Canada
Department of Mines and Resources
MINES AND GEOLOGY BRANCH
BUREAU OF MINES

PHYSICAL AND CHEMICAL SURVEY OF COALS FROM CANADIAN COLLIERIES

—NOVA SCOTIA—

INVERNESS COUNTY COALFIELD

Memorandum Series
No. 74
December, 1939

BUREAU OF MINES

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DEPARTMENT OF MINES AND RESOURCES

OTTAWA, CANADA

PHYSICAL AND CHEMICAL SURVEY OF COALS FROM CANADIAN COLLIERIES

- NOVA SCOTIA -

Inverness County Coalfield

by

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FOREWORD

The Physical and Chemical Survey of the coals of Canada was instigated as a result of a request, made by coal operators in the province of Nova Scotia, that a study be made with a view to obtaining a comprehensive knowledge of the coal produced from each operating colliery. Its purpose was to determine whether by specially preparing the coal by screening, with or without subsequent washing and blending of the different sizes, a general improvement in grade could be obtained, thus resulting in a wider use of Canadian coal.

On completion of the study of the samples from each colliery, a report was forwarded to the operator, the first of which was issued in June 1933. As the survey progressed, it was found that the reports met with a most favourable reception from the operators, and it was then decided that the work should be extended to all the coal fields of the Dominion, and that the data should be correlated and presented in published form.

The survey has, to date, proceeded on the basis of provincial boundaries, starting with the east and working westward, and sub-divided into areas within the provinces. The present report, as the title implies, contains the data obtained by the examination of the coal from four mines operating on four different seams in Inverness County, Nova Scotia, the samples from which mines were collected during the summers of 1937 and 1938. This is the first of a series of publications which, it is intended, will present a complete survey of the coal as produced at the various collieries throughout Canada.

The investigation was conducted by the staff of the Fuel Research Laboratories. The geological information contained in this and similar reports to follow has been abstracted from published bulletins of the Bureau of Geology and Topography of this Department. It is hoped that this collection of data will serve as a means of acquainting all interested with the characteristics of Canadian coal, and result in its more efficient utilization, to the benefit of both consumer and producer.

B. F. HAANEL

Chief, Division of Fuels

PHYSICAL AND CHEMICAL SURVEY
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At the beginning of the survey of the coals from Canadian collieries, a suitable method for collecting large (ton lot) samples was decided upon and a standard method of examination of the coal was developed. In cases of large organizations which maintain a technical staff, the samples, to date, have been collected by the operators, but at small properties, an engineer of the Division of Fuels has visited the colliery and personally supervised the sample collection. The manner in which the coals described in this report were sampled is given in Chapter III, and a description of the methods of analyses and their significance is given in the Appendix.

The survey of the coals from Inverness coalfield was confined to the operating collieries in the field, which are working the following mines and seams:-

1. Port Hood mine...... "Main" seam--Port Hood, N.S., operated by Port Hood Mines Limited.
2. Inverness No. 1 mine "Seven-Foot" seam--at Inverness, N.S., operated under control of the Provincial Government.
3. Inverness No. 4 mine "Thirteen-Foot" seam--at Inverness, N.S., operated under control of the Provincial Government.
4. St. Rose mine....... "Six-Foot" seam--St. Rose, N.S., operated jointly by G.V. Evans and S.J. Doucet.

The examination of the samples collected comprized: (a) physical tests including screen analyses, bulk density and apparent specific gravity of each size, size stability and grindability; (b) chemical analyses including both proximate and ultimate analyses, calorific value, sulphur and forms of sulphur, fusibility of ash, and analyses of ash; (c) classification; (d) distribution of fusain; (e) washability characteristics; and (f) laboratory coking tests. The analytical and other data obtained are reported in Chapter III tables, and the results are discussed in Chapter IV.

The advantages of coal preparation are quite obvious, and a knowledge of the washing characteristics of the coals produced, in conjunction with their sizing possibilities, is of great importance in deciding on the operation of the collieries to yield the best results for both the producer and the consumer. It is with this objective in mind that the present report has been prepared. The comparisons made in the summary and discussion of results in Chapter IV are not intended to indicate the superiority of any one of the four coals reviewed, but are recorded for the purpose of indicating to those interested in the use of these coals, their relative merits.

Chapter I

DESCRIPTION OF THE COAL FIELD AND SEAMS

On the western side of Cape Breton, in Inverness County, five coal basins contained in the Pennsylvania strata of the Carboniferous rocks occur within a length of forty-five miles along the shore (see Figure 1). These are known, from south to north, as the Port Hood, Mabou, Inverness, St. Rose, and Chimney Corner basins, and are all presumably landward extensions of a coalfield now covered by the waters of the Gulf of St. Lawrence. According to Norman,(1)* "at Port Hood the coal-bearing strata outcrop in a narrow strip along the mainland, the coal basin being largely submarine and extending seaward in a general southwesterly direction". Similarly, "the Mabou and Inverness coal basins have also only a small landward extension being for the most part submarine".

Port Hood Basin

The coal measures at Port Hood lie in a gently folded syncline, the structure being limited to the west and to the east by faults along which older rocks are brought to the surface. The section of the strata with the coal seams of the Port Hood Basin are as follows, in descending order(1):-

	Strata	60+ ft.
1.	Coal, seven inches, interbedded with shale	2 ft.
	Strata	42 ft.
2.	Coal seams, up to four inches thick with shale	5 ft.
	Strata (concealed measures)	35 ft.
3.	Six-foot coal seam included in above concealed measures	

The strata underlying the Six-foot seam contain several thin coal seams varying in thickness from only a few inches to slightly more than two feet, but up to the present only the one workable bed, the Six-foot seam, has been proved. This seam originally outcropped on the shore a short distance south of the wharf at Harbour View but is now concealed. It dips beneath the sea at an angle of 21 degrees, flattening to 12 degrees at 2,000 feet from the outcrop. The present mining operations work the seam from a point about half a mile south of the original pit, which was flooded in 1911 when an inbreak of the sea water occurred in the lowest level of the mine. The coal seam varies in thickness from 5 feet 6 inches to about 7 feet, with a strong shale roof and a pavement which has a tendency to heave. There is a band of bony coal about 4 inches in thickness, approximately 21 inches from the roof. Some sulphur balls and streaks are present, as well as numerous thin discontinuous stone bands.

* This and subsequent references are given in reference list following the Appendix.

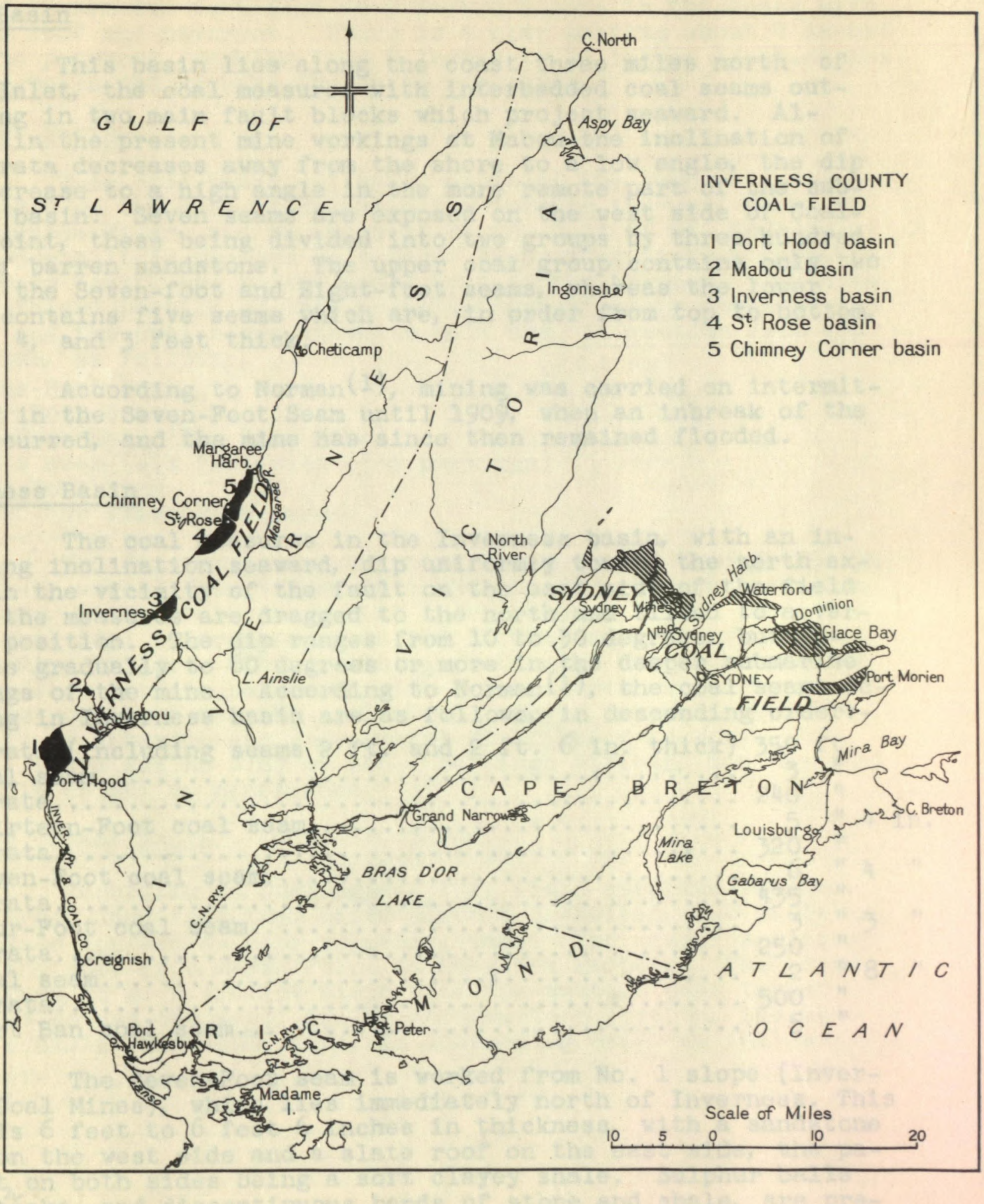

Fig. 1 - Map of Cape Breton Island N.S. showing the coal basins in the Inverness County coalfield.

Mabou Basin

This basin lies along the coast three miles north of Mabou Inlet, the coal measures with interbedded coal seams outcropping in two main fault blocks which project seaward. Although in the present mine workings at Mabou the inclination of the strata decreases away from the shore to a low angle, the dip may increase to a high angle in the more remote part of the submarine basin. Seven seams are exposed on the west side of Coal-Mine Point, these being divided into two groups by three hundred feet of barren sandstone. The upper coal group contains only two seams, the Seven-foot and Eight-foot seams, whereas the lower group contains five seams which are, in order from top to bottom, 15, 5, 4, and 3 feet thick.

