %	After 2 Drops %	After 4 Drops %	Before Test %	After 2 Drops %	After 4 Drops %
5 - 6in.				40.0	20.5	15.0
4 - 5 in.				60.0	19.5	17.5
3 - 4 in.					9.0	7.0
2 - 3 in.	100.0	40.0	30.5			14.5
1½ - 2 in.		17.5	14.5		6.0	6.0
1 - 1½ in.		11.0	12.0		5.5	9.0
3/4 - 1 in.		6.5	6.0		3.5	3.5
1/2 - 3/4 in.		5.0	7.5		4.0	4.5
0 - 1/2 in.		20.0	29.5		14.0	23.0
Av'g Size in.	2.50	1.572	1.317	4.90	3.034	2.544
Size Stab'ty %		62.9	52.7		61.9	51.9

*Sample No.B 12714

TABLE XXIV

Friability of Channel Sample
(Tumbler Test)*

	Top Section	Bottom Section
Friability...........%	67.0	56.0
Abrasion Index.......%	31.3	22.3

* Test conducted on lumps 1-1½ in. sq. screen size.

TABLE XXV

Chemical Properties of Channel Sample

	Top 36" Section		Bottom 90" Section		Composite Channel
	A.R.*	D.B.*	A.R.*	D.B.*	D.B.*
Proximate Analysis					
Moisture ....%	2.9		2.9		
Ash ....%	16.4	16.9	10.2	10.5	12.3
Volatile Matter............%	33.3	34.3	34.1	35.1	34.9
Fixed Carbon...............%	47.4	48.8	52.8	54.4	52.8
Calorific Value.......BTU/lb.	11,525	11860	12470	12840	12560
Coking Properties (by volatile button at 950° C)	Poor		Poor		Poor
Ultimate Analysis					
Carbon.....................%	66.6	68.6	72.6	74.7	73.0
Hydrogen...................%	4.7	4.5	4.9	4.7	4.7
Sulphur....................%	0.4	0.4	0.4	0.4	0.4
Nitrogen...................%	0.9	0.9	1.0	1.0	0.9
Oxygen.....................%	11.0	8.7	10.9	8.7	8.7
Ash Fusibility.					
Initial Temp...............°F.	2220		2100		-
Softening Temp.............°F.	2310		2210		-
Fluid Temp.................°F.	2340		2310		-
Calorific Value (Mineral Matter free)......BTU/lb.	14,583		14,516		14,532

* A.R. - As received basis
D.B. - Dry basis.

VI.

DISCUSSION OF RESULTS

MINE RUN SAMPLE

The mine run samples of coal from the Tantalus Butte Mine were collected at the mine head by sampling freshly mined, unmodified run-of-the-mine coal in the manner detailed in Chapter III. The coal coming from the No. 5 and No. 6 raises, which were in operation during the period of sampling, was sampled separately and segregated because of apparent differences in physical quality. In addition the coal mined at each location was sampled twice on successive days, on July 22nd and 23rd, and these samples were also kept separate. Thus four gross samples, each weighing approximately 1000 pounds were collected, two from each location. These were coned and quartered, one half of each weighing approximately 452 pounds, being shipped to Ottawa for examination. After approximately one-fifth of each of the four samples was taken off at Ottawa as samples for chemical analyses, the remainders were screened separately to determine their size distribution. For all subsequent examination the individual screen sizes of each of the four samples were mixed in the proportions as received to produce composite samples of the mine run coal, and this should be kept in mind when examining the data presented in this report.

A. Physical Properties

(a) Sizing as Mined

The results of the screening tests on each of the four mine run samples of coal after delivery to Ottawa are shown in Table I. The table below shows the main size divisions of the coal from each location in terms of probable commercial preparation.