According to Norman[1], mining was carried on intermittently in the Seven-Foot Seam until 1909, when an inbreak of the sea occurred, and the mine has since then remained flooded.

Inverness Basin

The coal measures in the Inverness basin, with an increasing inclination seaward, dip uniformly toward the north except in the vicinity of the fault on the east side of the field where the measures are dragged to the north and tilted to a vertical position. The dip ranges from 10 to 30 degrees, but increases gradually to 60 degrees or more in the deeper submarine workings of the mine. According to Norman[1], the coal seams occurring in Inverness basin are as follows, in descending order:-

	Strata (including seams 2 ft. and 2 ft. 6 in. thick)	350	ft.	
1.	Coal seam	3	"	
	Strata	240	"	
2.	Thirteen-Foot coal seam	5	"	4 in.
	Strata	320	"	
3.	Seven-Foot coal seam	6	"	4 "
	Strata	435	"	
4.	Four-Foot coal seam	3	"	3 "
	Strata	250	"	
5.	Coal seam	2	"	8 "
	Strata	500	"	
6.	Port Ban coal seam	5	"	

The Seven-Foot seam is worked from No. 1 slope (Inverness Coal Mines), which lies immediately north of Inverness. This seam is 6 feet to 6 feet 6 inches in thickness, with a sandstone roof on the west side and a slate roof on the east side, the pavement, on both sides being a soft clayey shale. Sulphur balls and streaks, and discontinuous bands of stone and shale, are present throughout the entire coal seam.

The Thirteen-Foot seam is a group of interbedded coal seams and fireclay. The main bench of this seam, which is worked from No. 4 mine (Inverness Coal Mines) on the north side of the town of Inverness, is 5 feet to 5 feet 6 inches in thickness with a shale roof and pavement. There is a clay parting about 4 inches from the pavement, varying from 9 inches to 12 inches in thickness. Sulphur balls and streaks are quite numerous.

St. Rose Basin

This coal basin, situated north of the town of Inverness, is bounded on the east by an anticline forming the west bank of the Margaree River, and on the west by the Gulf of St. Lawrence. To the north it is bounded by a fault separating it from the Chimney Corner basin, and to the south by a barren barrier. The area of the inland portion of this basin is approximately three square miles, and the coal seams known to date are, in section from top to bottom, as follows:-

1. Three-Foot seam
2. Four-Foot seam
3. Six-Foot seam (St. Rose Mine)
4. Betts seam (six feet with clay partings)
5. Four-Foot seam
6. A Two- or Three-Foot seam.

The Six-Foot seam, which is being worked through the St. Rose Mine, varies from 4 feet 10 inches to five feet 4 inches in thickness, with about 4 inches of inferior coal in the lower levels, this coal being brought to the surface separately and used in the mine boilers. The remaining portion of the seam is quite uniform from roof to pavement, with a thin layer of pyrite between the roof coal and the coal mined. There is an appreciable quantity of ankerite and some pyrite distributed in very thin bands. There are no clay or shale partings visible, and the coal is fairly bright in appearance.

Chimney Corner Basin

According to Dowling(2), this field comprizes a somewhat larger land area than those already described, but it is not thought to contain as many valuable seams. The measures outcrop along the coast from Marsh Point to Margaree Harbour. The land area seems to be a shallow basin with the western edge turned downward toward the sea. In the northwestern portion, the measures contain four coal seams, in descending order as follows:-

	Strata....................	
1.	Coal......................	1 ft. 6 in.
	Strata....................	300 "
2.	Coal......................	3 "
	Strata....................	68 "
3.	Coal......................	5 "
	Strata....................	200 "
4.	Coal......................	3 "

Apparently very little mining has been conducted in this area.

Chapter II

DESCRIPTION OF THE MINES

As the Physical and Chemical Survey has been confined to regularly operating collieries, the investigation of the Inverness County coal seams includes only those seams worked in the Port Hood, Inverness, and St. Rose coal basins. One seam, the Six-Foot or Main seam, is worked at the Port Hood Mine in the Port Hood basin by the Port Hood Coal Mines Limited; two seams, the Thirteen-Foot and Seven-Foot, are mined in the Inverness basin at the Inverness Coal Mine under Government control; and one seam, the Six-Foot seam, is worked at the St. Rose Mine in the St. Rose basin by Messrs. Evans & Doucet.

Port Hood Coal Mines Limited

Coal mining in the Six-Foot or Main seam has been carried on intermittently at Port Hood since 1865, without much success, until a reorganization in 1905 with the formation of the Port Hood-Richmond Railway & Coal Company. This Company continued operating the mine until 1911, when an inbreak of sea water occurred, the mine remaining flooded ever since. In 1930, Mr. E.C. Henderson opened a pit on this seam about half a mile south of the old workings. After a short period of operation, it was closed down, but was reopened in 1934 by the Provincial Government. In July 1934, the mine passed into private ownership, and, after several changes of ownership, the present Port Hood Coal Mines Limited was formed in 1936. This Company operates the one mine, called Port Hood, on the Main seam.

Port Hood Mine (Six-Foot or Main seam)

The seam is entered by a slope 5 by 10 feet, which, at the time of sampling (July 1937), was down 1,200 feet, the course being N.70°W., with a maximum cover of 377.5 feet. Two levels had been started, and on their completion eight rooms were to be available, at which time hand-pick mining was to be replaced by the use of an air-operated Ingersol-Rand radial cutter with a 6-foot rod.

The mine is fairly dry, free from dust and gas, and is ventilated by a steam-driven fan with 40,000 cu. ft. capacity, circulating 15,000 cu. ft. per minute.

Haulage is effected by a single rope, steam-driven hoist, drawing four 1,400-pound capacity boxes per trip up the single-tracked slope.

The mine has an average daily output of 125 gross tons, with a total output for 1936 of 8,196 gross tons. Based on the employment of 54 men, the mine yields slightly over 2.3 tons per day per man. If the mine is developed to its maximum, an average output of 300 tons per day is expected.

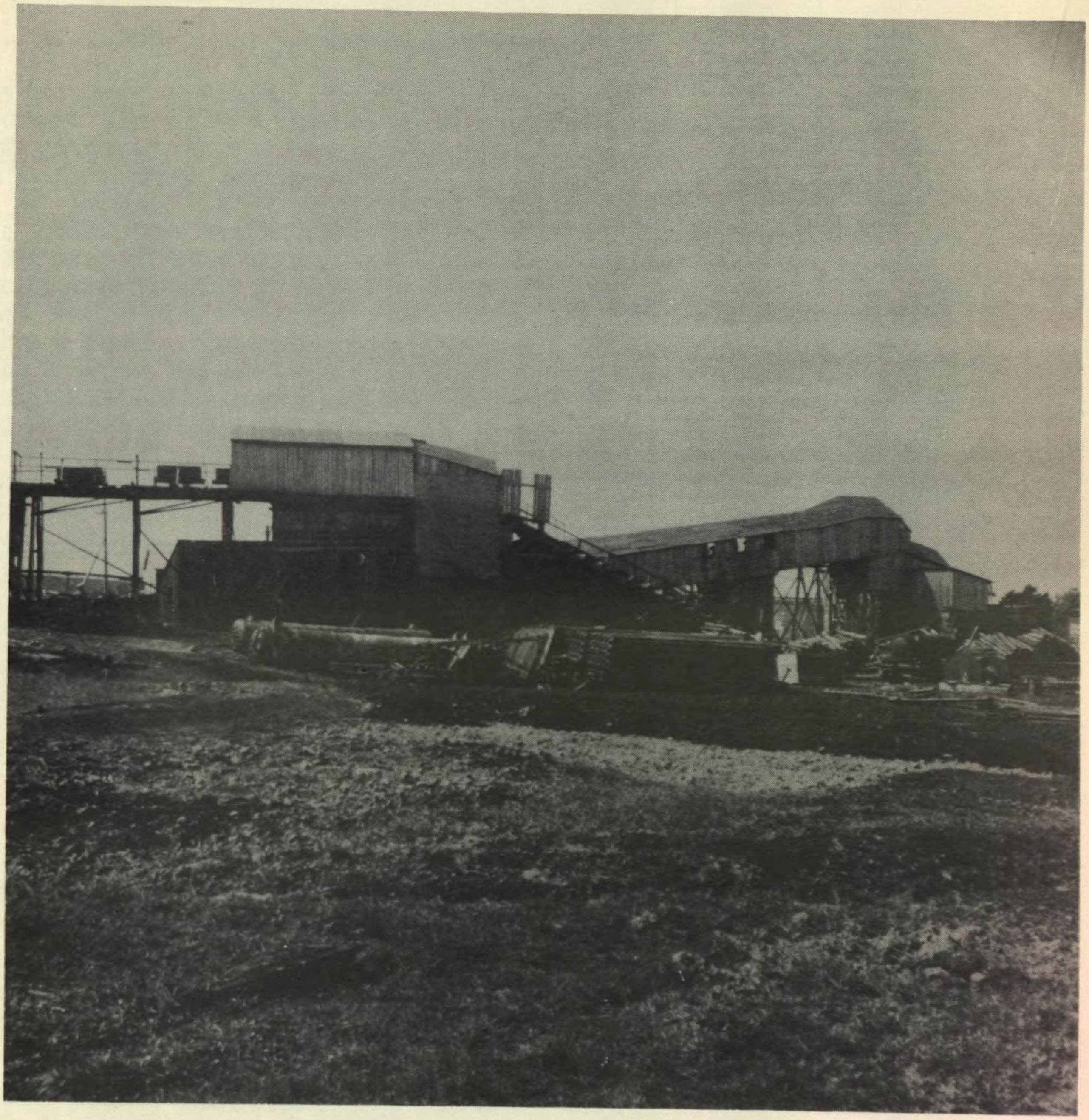

Plate 1 -

Bankhead — Port Hood Mine.

Bankhead--Port Hood Mine

In 1936 a new bankhead was completed, the one building housing the tippler, screening equipment, and picking belt. The coal passes over a simple end-dump tippler, and is discharged into a storage bin with a capacity of approximately 40 tons. By means of gates at the bottom of the bin, the flow of coal is regulated onto a belt conveyor about 3 feet wide and approximately 60 feet in length. At the discharge end of the belt, four men pick the coal, the refuse being discarded to the dump. The picked coal then passes over a double-decked Niagara shaker screen, the upper deck consisting of a 1-1/4 inch wire mesh screen 8 feet long by 4 feet wide, and the lower deck of a 3/8 inch wire mesh screen 8 feet by 4 feet. The oversize, +1-1/4 inch coal, passes down a short chute into railroad cars. The intermediate size, 3/8 to 1-1/4 inch nut coal, may be either stored in a bin or loaded with the +1-1/4 inch lump; whereas, the slack, 0 to 3/8 inch coal, is either loaded into cars immediately below the screens, or mixed with the oversize for run-of-mine. During 1936, the sales of the different sizes produced were as follows:-

Screened lump.....	4,604	long tons	44.2	per cent
Run-of-mine.......	3,381	" "	32.5	" "
Nut...............	697	" "	6.7	" "
Slack.............	1,727	" "	16.6	" "
	10,409	" "	100.0	" "

About five per cent of the material brought to the surface has to be discarded from the picking belt as refuse.

No coal is stored at the mine, and all shipments, so far, have been by rail. The Provincial Government is contemplating the construction of a loading wharf at Port Hood for all the coal mines of Inverness County, but this project will take several years to complete.

Inverness Coal Mine--Government Control

Prior to 1900, before the present railway to Point Tupper had been built, operations on a small scale to extract the coal from the Seven-Foot seam were carried on at the outcrop of this seam on Broad Cove river. In 1900, the Inverness Railway & Coal Company opened No. 1 Mine on the Seven-Foot seam, and work has been carried on almost continuously since that date. In 1920, the Company developed a second colliery, No. 4 Mine, winning the coal from the Thirteen-Foot seam. These mines, situated in the town of Inverness and now operated under Government control, were, in 1934, connected by tunnel, the No. 4 Mine being worked from No. 1 Mine slope.

Inverness No. 1 Mine (Seven-Foot seam)

The seam is entered by a 6 by 12-foot slope, which is double-tracked for a distance of approximately 300 feet, from where it branches off into the West and East Angle slopes. At the time of sampling in July 1937, the West Angle slope was 4,047 feet long with a dip of 43 degrees, the course being N.69°W., with a cover of 862 feet at the eighth level. The East Angle slope was 1,505 feet in length with a dip of 20 degrees, the course being N.45°30'E., with a cover of 296 feet at the third level. The coal is hand-pick mined, using the room and pillar method, with a total of thirty-two working places.

The mine is damp, free from dust and gas, and is ventilated by means of an electrically-driven fan with a capacity of 160,000 cubic feet per minute.

Haulage on the slopes is effected by means of a double-drum steam-driven hoist, each trip consisting of fifteen to seventeen boxes of one-ton capacity, one rope pulling from the West Angle while the other draws from the East Angle.

This mine has an average output of 600 long tons per day, the total output for 1936 being 130,424 tons for 201 working days. The mine, employing a total of 249 men, yielded 2.41 gross tons per man per day

Inverness No. 4 Mine (Thirteen-Foot seam)

This mine is connected by tunnel to the West Angle slope of No. 1 mine, and the total length of the deep from the mouth of No. 1 to the bottom of No. 4 is 5,682 feet. The dip is 25 degrees, the course for the main deep being N.35°47'E., with a maximum cover of 714 feet. The mine is worked by the room and pillar method, with nine working places. An Ingersol-Rand radial cutter with a 6-foot bar is used for mining the coal.

The mine is damp, free from dust and gas, and is ventilated by means of an electrically-driven fan with a capacity of 10,000 cubic feet per minute.

Haulage in the main deep is effected by means of a single cylinder, friction-drum, air-operated engine, which hauls the trips of fifteen to seventeen one-ton boxes up to the tunnel at which point the surface hoist of No. 1 mine takes the trip.

The mine has an average output of 100 long tons per day, and, employing a total of 49 men, yielded slightly over two tons per man per day.

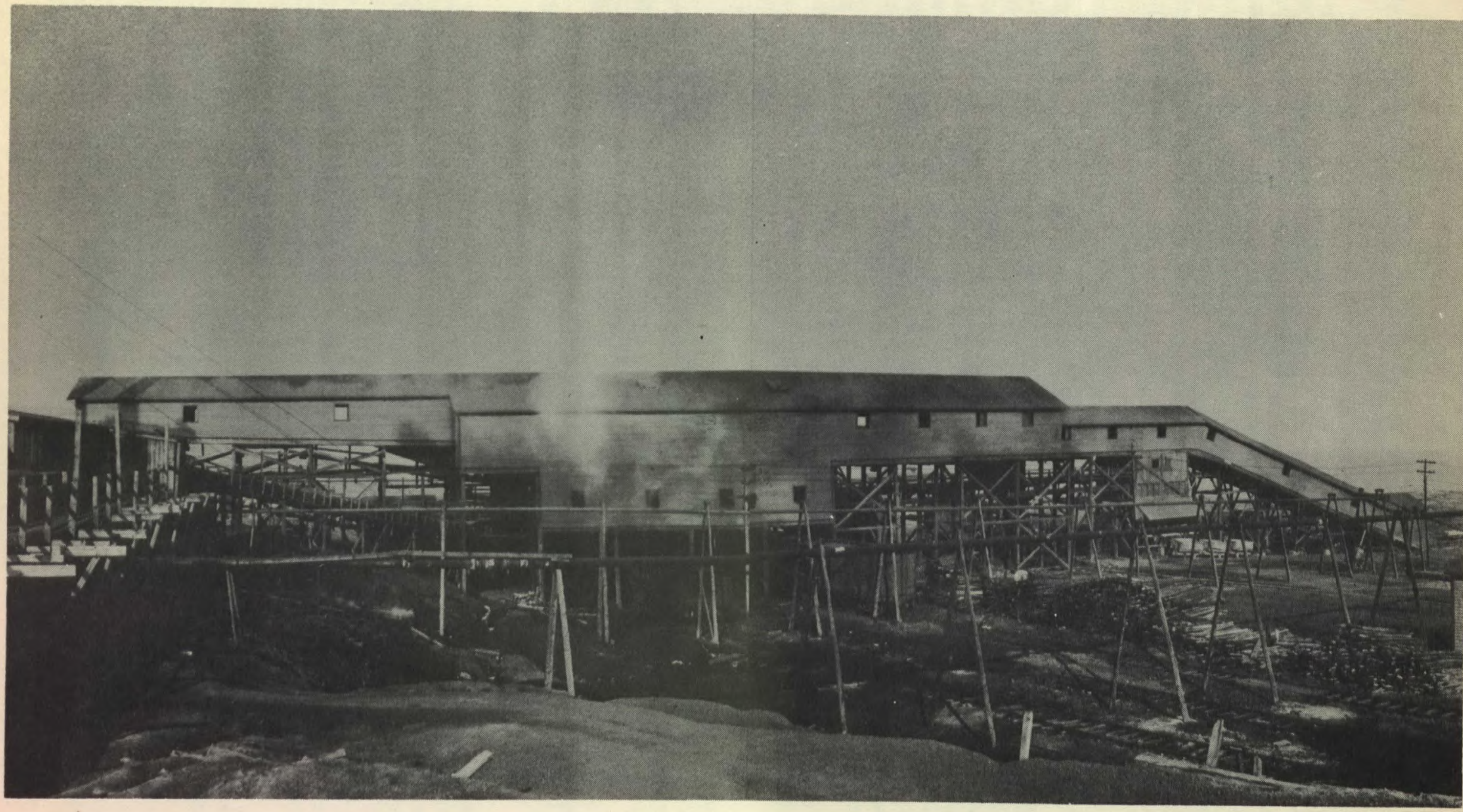

Plate 11 -

Bankhead — Inverness No. 1 and No. 4 Mines.

Bankhead--Inverness No. 1 and No. 4 Mines

During 1934, a new bankhead was constructed to handle the output from both mines, the one building housing the tipples, screening equipment, and picking belts. Two revolving tipples, preceded by a five-ton capacity weigh scale, handle all the coal and stone. The stone tippler, placed behind the coal tippler, discharges the hoisted stone into a four-ton chute, which feeds a scraper conveyor carrying the material to an eighteen-ton chute. From here the stone is fed to side dump cars and conveyed to the dumping ground.

The coal, which is discharged from the tippler onto a steel belt conveyor four feet wide, is carried up a steep incline and is dropped about three feet onto the distributor plate of the screening equipment. Screening is effected by means of a double-decked shaker screen about four feet wide, which is continuous with a very long shaker plate that spreads out the coal and delivers it to the picking belt. The upper deck of the shaker screen consists of a series of round-holed and so-called lipped-plate screens, in the following order from feed to discharge end:- (1) A 4-foot square plate screen with 5/8 inch round-hole openings; (2) A 4-foot square lipped-plate screen with openings equivalent to 3/4 inch; (3) A 4-foot square plate screen with 5/8 inch round-hole openings; (4) A 4-foot square lipped-plate screen as above; and (5) A 4-foot square plate screen with 5/8 inch round-hole openings.

The oversize coal continues down the steel plate shaker which is about twenty feet long, and is discharged onto a steel belt running at right angles to the screens. This picking belt is approximately 40 feet long and 4 feet wide, lighted by a bank of twenty 100-watt lamps, with three men picking on each side. The stone and so-called "splint" are carted by wheelbarrow to a chute some thirty to forty feet from the belt, and the "splint" is then carried by a scraper conveyor to the boiler house where it is mixed with run-of-mine coal.

The coal passing the top deck of the screen falls onto the lower deck equipped with three 4-foot square plate screens with 5/8 inch round-hole openings. The coal remaining on this screen is that passing the lipped-plate screens, and is designated as "stoker nut". When there is no demand for this size, it passes onto the screened-coal picking belt, otherwise it is bypassed to a steel conveyor-type picking belt similar to the one described above and running parallel to it, where four men pick the coal.