Commercial Sizes from Separate Mine Run Samples

Location of Coal	No. 5 Raise		No. 6 Raise	
Date Sampled	July 22	July 23	July 22	July 23
Plus 4 in. .... %	7.7	9.8	2.4	15.4
1½ - 4 in. .... %	11.4	13.4	4.1	10.2
¼ - 1½ in. .... %	35.3	37.8	22.4	22.2
0 - 1/4 in. .... %	45.6	39.0	71.1	52.2

It is quite apparent that, on the average, the No.6 raise coal was somewhat smaller than that from No. 5 raise, and this may either be due to the fact that there was a fault in the immediate vicinity of the No. 6 raise or it may indicate variations in the normal seam itself. However, it should be noted that even the coal from No.5 raise is not very large producing on the average 42.3% of 0 -1/4 in. fines.

Thus the screen analysis of the Composite Mine Run shown in Table II cannot be considered far out from what should be expected from this coal under the conditions of mining, the coal being shot from the solid. To designate in a simple manner the screen analysis of the coal, the upper screen limit on which approximately 5% of the coal is retained is used in conjunction with the lower screen limit through which approximately 15% of the coal passes, both being related to the average particle size. For the composite mine run the size consist may be stated as follows:-

Mine Run: $\frac{5.4\% \text{ Plus } 5 \text{ in.}}{20.4\% \text{ Minus } 1/32 \text{ in.}} = 1.017$ in.

This coal definitely exhibits an excessive quantity of fines.

(b) Density of the Coal

The bulk density and the apparent specific gravity of the various screened sizes of the composite mine run are shown in Tables I and II. The bulk density of the coal decreases more or less regularly with a decrease in size from about 51.5 lbs./cu.ft. for the Plus 4 inch lumps to 42.3 lbs./cu.ft. for the 1/16 - 1/32 in. fines.

The apparent specific gravity also appears to decrease with a decrease in size from approximately 1.39 for the lumps retained on a 4 inch screen to 1.24 for the 1/4 - 3/8 inch smalls. The decrease in specific gravity does not appear to be related to the ash content of the coal sizes tested.

(c) Size Stability of the Coal

The stability to handling was determined by the Drop-Shatter test method on two sizes prepared from the Composite Coal, namely 2 - 3 inch and 4 - 6 inch, the results being shown in detail in Table III. For comparative purposes the values obtained as a result of four drops are shown below:

Size Stability - Four Drop Shatter

	Size of Coal Tested	
	2 - 3 in.	4 - 6 in.
Size Stability .... %	62.2	44.1
Fines on Shattering(-½")... %	23.5	24.6
Slack on Shattering(-1½").. %	45.0	42.1
Average Particle Size...... After shattering....... in.	1.56	2.21
Proportion remaining in original Size........ %	43.0	21.1

Although the above data indicates that the Tantalus Butte coal is quite friable, the degree of instability to handling of these sizes does not conform with the low average particle size of the mine run coal. It is obvious that those portions of the mine run coal remaining as large lumps must be more resistant than the bulk of the coal, and the size stability of these lumps is no good criterion of the natural friability of the coal seam as a whole.

(d) Grindability

The grindability or ease of pulverizability of various sized mixtures prepared from the mine run coal as determined by the Hardgrove Machine method is shown in Table IV. The coal appeared to be one that may be considered as relatively easy to grind. The 0 - 1/4 in. fines exhibited a substantially higher grindability index than the 1/4 - 1½ in. and larger sizes, but this difference cannot be related to the ash content and thus must be considered as an inherent characteristic of the various sizes tested.

(e) Crushing Characteristics of the Lump Sizes

The results of the crushing test conducted on the plus

4 inch pieces of coal prepared from the Composite Mine Run are shown in Table V. The test indicated that when the double-roll crusher was set so that the cutting edges of the rolls were 1½ inches apart, the plus 4 inch coal, in one pass, was reduced from an average particle size of 5.864 inches to an average particle size of 1.652 inches. The average size of the crushed product was thus 28.2% of the average size of the uncrushed lumps. The crushing resulted in the production of the following relative amounts of commercial sizes.