The slack, 0 to 5/8 inch, may either be loaded directly into hopper cars, or mixed with the screened picked coal and distributed as run-of-mine. The screened and picked coal is loaded by means of a chute at the end of the picking belt, either into box or hopper cars, six men being employed as trimmers in the box cars. The distribution of the output according to the various products was, for 1937, on a 750 tons daily output basis as follows:-

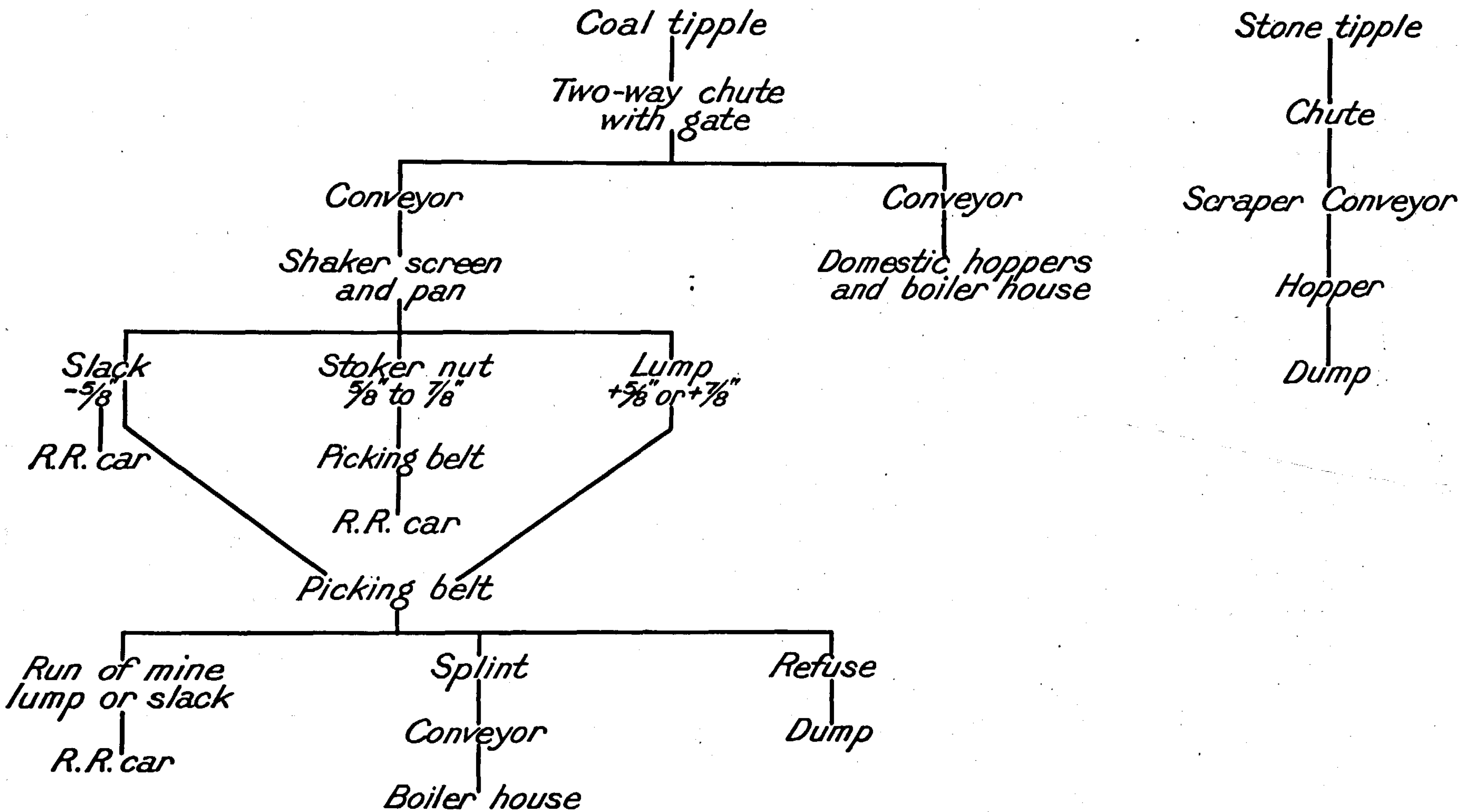

Fig. 2 - Flow-sheet of Bankhead or Tipple at Inverness colliery.

Screened coal..........%	48.0
Run-of-mine............%	9.0
Slack..................%	40.0
Splint and stone.......%	3.0

No coal is banked at the mine, and all shipments are by rail.

St. Rose Mine

This mine, situated at St. Rose about 11-3/4 miles north of Inverness, is operated by Messrs. George Evans and S.J. Doucet, each having a 3-year sub-lease from the Wm. Roche Estate of Halifax, obtained in the spring of 1936. At the time the last sub-lease was procured, the slope was down 540 feet, Mr. Evans having worked this mine intermittently during the past twenty years. The mine is now operated on a partial partnership basis; the surface workings are on a joint basis, whereas underground each party has developed his own section. Originally, Mr. Evans mined the east section and Mr. Doucet the west section, but since Mr. Evans has struck a fault, or an erosion, he is now mining with Mr. Doucet in the west section.

The mine is entered by a slope driven a distance of 540 feet N.45°W. on an 18° dip, from which several levels have been struck off. The aforementioned fault was encountered about 400 feet west of the main slope on the upper levels. At the lower level, the coal thins out to 2 feet 6 inches about 250 feet from the main slope, and at the present stage of development it appears that the fault does not strike the lower levels. In the upper levels the coal suddenly breaks off without the seam becoming thinner, and a soft muddy clay is encountered. At the time of sampling, July 1938, the level had been driven a distance of 10 feet in the mud, and preparations were being made to drill from that point. The supposition was that it is not a fault but an erosion, and that probably a post-glacial stream had worn away the coal and left in its place the soft clay deposit.

All the coal is machine-mined by the room and pillar system. A compressed air operated radial coal cutter with a 6-foot bar making a 5-inch kerf was employed, the cut being made about 18 inches from the pavement. The coal is hand-loaded into one-ton capacity boxes, and hauled to the surface by means of a single drum steam-driven hoist, one box at a time.

The mine is fairly dry, water being pumped at a rate of forty gallons per minute for about two and a half hours per day. The mine is free from dust and gas, and air circulates at about 15,000 cubic feet per minute, effected by natural draft aided by the exhaust of the pump and the heat of the steam line to the pump.

Bankhead--St. Rose Mine

The coal is raised from the mouth of the mine to a height of thirty feet on the bankhead where allowance has been made for two tipples, one for Evans' coal, and the other for Doucet's coal.

Plate 111 -

Bankhead -- St. Rose Mine.

Evans' Tipple--The coal is dumped by means of a simple hand-operated end-dump tippler onto a stationary double-decked screen 10 feet long by 6 feet wide, set at an angle of 45°. The upper deck is equipped with a 5/8 inch wire mesh screen, and the lower deck with a 3/8 inch wire mesh screen. The 3/8 inch slack, amounting to about 9 per cent of the total output, passes to a special slack bin immediately underneath the screen and is discarded. The coal remaining on the 3/8 inch screen passes, together with the coal remaining on the 5/8 inch screen, into a 75-ton bin, from which it is loaded to trucks for distribution.

Doucet's Tipple--The coal is discharged from the boxes by means of a hand-operated side-dump tippler onto a double-decked stationary screen 10 feet long and 4 feet wide. The upper deck contains a bar screen constructed of 1-1/4 inch pipe, set three inches apart and resting at an angle of 30 degrees. The lower deck is equipped with a 1/4 inch wire mesh screen set at an angle of 35 degrees. The 1/4 inch slack is discarded, whereas all the oversize coal drops into a 40-ton hopper from which it is loaded to trucks for distribution.

During 1937, the output of the whole mine was approximately 3,500 tons. It was marketed locally, and also distributed to Cheticamp, Truro, Halifax, Campbellton, and Prince Edward Island. As the nearest railroad is at Inverness, 11-3/4 miles from the mine, distribution costs are unusually high. During average producing periods, the mine yields 2-1/2 to 3 tons per man per day.

Chapter III

PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE COALS FROM INVERNESS COUNTY COALFIELD

The samples of coal from this field, which are reported upon in this publication, were taken under the supervision of an officer of the Division of Fuels during the summers of 1937 and of 1938, the manner of sampling being as follows:-

1. Port Hood mine--Main seam:- The sample was collected intermittently from the conveyor belt carrying the coal from the tipple hoppers to the screening plant.

2. Inverness No. 1 mine--Seven-Foot seam:- Boxes of coal coming from the various working places were chosen at random, dumped on a scraper conveyor, and approximately 200 pounds of coal taken from each box.

3. Inverness No. 4 mine--Thirteen-Foot seam:- Boxes of coal coming from the various working faces were chosen at random, dumped onto a scraper conveyor, and approximately 200 pounds of coal taken from each box.

4. St. Rose mine--Six-Foot seam:- The sample was collected from the storage bins at the tipple, a portion being taken from each of the two bins representing the output of the entire mine.

Approximately 2,500 pounds of coal, representative of a day's output, was collected from each seam. Each sample was mixed, coned, and quartered, one half being used for the investigation of the physical and chemical characteristics of the coal, and the other half being reserved for special investigation. The data obtained from each seam studied in the area are presented in the following sets of tables, as listed below:-

Physical Tests:
- Table I - Screen analyses, bulk density, and apparent specific gravity.
- Table II - Size stability.
- Table III - Grindability.

Chemical Analyses:
- Table IV - Proximate analyses, sulphur, and calorific value.
- Table V - Ultimate analyses.
- Table VI - Sulphur forms and fusain.
- Table VII - Fusibility of ash.
- Table VIII - Chemical analysis of ash.

Washing Tests:
- Table IX - Float and Sink data on 1-1/2 inch slack--Ash and Sulphur.
- Table X - Chemical analyses and fusibility of ash of float and sink portions of 1-1/2 inch slack.

Table XI - Chemical analyses of raw coal, clean coal, and refuse.
Table XII - Sulphur forms and fusain of raw coal, clean coal, and refuse.
Table XIII - Screen analyses and chemical analyses of sizes prepared from 1-1/2 inch slack for washing tests.
Table XIV - Analyses of clean coal and refuse of screened sizes at a selected gravity.
Figures 3, 6, 9 and 12 -- Washability curves re ash.
Figures 4, 7, 10 and 13 -- Washability curves re sulphur.
Figures 5, 8, 11 and 14 -- Diagrammatic comparison of washability of screened sizes.

Coking Tests:

Table XV - Physical properties of by-product cokes as indicated by the "swelling index" test; and Caking index.

A full discussion of the significance of all the tests employed in this investigation is presented in the Appendix of this report.

MAIN OR SIX-FOOT SEAM

PORT HOOD BASIN

PORT HOOD MINE, PORT HOOD COAL MINES LIMITED,

PORT HOOD, NOVA SCOTIA

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TABLE I

Screen Analyses, Bulk Density and Apparent Specific Gravity

Screen Sizes *	Screen Analyses: As Received % Weight	As Received % Cumulative	As Mined % Weight	As Mined % Cumulative	Bulk Density lb. per cu. ft.	Apparent Specific Gravity	Void %	Ash %
Plus 4 "	33.5	33.5	53.1	53.1	.....	....	....	....
2 " - 4 "	19.6	53.1	15.6	68.7	47.50	1.45	47.6	18.8
1½" - 2 "	6.0	59.1	5.0	73.7	48.50	1.44	46.1	14.9
1 " - 1½"	11.7	70.8	7.3	81.0	45.00	1.42	49.3	15.5
3/4" - 1 "	5.8	76.6	4.1	85.1	45.00	1.44	50.0	13.7
1/2" - 3/4"	6.7	83.3	4.7	89.8	45.25	1.43	49.4	13.9
1/4" - 1/2"	7.4	90.7	4.5	94.3	45.00	1.41	48.9	12.5
1/8" - 1/4"	3.7	94.4	2.3	96.6	42.25	1.44	53.0	13.8
No. 48 - 1/8"	4.1	98.5	2.5	99.1	} 48.00	....	....	....
0" - No. 48	1.5	100.0	0.9	100.0		....	....	....
Mine run	100.0			100.0	63.50	....	....	....
0 " - 4 "	66.5			46.9	57.00	....	....	....
1/8" - 4 "	60.9			43.5	56.50	....	....	....
3/4" - 4 "	43.1			32.0	49.00	....	....	....
0 " - 3/4"	23.4			14.9	52.00	....	....	....
0 " - 1½"	40.9			26.3	53.00	....	....	....
0 " - 1/8"	5.6			3.4	48.00	1.44	46.7	16.4

	As Mined	As Received
Average size of run-of-mine coal............in.	4.536	3.427
Size stability during handling from mine to Ottawa...............................%		75.6

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II

Size Stability

	Screen Analyses Before and After Drop-shatter Test									
	Single Sizes				Mixed Sizes					
	2" - 3"		3" - 4"		3/4" - 4"			0" - 4"		
	Before test %	After 2 drops %	Before test %	After 2 drops %	Before test %	After 2 drops %	After 4 drops %	Before test %	After 2 drops %	After 4 drops %
3 " - 4 "			100.0	53.0	19.2	12.5	12.2	12.5	9.3	8.3
2 " - 3 "	100.0	58.0		19.0	26.2	18.0	16.6	17.0	15.7	14.0
1½" - 2 "		16.7		4.5	13.9	20.0	15.3	9.0	8.7	9.0
1 " - 1½"		9.0		7.0	27.2	22.4	22.0	17.6	13.0	12.4
3/4" - 1 "		4.5		4.0	13.5	13.5	13.5	8.7	9.3	8.3
1/2" - 3/4"		3.8		3.5		6.8	7.5	10.1	12.6	13.3
0 " - 1/2"		8.0		9.0		6.8	12.9	25.1	31.4	34.7
Average size..In.	2.500	1.939	3.500	2.577	2.028	1.696	1.582	1.440	1.270	1.193
Size stability..%		77.6		73.6		83.6	78.0		88.2	82.9

TABLE III

Grindability

Screen Size of Coal Tested	Hardgrove Index
0" - 4 "	59.6
0" - 3/4"	59.7
0" - 1/8"	59.7

TABLE IV

Proximate Analyses, Sulphur, and Calorific Value

Screen Sizes *	Moisture -- (as rec'd)	Dry Basis				
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.
Plus 4 "	4.8	17.4	34.6	48.0	9.8	......
2 " - 4 "	4.3	18.8	34.3	46.9	8.9	......
1½" - 2 "	4.6	14.9	35.4	49.7	7.4	......
1 " - 1½"	4.5	15.5	35.6	48.9	7.9	......
3/4" - 1 "	4.4	13.7	36.1	50.2	7.5	......
1/2" - 3/4"	4.4	13.9	36.0	50.1	7.7	......
1/4" - 1/2"	4.4	12.5	36.2	51.3	7.1	......
1/8" - 1/4"	4.3	13.8	36.0	50.2	7.3	......
No. 48 - 1/8"	3.6	15.8	35.8	48.4	7.0	......
0 " - No. 48	3.5	24.3	34.3	41.4	7.5	10,240
Mine run	4.7	17.5	35.6	46.9	8.7	11,300
0 " - 4 "	4.5	15.3	35.3	49.4	7.8	11,790
1/8" - 4 "	4.6	16.7	34.7	48.6	8.0	11,520
3/4" - 4 "	4.6	17.1	34.2	48.7	8.5	11,380
0 " - 3/4"	4.4	15.2	35.5	49.3	7.5	11,675
0 " - 1½"	4.8	15.4	36.0	48.6	7.7	11,665
0 " - 1/8"	4.4	16.4	36.0	47.6	7.2	11,475

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE V

Ultimate Analyses

Sample	Dry Basis					
	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %
1/8" - 4 "	64.3	4.3	8.0	1.4	5.3	16.7
0 " - 1/8"	64.4	4.4	7.2	1.5	6.1	16.4

TABLE VI

Sulphur Forms and Fusain

Screen Sizes	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
0 " - 4 "	7.40	0.23	3.1	3.91	52.8	3.26	44.1	2.26
1/8" - 4 "	7.63	0.23	3.0	3.84	50.4	3.56	46.6	1.94
3/4" - 4 "	8.11	0.29	3.6	4.13	50.9	3.69	45.5	1.86
0 " - 3/4"	7.16	0.30	4.2	3.82	53.3	3.04	42.4	2.54
0 " - 1½"	7.35	0.26	3.5	4.05	55.1	3.04	41.4	2.36
0 " - 1/8"	6.84	0.38	5.5	3.85	56.3	2.61	38.2	7.24

TABLE VII

Fusibility of Ash

Screen Sizes*	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.	Ash %
Plus 4 "	1910	1980	2010	100	70	30	17.4
2 " - 4 "	1890	1950	1970	80	60	20	18.8
1½" - 2 "	1890	1960	1980	90	70	20	14.9
1 " - 1½"	1890	1950	1970	80	60	20	15.5
3/4" - 1 "	1890	1960	1980	90	70	20	13.7
1/2" - 3/4"	1890	1950	2000	110	60	50	13.9
1/4" - 1/2"	1870	1970	2090	220	100	120	12.5
1/8" - 1/4"	1900	2005	2100	200	105	95	13.8
No. 48 - 1/8"	1860	1980	2060	200	120	80	15.8
0 " - No. 48	2010	2090	2130	120	80	40	24.3
Mine run	1890	1960	1990	100	70	30	17.5
0 " - 4 "	1890	1965	2000	110	75	35	15.3
1/8" - 4 "	1900	1950	2000	100	50	50	16.7
3/4" - 4 "	1890	1960	2010	120	70	50	17.1
0 " - 3/4"	1880	1920	2000	120	40	80	15.2
0 " - 1½"	1880	1950	2000	120	70	50	15.4
0 " - 1/8"	1840	1900	1950	110	60	50	16.4

TABLE VIII

Chemical Analysis of Ash ≠

Screen Sizes*	SiO_2	Fe_2O_3	Al_2O_3	CaO+MnO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	Total
1/8" - 4 "	32.6	41.7	11.5	5.3	0.3	1.3	0.3	0.5	2.1	4.5	100.1
0 " - 1/8"	23.6	33.6	9.7	14.0	0.4	1.1	1.1	0.4	0.7	15.5	100.1

≠ Analysis made in chemical laboratory, Division of Metallic Minerals, under the direction of J.A. Fournier, Chief Chemist.

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE IX

Float and Sink Data on 1½" Slack - Ash and Sulphur

Specific Gravity		Weight	Ash	Sul-phur	Cumulative						±.10 Specific Gravity Distribution	
					Floats			Sinks				
		Weight %	Ash %	Sul-phur %	Weight %	Ash %	Sulphur %	Weight %	Ash %	Sulphur %	Gravity	Calculated Ordinate
Sinks	Floats										1.35	77.7
	1.30	5.1	5.6	4.4	5.1	5.6	4.4	100.0	15.1	7.3	1.40	80.6
1.30	1.40	50.4	7.0	5.1	55.5	6.9	5.0	94.9	15.6	7.4	1.45	54.4
1.40	1.50	22.9	14.8	7.3	78.4	9.2	5.7	44.5	25.3	10.0	1.55	16.5
1.50	1.60	6.3	22.9	9.1	84.7	10.2	6.0	21.6	36.4	12.9	1.65	5.8
1.60		15.3	41.9	14.5	100.0	15.1	7.3	15.3	41.9	14.5	1.75	3.8
Curve No.	4		2	2	1,2,4	1	1	3	3	3	5	5

TABLE X

Chemical Analysis of Coal and Fusibility of Ash on Float and Sink Portions of 1½" Slack

Specific Gravity		Ash %	Vola-tile Matter %	Fixed Carbon %	Coking Properties	Sul-phur	Initial Deform-ation °F.	Soft-ening Point °F.	Fluid Tempe-rature °F.	Melt-ing Range °F.	Soften-ing In-terval °F.	Flow Inter-val °F.
Sinks	Floats											
	1.30	5.8	39.4	54.8	Fair to Good	4.6	1880	1965	1990	110	85	25
1.30	1.40	7.3	39.0	53.7	Fair to Good	5.3	1900	1970	2020	120	70	50
1.40	1.50	15.3	35.9	48.8	Poor to Fair	7.5	1910	1975	1995	85	65	20
1.50	1.60	23.6	31.7	44.7	Poor	9.3	1890	1960	1990	100	70	30
1.60		43.0	26.3	30.7	Agglomerating	14.9	1900	1960	1990	90	60	30