Commercial Sizes from Crushing of Plus 4 in. Coal

	%
Egg (Plus 4 in.)............	0.0
Stove (1½ - 4 in.)..........	56.2
Nut & Stoker (¼ - 1½ in.)...	29.1
Fines (0 - ¼ in.)...........	14.7

It should again be noted that the crushing characteristics of the sizes retained as larger lumps after mining and shipment cannot be used as a criterion of the natural friability of the coal as a whole. Only the screen analysis of the mine run coal is, in the case of this coal, the best indication.

B. Chemical Properties of the Coal and Ash

(a) Proximate Analysis and Calorific Value

1. The Separate Mine Run Samples

The proximate analyses of the four mine run samples taken from No. 5 and NO. 6 raises are shown in Table VI. The No. 6 raise coal, taken from the immediate vicinity of a local fault shows an excessively high ash content of 25.0% - 29.6% on the dry basis in comparison to 12.9% to 13.4% for the coal taken in the counter off No. 5 raise. These values, for comparative purposes, should be considered in conjunction with the analyses of the channel samples, taken at a still lower level in the main slope, that is, beyond No. 6 raise. The ash content of the channel sample (see Table XXV) was 12.3% on the dry basis. This would tend to indicate that the high ash content of the coal coming from No. 6 raise is rather the exception than the rule, and may possibly be attributed to contamination as a result of the faulting condition.

2. The Composite Mine Run Samples

In examining the analyses for the composited mine run samples shown in Table VII the remarks above regarding No. 6 raise coal should be borne in mind, as it is this portion of the composited samples which resulted in the overall high ash content.

The various sizes of the composited coal showed an exceptional uniformity in ash content. Only in the case of the plus 4 in. coal was there a definite substantial increase over the average of about 20.0% ash on the dry basis, the plus 4 in. showing 23.4% ash. Examination of the washing data on various sizes (see Tables XIII to XVI) also indicates that the ash appears to be uniformly distributed between the various sizes. If the various coal sizes are separated at a gravity of 1.60 to throw out the very high ash material the ash contents of the clean fractions would be approximately as follows:-

	Ash %
Plus 4 in.	13.3
1½ - 4 in.	12.7
1/8 - 1½ in.	13.8
48 mesh - 1/8 in.	13.5

It should be noted that these values are in close agreement with the ash contents of the coal from No. 5 raise and from the channel sample, a fact which corroborates the remark made previously that No. 6 raise coal is only high in ash because of probable contamination due to local faulting.

The volatile matter of the coal is fairly high, the pure coal (mineral-matter free) exhibiting an average volatile matter content of 39.2%.

According to the Specific Volatile Index* method of classification by rank where rank is based on the unit heating value of the volatile matter evolved at 950°C., this coal has an average index of 139 which places it in the subbituminous (meta lignitous) class. According to the A.S.T.M. classification by rank Designation D388-38T, where rank is based on the fixed carbon and calorific value, calculated to the mineral-matter-free basis this coal is classed as High Volatile B bituminous (13,620 B.T.U./lb. moist mineral-matter-free) on the border of the High Volatile C bituminous. In this coal it is worthy to note that the plus 4 inch lump coal was of substantially lower rank than the smalls and fines. According to the Specific Volatile Index method of classification the plus 4 inch lump has an index of 107 in comparison to 139 for the fines, which places the lump sizes in the Ortho-lignitous or so-called Black Lignite class. According to the A.S. T.M. classification the lump sizes are High Volatile C bituminous to Subbituminous A (12,245 B.T.U./lb.-moist mineral-matter-free).

The moisture content of the coal as mined was approximately 4.8%.

The calorific value of the coal varies with the quantity of mineral matter present as indicated in Table VII. On the pure coal basis, that is the dry mineral-matter-free basis, the calorific values of several single and mixed sizes are as shown below:-

	Calorific Value - MM.Free B.T.U./lb.
Plus 4 in. Lump	12,951
0-1/32 in. Fines	14,266
Mine Run	14,337
Plus 1½ in. Lump	13,428
1/4-1½ in. Smalls	14,286
0-1/4 in.	14,342

Again it should be noted that the lump sizes are substantially lower in calorific value than the smalls and fines. The explanation for this is not obvious.

Assuming that an average mine run sample would contain not more than 13.0% ash on the "as mined" basis the analysis of the coal would be as follows:-

Analysis of Mine Run - As Mined

Moisture	%	4.9
Ash	%	13.0
Volatile Matter	%	33.6
Fixed Carbon	%	48.5
Sulphur	%	0.4
Calorific Value - B.T.U./lb.		11,600

*"Classification of coal using Specific Volatile Index" by R.A. Strong, E.J. Burrough and E. Swartzman - Mines Branch Publication No. 752-2.

(b) Ultimate Analysis

The ultimate analysis of the mine run composite sample calculated from the analyses of the channel sample is shown in Table VIII. On the ash and sulphur-free basis the analysis is as follows:-

Carbon %	Hydrogen %	Nitrogen %	Oxygen %
83.0	5.4	1.0	10.6

This is a medium carbon high oxygen coal, and by Seyler's method of classification using carbon and hydrogen the coal is in the Meta-lignitous or subbituminous class. This agrees more closely with the specific volatile index classification than with the A.S.T.M. method which places the coal in the High Volatile B bituminous class.

(c) Sulphur Content

The total sulphur content of the various sizes and size mixtures, shown in Table VII, is very low and uniform at about 0.4%. This coal may thus be considered as practically free of pyrite.

(d) Fusibility of the Ash

In Table IX are presented the results of the ash fusion determinations for the various sizes and size mixtures of the Tantalus Butte composite mine run coal. The softening temperatures are relatively low and fairly uniform varying from 2190°F to 2350°F, with the average at about 2250°F. This compares favourably with the channel sample which has a substantially lower ash content than the mixed mine run samples, and indicates that the fusibility of the ash is fairly uniformly low irrespective of possible contamination due to local faulting. It should be noted that the melting range of the ashes, that is, the temperature interval between the initial and fluid temperatures, is very low and uniform with an average of about 100°F. These uniformly low values are due to the high lime content of the ash and indicate the ready formation of a fluid, bothersome slag on combustion.

(e) Chemical Analysis of Ash

The complete chemical analysis of the ash from the composite mine run sample is shown in Table X. It is to be noted that the ash is very low in iron oxide but very high in lime and magnesium oxide. The high lime and magnesium accounts for the low ash fusibility and very low melting range.

C. Coking Properties

The physico-chemical phenomenon of coking whereby a bituminous coal becomes plastic during thermal decomposition and then fuses to a solid cellular mass of devolatilized material, is considered to be a combination of two main measurable effects, one resulting in the swelling of the plastic mass and the other being responsible for the ultimate binding or "caking". When poorly coking coals are being considered the degree of coking can most readily be evaluated by means of the Free Swelling Properties of the coal. These were determined by both the F.R.L. and A.S.T.M. Free Swelling Index methods, and the results are given in Table XII for several size mixtures prepared from the composite mine run coal.

The A.S.T.M. Free Swelling Index for the Mine Run coal was 1, that is, it showed no swelling whatsoever. The F.R.L. Swelling Indexes showed however that there was some difference between the larger sizes and the fines. The lumps and smalls showed a contraction whereas the 0 - 1/4 in. fines exhibited a definite swelling, sufficiently high to result in some swelling in the mixture of lumps, smalls and fines, namely in the mine run composite.

It may thus be concluded that this is a very poorly coking coal with the lump sizes merely agglomerating. Even so, on combustion, some caking should be expected.

D. Washing Characteristics

Washing tests, by the standard float-and-sink method using heavy media prepared from an admixture of organic liquids, were conducted on four sized fractions prepared from the mine run coal, namely, Plus 4 inch pieces crushed to pass 4 inch, 1½ - 4 inch pieces, 1/8 - 1½ inch smalls, and 48 mesh - 1/8 inch fines. The results obtained are given in a series of tables and curves shown in Chapter V.