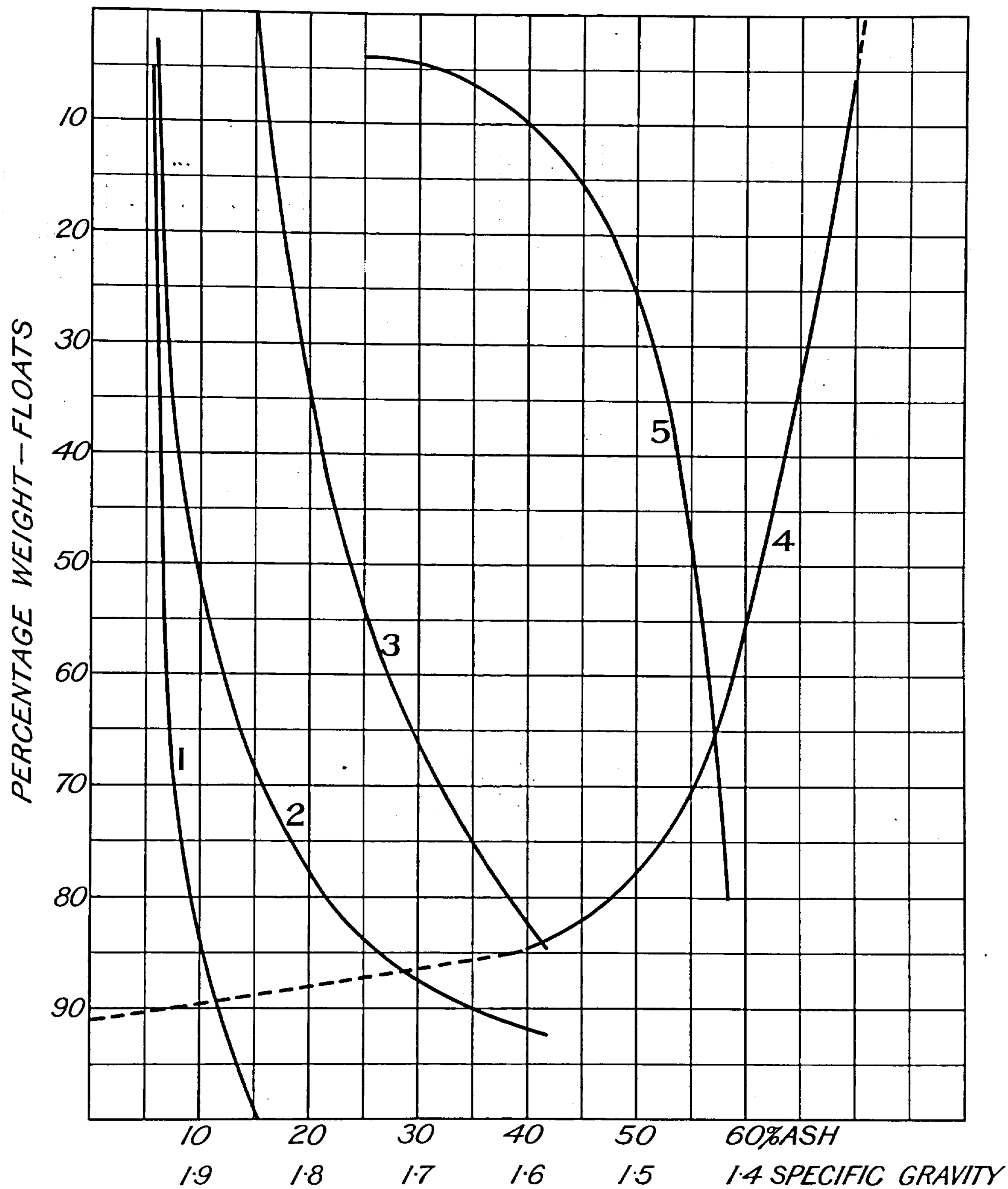

Fig. 3 - Washability curves for Port Hood Mine - Ash.

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

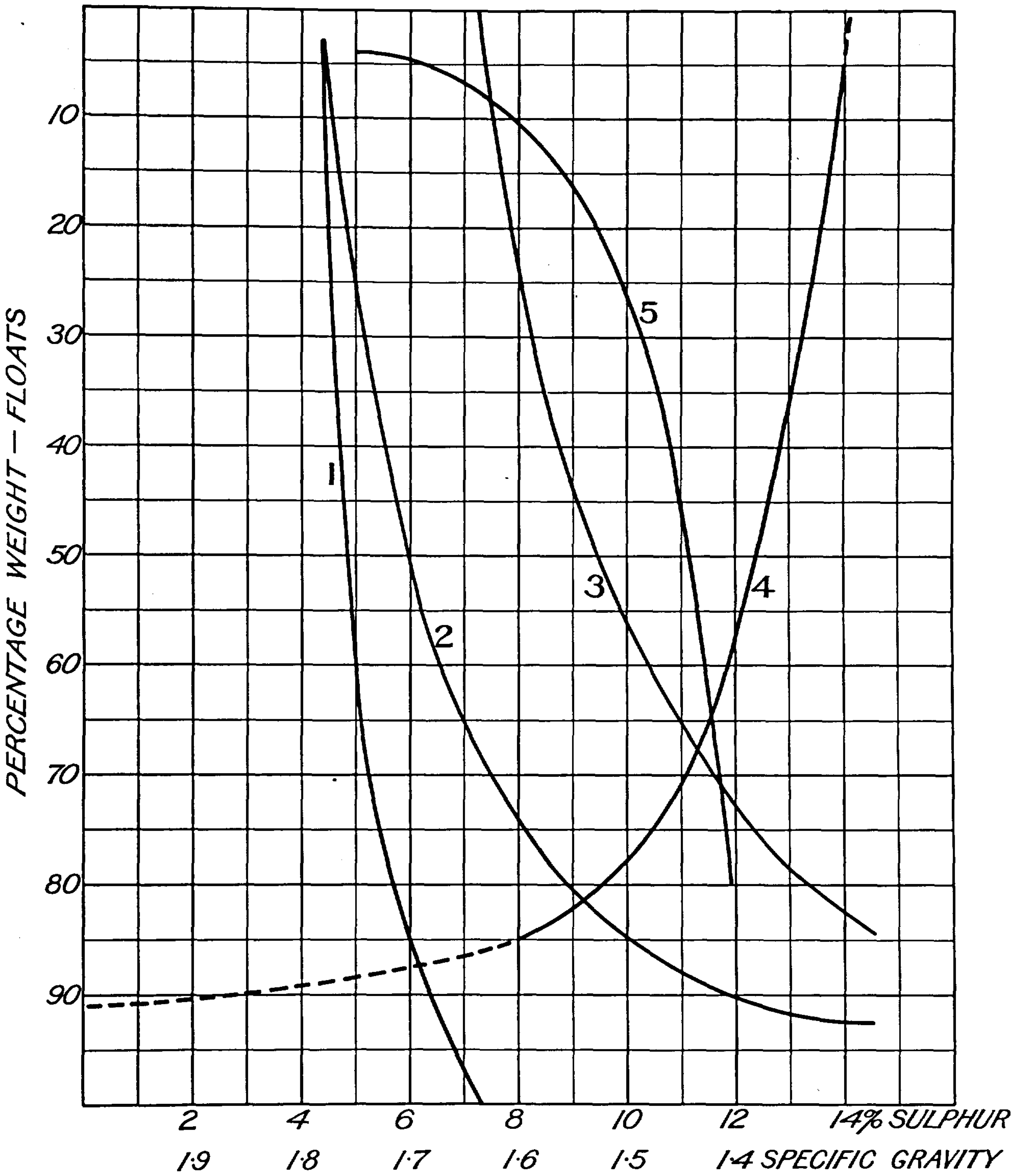

Fig. 4 - Washability curves for Port Hood Mine - Sulphur

Curve 1 - Cumulative coal-sulphur percentage (float).
Curve 2 - Actual sulphur percentage.
Curve 3 - Cumulative refuse-sulphur percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ±.10 specific gravity distribution.

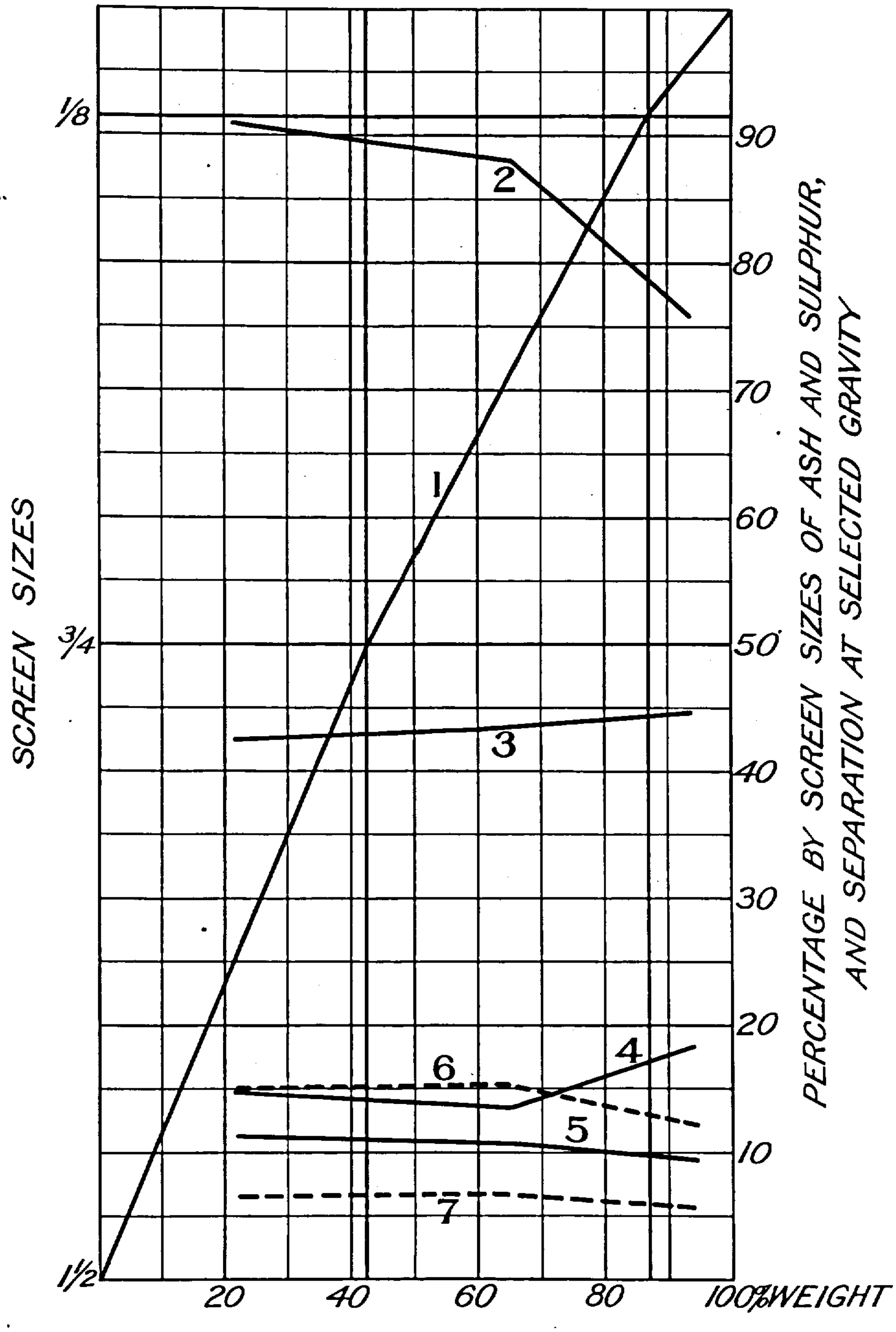

Fig. 5 - Curves showing screen analysis and washing data on screen sizes for Port Hood Mine.

Curve 1 - Sizing curve.
Curve 2 - Percentage float at 1.60 specific gravity.
Curve 3 - Percentage ash in sinks at 1.60 specific gravity.
Curve 4 - Percentage ash in screen sizes.
Curve 5 - Percentage ash in floats at 1.60 specific gravity.
Curve 6 - Percentage sulphur in screen sizes.
Curve 7 - Percentage sulphur in floats at 1.60 specific gravity.