Referring to Tables XIII to XVI inclusive it will be noted that the inherent ash contents of the different sizes, as indicated by the fractions floating at a specific gravity of 1.30 to 1.33 are uniformly medium to high varying between 3.9% and 5.4%. It is of importance to note that the quantity of coal reclaimed at these lower gravities is very small varying between 1.5% and 10.1% of the total of each size tested.

Using 10% on the ±.10 specific gravity distribution curves shown in Figures I to IV inclusive, an indication of the equivalent gravity at which relatively simple wet washing may be effected, with the production of only two products, namely clean coal and refuse, is obtained. These gravities and the quantity and quality of products that may be produced are shown below.

Simple Wet Washing

	Gravity of Separation	Clean Coal		Refuse	
		Yield %	Ash %	Yield %	Ash %
Plus 4 in. (Crushed Lump)	1.750	69.8	14.5	30.2	39.5
1½ - 4 inch	1.665	81.0	13.0	19.0	43.5
1/8 - 1½ inch	1.710	74.5	14.8	25.5	55.0
48 mesh - 1/8 in.	1.660	74.2	14.0	25.8	60.0

These results indicate very clearly that the coal is not readily amenable to simple wet cleaning. The inherent ash is high and especially in those sizes retained on a 1½ inch screen the proportion of so-called boney coal is high.

Even the refuse rejected at 1.65 to 1.75 in these larger sizes only contained 39.5% to 43.5% ash.

If all the sizes down to 48 mesh were washed in an efficient heavy-media separator at a gravity of 1.70 the quantity and quality of products that would be produced from this composite mine run coal are as follows:-

Washing at Gravity of 1.70

	Plus 4 in. Crushed Lump	1½ - 4 in.	1/8-1½ in.	48 mesh-1/8 in.
Clean Coal				
Yield .... %	67.7	82.0	74.0	75.5
Ash .... %	14.3	13.0	14.6	14.2
Refuse				
Yield .... %	32.3	18.0	26.0	24.5
Ash .... %	39.0	45.5	55.0	60.5
Raw Coal				
Ash .... %	21.3	18.5	25.2	25.8

It should be noted that the quality of the clean coal indicated above is similar to the quality of the coal as mined at No. 5 raise and as obtained in the channel sample below No.6 raise. All the above results would appear to indicate that if it were possible to eliminate those sections in the seam, such as those in the immediate vicinity of a fault, which may be contaminated and yield high ash, a product with 12% to 14% could probably be produced and this product would be as clean as could be expected even if washing were included in the preparation.

E. Petrographic Constitution

Fusain, the almost pure petrographic constituent which appears as a fibous charcoal-like material occurring in irregular wedges on the bedding plane was determined by the preferential chemical oxidation method developed by Heathcoat, and described in Chapter IV. The results obtained by this test on various size mixtures of the composite coal are shown in Table XI. The coal is relatively low in fusain with an appreciable concentration in the 0 -1/4 inch fines. The plus 1½ inch lump showed only 0.73% of fusain.

The other petrographic constituents were not separated as it was observed that this coal contained very little "bright" coal, it being mainly of the so-called "dull" attrital type. This would account for the high inherent ash of the coal.

F. General Burning and Clinkering Properties

The results of the simple burning tests conducted to determine the characteristics of the burning fuel and ash residue on a comparative basis are shown in Table XXI. Although the test is usually conducted on a 1/8 - 1¼ inch size, comparable to the average used in underfeed stokers, for these tests only the composite mine run crushed to pass 1/2 inch was available, as explained in Chapter V. For comparative purpose a 1½ inch slack, prepared from a succeeding sample of mine run coal specially shipped for more extensive combustion tests, was also tested.

(a) Clinkering Characteristics

The clinkering properties of the coals were studied and related to each other on the basis of qualitative and quantitative analyses. The following table presents the pertinent data:-

Clinker from Coals

	Mine Run Comp. Crushed to ½ in.	1½ in. Slack
Quantity of Clinker*.... %	31.8	17.5
Average Particle Size.. in.	2.399	4.321
Plus 2 in. Clinker**.... %	46.1	50.0
Apparent Specific Gravity	1.50	1.50

* Calculated as a percentage of the total clinker and -½ in. residue
** As percentage of total clinker

In both the above cases irrespective of the wide variation in ash content the clinker produced was fairly hard but rather porous, typical of high lime ash clinker. There was a tendency for the material to slag readily producing a rather glassy looking product which could be expected to run on a grate. It should be noted that in this test the coal is burned in a deep narrow firepot and when the coal has a high ash content much of the ash remains unclinkered because it is impossible to maintain a large enough body of fire for the mass of ash. If this coal were burned in thin layers there is no doubt that the bulk of the ash would clinker and form a product similar to that produced in this test.

(b) Burning Characteristics

The coal was relatively free burning, showed no tendency towards bridging , was non-swelling, and formed only a very light cake over the fire when fresh fuel was charged. However it was noted that the coal was rather slow to ignite, it lying "dead" on the fire for some time after charging.

Because of the high ash content of the fuel the bed of ashes became so thick that it was difficult to get the air through to the fuel. This at least partially accounted for the low burning rate in comparison to other coking high volatile bituminous coals tested in this same furnace. The fact that there was an excessive quantity of fines in the coal, resulting in a rather dense fuel bed also contributed to the slow burning rate. In this regard it should be noted that even when the larger slack (0 - 1½ in.) with the much lower ash (12.1%) was burned its burning rate was also substantially lower than for the average high volatile bituminous coal. The above tests thus indicate that very frequent cleaning, shaking and slicing would be required in the ordinary hand fired equipment, and because the coal is very poorly coking the loss of combustible in the refuse might be expected to be high. Burning this coal in thin layers on chain grates might be much more effective.

CHANNEL SAMPLE

One channel sample, in two sections, collected at a point 455 feet down the main slope, was studied for its physical and chemical properties.

A. Physical Properties

(a) Size Distribution

The screen analyses of the top 36 in. section and the bottom 90 in. section are shown in Table XXII. As was noted by the sampler when the coal was taken from the seam the top 36 in. of coal broke down to a far greater degree than the bottom section of coal. The top coal had an average particle size of 1.067 in. in comparison to 3.184 in. for the bottom coal. The average particle size of the full seam channel sample was 2.579 in. This value appears to indicate that with the employment of more suitable mining methods that is, if the coal were not just merely shot from the solid, it might be possible to produce a larger coal than is being produced at the present time. But even under the best conditions of mining the coal would apparently contain at least 63.0% of 1½ in. slack and probably much more after ordinary handling.

(b) Size Stability and Friability

The size stability of the larger sizes, from the bottom coal as determined by the Drop-Shatter Test is shown in Table XXIII. For comparative puposes the values obtained for two sizes as a result of four drops are shown below:-

Size Stability - Four Drop Shatter

	Size of Coal Tested	
	2 - 3 in.	4 - 6 in.
Size Stability.......... %	52.7	51.9
Fines on Shattering(-½in)%	29.5	23.0
Slack on Shattering(-1½in.)%	55.0	40.0
Average Particle Size After Shattering .....in.	1.32	2.54
Proportion remaining in original size......%	30.5	32.5

The above results compare very favourably with those obtained on the lumps from the mine run and indicate that the coal is quite friable. However the degree of stability to handling of these sizes is not necessarily an index of the natural friability of the coal, as even with very careful winning, as in the case of the channel sample, the coal contained at least 63.0% of 1½ in. slack in comparison to only 40.0% of 1½ in. slack which resulted from the drop shattering of the 4 - 6 in. lumps.

The friability of smaller sizes, namely 1 - 1½ in. size, from both the top and bottom sections of the channel sample are shown in Table XXIV. These results indicate that the coal is quite friable and corroborate the observation that the top coal is substantially more friable than the bottom coal.

B. Chemical Properties

The results of the chemical analyses shown in Table XXV, indicate that the top section of the channel sample contains about 6.5% more ash than the bottom section. Otherwise there is no apparent difference between them. On the average the composite channel sample is very similar in chemical quality to the mine run coal taken from No. 5 raise (See Table VI).