TABLE XI

Chemical Analyses of Raw Coal, Clean Coal, and Refuse

	Raw Coal	Clean Coal Floats 1.60	Refuse Sinks 1.60
Weight....................%	100.0	86.4	13.6
Proximate analysis (dry basis)			
Ash...................%	15.4	10.7	42.8
Volatile Matter.........%	36.0	36.3	25.0
Fixed Carbon............%	48.6	53.0	32.2
Sulphur.................%	7.7	6.7	17.3
Calorific value.....Btu/lb	11,665	12,560	6,900 *
Fusion Point of Ash....°F.	1950	1930	1950
Melting Range of Ash...°F.	120	90	140
Coking properties.........	Poor	Poor to Fair	Non-coking

* Calculated.

TABLE XII

Sulphur Forms and Fusain of Raw Coal, Clean Coal and Refuse

	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
$1\frac{1}{2}$" Slack (raw)...	7.35	0.26	3.5	4.05	55.1	3.04	41.4	2.36
Clean coal: floats	6.42	0.17	2.6	2.91	45.3	3.34	52.1	2.24
Refuse: sinks.....	16.94	0.58	3.4	11.60	68.5	4.76	28.1	12.86

TABLE XIII

Screen and Chemical Analyses of Sizes Prepared from $1\frac{1}{2}$" Slack for Washing Tests -- Dry Basis

Screen Sizes (round holes)	Weight %	Cumulative Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - $1\frac{1}{2}$"	42.8	42.8	14.9	7.8	1955
1/8" - 3/4"	43.5	86.3	13.3	7.4	1970
0 " - 1/8"	13.7	100.0	16.4	7.2	1900

TABLE XIV

Analyses of Clean Coal and Refuse of Screened Sizes (Washed at Selected Gravity of 1.60)

Screen Sizes (round holes)	Floats				Sinks			
	Weight %	Ash %	Sulphur %	F.P.A. °F.	Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - $1\frac{1}{2}$"	90.9	11.2	6.4	1960	9.1	42.6	15.0	1960
1/8" - 3/4"	88.1	10.3	6.6	1950	11.9	43.3	15.2	1940
0 " - 1/8"	76.0	9.5	5.6	1955	24.0	44.7	12.2	2100

TABLE XV

Physical Properties of By-Product Coke
as Indicated by the "Swelling Index" Test

	1½" Slack	
	As received	After washing
Volatile matter at 600°C. (dry basis)..%	28.6	29.8
Swelling index..........................	-210	-190
Section--Coke classification chart......	XIII opposite VI	
Specific volatile index.................	138.7	143.0
Section--Coal classification chart......	C Sub-bituminous	
Ash per cent in coal (dry basis).......%	15.4	10.7
Physical properties of by-product coke:		
Size on wharf (% on 3" screen.........	....	....
(Breeze: % -1/2"........	....	....
Shatter test. (Index: % on 2" screen..	....	....
(Breeze: % -1/2"........	....	....
Abrasion test (Index: % on 1½" screen.	....	....
(Dust: % -1/16".........	....	....
Density...... (App. specific gravity..	....	....
(Lb. per cubic foot.....	....	....
Transverse shrinkage....................	Good	
Appearance of natural surface...........	....	
Shape...................................	....	
Strength................................	Very fragile	
Cross fracture..........................	....	
Longitudinal fracture...................	....	
Cell structure..........................	Practically none	
Sponge..................................	Granular	
Pebbly seam.............................	Pebbly	
Remarks.................................	Practically non-coking. Residue on carbonization is merely a char, not a coke.	

Caking Properties

	Caking index by Gray's method
0" - 4" sample..................................	24

SEVEN-FOOT SEAM

INVERNESS BASIN

NO. 1 MINE, INVERNESS COAL MINE, GOVT. CONTROL

INVERNESS, NOVA SCOTIA

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TABLE I

Screen Analyses, Bulk Density and Apparent Specific Gravity

Screen Sizes*	Screen Analyses As Received % Weight	Screen Analyses As Received % Cumulative	Screen Analyses As Mined % Weight	Screen Analyses As Mined % Cumulative	Bulk Density lb. per cu. ft.	Apparent Specific Gravity	Void %	Ash %
Plus 4 "	16.5	16.5	20.4	20.4	.....	....	....	....
2 " - 4 "	20.1	36.6	20.8	41.2	49.00	1.37	42.8	13.5
1½" - 2 "	8.3	44.9	8.7	49.9	46.50	1.39	46.4	11.5
1 " - 1½"	13.1	58.0	11.7	61.6	47.50	1.38	44.9	11.9
3/4" - 1 "	7.5	65.5	6.8	68.4	47.50	1.39	45.3	10.9
1/2" - 3/4"	9.6	75.1	9.0	77.4	47.00	1.38	45.5	12.1
1/4" - 1/2"	11.7	86.8	10.8	88.2	43.50	1.35	48.4	9.7
1/8" - 1/4"	6.4	93.2	5.2	93.9	44.00	1.37	48.6	13.0
No. 48 - 1/8"	5.2	98.4	4.8	98.2	.....	....	....	....
0 " - No. 48	1.6	100.0	1.8	100.0	.....	....	....	....
Mine Run		100.0		100.0	53.75	....	....	....
0 " - 4 "		83.5		79.6	56.50	....	....	....
1/8" - 4 "		76.7		73.0	52.75	....	....	....
3/4" - 4 "		49.0		48.0	47.25	....	....	....
0 " - 3/4"		34.5		31.6	51.75	....	....	....
0 " - 1½"		55.1		50.1	54.25	....	....	....
0 " - 1/8"		6.8		6.6	49.75	1.35	40.1	19.2

	As Mined	As Received
Average Size of run-of-mine coal............in.	2.284	2.074
Size Stability during handling from mine to Ottawa.................................%		89.5

* All screens 1/8" and larger are round hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II

Size Stability

	Screen Analyses Before and After Drop-shatter Test									
	Single Sizes				Mixed Sizes					
	2" - 3"		3" - 4"		3/4" - 4"			0" - 4"		
	Before test %	After 2 drops %	Before test %	After 2 drops %	Before test %	After 2 drops %	After 4 drops %	Before test %	After 2 drops %	After 4 drops %
3 " - 4 ".......			100.0	48.5	14.4	13.4	7.7	8.7	8.0	7.3
2 " - 3 "......	100.0	61.0		25.5	29.0	23.3	22.3	17.5	16.0	13.4
1½" - 2 "......		15.5		7.0	18.1	14.7	16.3	10.9	10.7	11.3
1 " - 1½"......		9.5		6.0	24.4	21.3	20.7	14.7	15.0	14.0
3/4" - 1 "......		4.0		3.0	14.1	13.3	13.3	8.5	11.7	12.0
1/2" - 3/4"......		3.0		3.0		6.7	8.0	11.3	13.3	13.4
0 " - 1/2"......		7.0		7.0		7.3	11.7	28.4	25.3	28.6
Average size..in.	2.500	1.987	3.500	2.596	1.974	1.751	1.567	1.333	1.298	1.217
Size stability..%		79.5		74.2		88.7	79.4		97.4	91.3

TABLE III

Grindability

Screen Size of Coal Tested	Hardgrove Index
0" - 4 "	62.3
0" - 3/4"	59.4
0" - 1/8"	61.3

TABLE IV

Proximate Analyses, Sulphur, and Calorific Value

Screen Sizes*	Moisture (as rec'd)	Dry Basis Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value BTU/lb.
Plus 4 "	5.0	15.7	39.0	45.3	9.2	.....
2 " - 4 "	5.0	13.5	39.9	46.6	8.1	.....
1½" - 2 "	5.2	11.5	39.9	48.6	6.9	.....
1 - 1½"	5.2	11.9	39.5	48.6	7.1	.....
3/4" - 1 "	5.3	10.9	39.8	49.3	6.5	.....
1/2" - 3/4"	5.3	12.1	39.1	48.8	6.3	.....
1/4" - 1/2"	5.4	9.7	40.0	50.3	5.4	.....
1/8 " - 1/4"	5.2	13.0	38.5	48.5	5.4	.....
No. 48 - 1/8"	3.8	19.1	35.4	45.5	5.2	.....
0 " - No. 48	2.9	26.2	28.5	45.3	5.6	9,955
Mine Run	4.9	13.7	39.8	46.5	8.6	11,680
0 " - 4 "	5.2	13.8	38.6	47.6	6.9	11,820
1/8" - 4 "	5.1	12.8	39.7	47.5	6.9	12,010
3/4" - 4 "	5.1	13.1	39.7	47.2	7.2	11,890
0 " - 3/4"	5.2	13.9	38.5	47.6	5.6	11,935
0 " - 1½"	5.3	14.1	38.0	47.9	6.3	11,925
0 " - 1/8"	4.7	19.2	34.2	46.6	6.7	10,920

* All screens 1/8" and larger are round-hole screens; No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE V

Ultimate Analyses

Sample	Dry Basis Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %
1/8" - 4 "	67.0	4.8	6.9	1.2	7.3	12.8
0 " - 1/8"	61.8	4.4	6.7	1.1	6.8	19.2

TABLE VI

Sulphur Forms and Fusain

Screen Sizes	Total Sulphur % of coal	Sulphate Sulphur % of coal	Sulphate Sulphur % of sulphur	Pyritic Sulphur % of coal	Pyritic Sulphur % of sulphur	Organic Sulphur % of coal	Organic Sulphur % of sulphur	Fusain % of Pure coal
0 " - 4 "	6.51	0.12	1.8	3.99	61.3	2.40	36.9	2.01
1/8" - 4 "	6.59	0.11	1.7	2.92	44.3	3.56	54.0	1.73
3/4" - 4 "	6.81	0.11	1.6	4.07	59.8	2.63	38.6	1.76
0 " - 3/4"	5.27	0.10	1.9	4.05	76.8	1.12	21.3	2.25
0 " - 1½"	6.00	0.14	2.3	3.70	61.7	2.16	36.0	2.65
0 " - 1/8"	6.40	0.18	2.8	3.20	50.0	3.02	47.2	5.92

TABLE VII

Fusibility of Ash

Screen Sizes*	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.	Ash %
Plus 4 "	1970	2080	2170	200	110	90	15.7
2 " - 4 "	1970	2070	2170	200	100	100	13.5
1½" - 2 "	1920	2050	2080	160	130	30	11.5
1 " - 1½"	1930	2080	2140	210	150	60	11.9
3/4" - 1 "	1930	2070	2120	190	140	50	10.9
1/2 "- 3/4"	1930	2040	2080	150	110	40	12.1
1/4" - 1/2"	1930	2010	2040	110	80	30	9.7
1/8" - 1/4"	1900	1970	2040	140	70	70	13.0
No. 48 - 1/8"	1920	2105	2190	270	185	85	19.1
0 " - No. 48	1940	2100	2390	450	160	290	26.2
Mine run	1970	2070	2170	200	100	100	13.7
0 " - 4 "	1900	2020	2040	140	120	20	13.8
1/8" - 4 "	1970	2070	2080	110	100	10	12.8
3/4" - 4 "	1930	2030	2070	140	100	40	13.1
0 " - 3/4"	1930	2020	2075	145	90	55	13.9
0 " - 1½"	1930	2025	2070	140	95	45	14.1
0 " - 1/8"	1980	2100	2200	220	120	100	19.2

TABLE VIII

Chemical Analysis of Ash ≠

Screen Sizes*	SiO_2	Fe_2O_3	Al_2O_3	CaO+MnO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	Total
1/8" - 4 "	27.0	51.4	15.2	2.5	0.1	0.8	0.9	0.7	0.1	1.0	99.7
0 " - 1/8"	43.8	26.6	21.5	2.4	1.0	1.2	1.7	0.9	0.1	0.3	99.5

≠ Analysis made in chemical laboratory, Division of Metallic Minerals, under the direction of J.A. Fournier, Chief Chemist

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE IX

Float and Sink Data on 1½" Slack - Ash and Sulphur

Specific Gravity		Weight %	Ash %	Sulphur %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Floats Sulphur %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	Cumulative Sinks Sulphur %	±.10 Specific Gravity Distribution: Gravity	±.10 Specific Gravity Distribution: Calculated Ordinate
Sinks	Floats										1.35	84.1
	1.30	9.3	2.7	2.5	9.3	2.7	2.49	100.0	11.1	5.3	1.40	79.1
1.30	1.40	63.9	5.2	4.0	73.2	4.9	3.84	90.7	12.0	5.6	1.45	42.4
1.40	1.50	11.6	13.8	7.2	84.8	6.1	4.30	26.8	28.1	9.2	1.55	12.8
1.50	1.60	5.8	19.6	9.4	90.6	7.0	4.62	15.2	39.0	10.7	1.65	5.8
1.60		9.4	50.9	11.6	100.0	11.1	5.28	9.4	50.9	11.6	1.75	1.6
Curve No.--4			2	2	1,2,4	1	1	3	3	3	5	5

TABLE X

Chemical Analysis of Coal and Fusibility of Ash on Float and Sink Portions of 1½" Slack

Specific Gravity		Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Sinks	Floats											
	1.30	2.9	43.5	53.6	Fair	2.6	1965	2100	2320	355	135	220
1.30	1.40	5.4	42.9	51.7	Fair to Poor	4.2	2000	2350	2650	650	350	300
1.40	1.50	14.3	40.1	45.6	Poor	7.4	1930	2050	2150	220	120	100
1.50	1.60	20.3	36.5	43.2	Poor	9.7	1930	2050	2150	220	120	100
1.60		52.1	21.5	26.4	Non-coking	11.9	1920	2040	2160	240	120	120

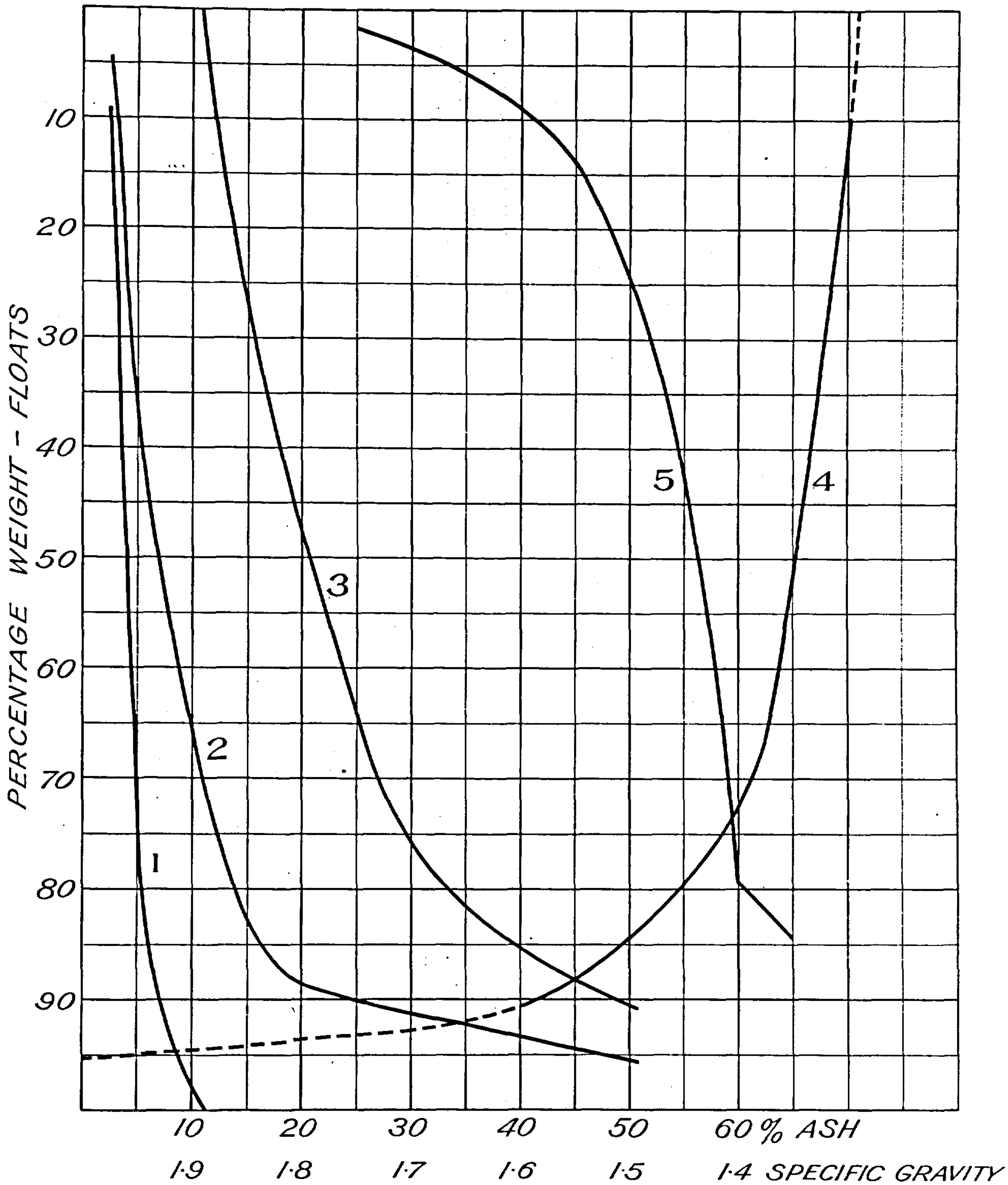

Fig. 6 - Washability Curves for Inverness No. 1 Mine — Ash

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

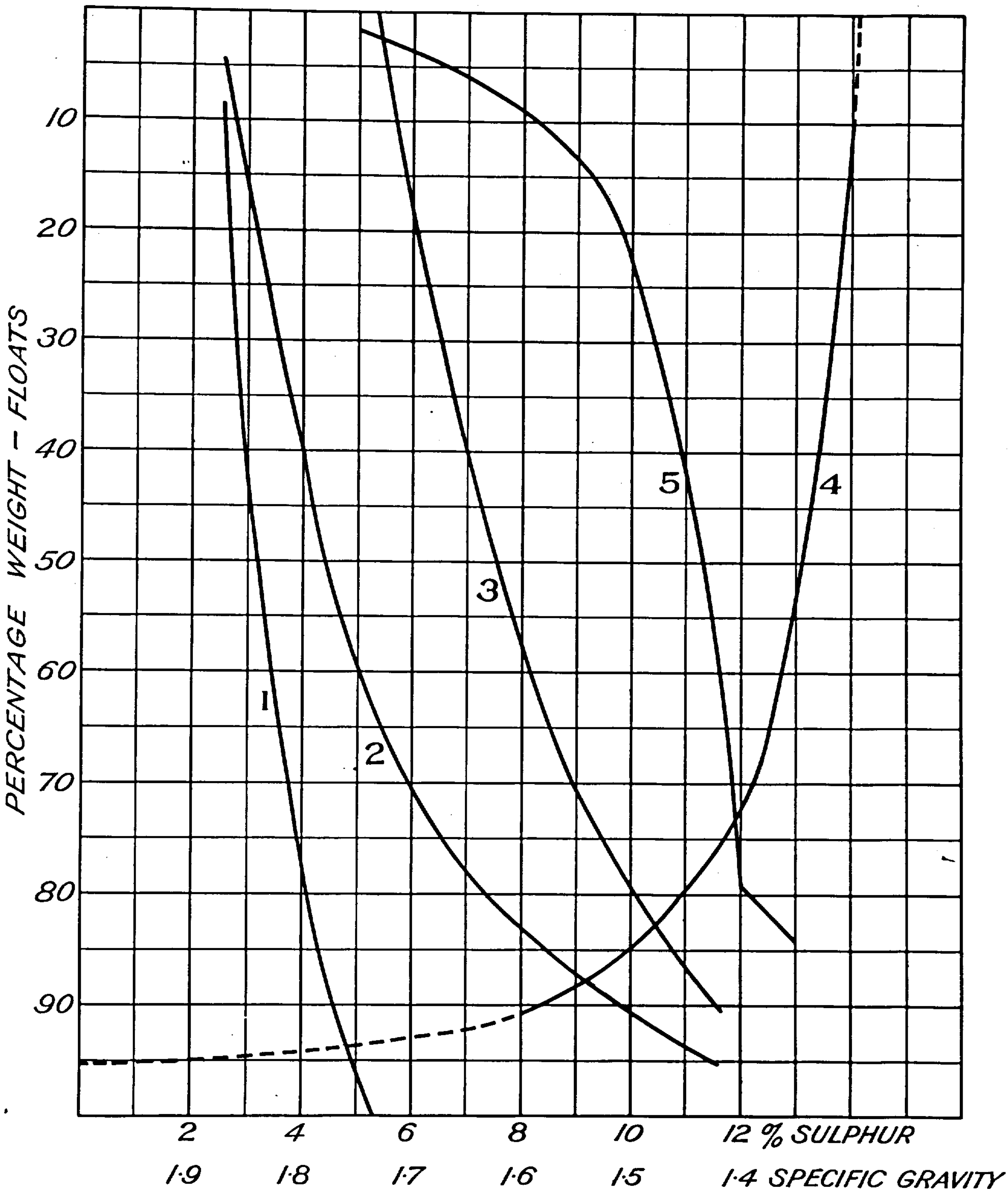

Fig. 7 - Washability Curves for Inverness No. 1 Mine —Sulphur

Curve 1 - Cumulative coal-sulphur percentage (float).
Curve 2 - Actual sulphur percentage.
Curve 3 - Cumulative refuse-sulphur percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ±.10 specific gravity distribution.

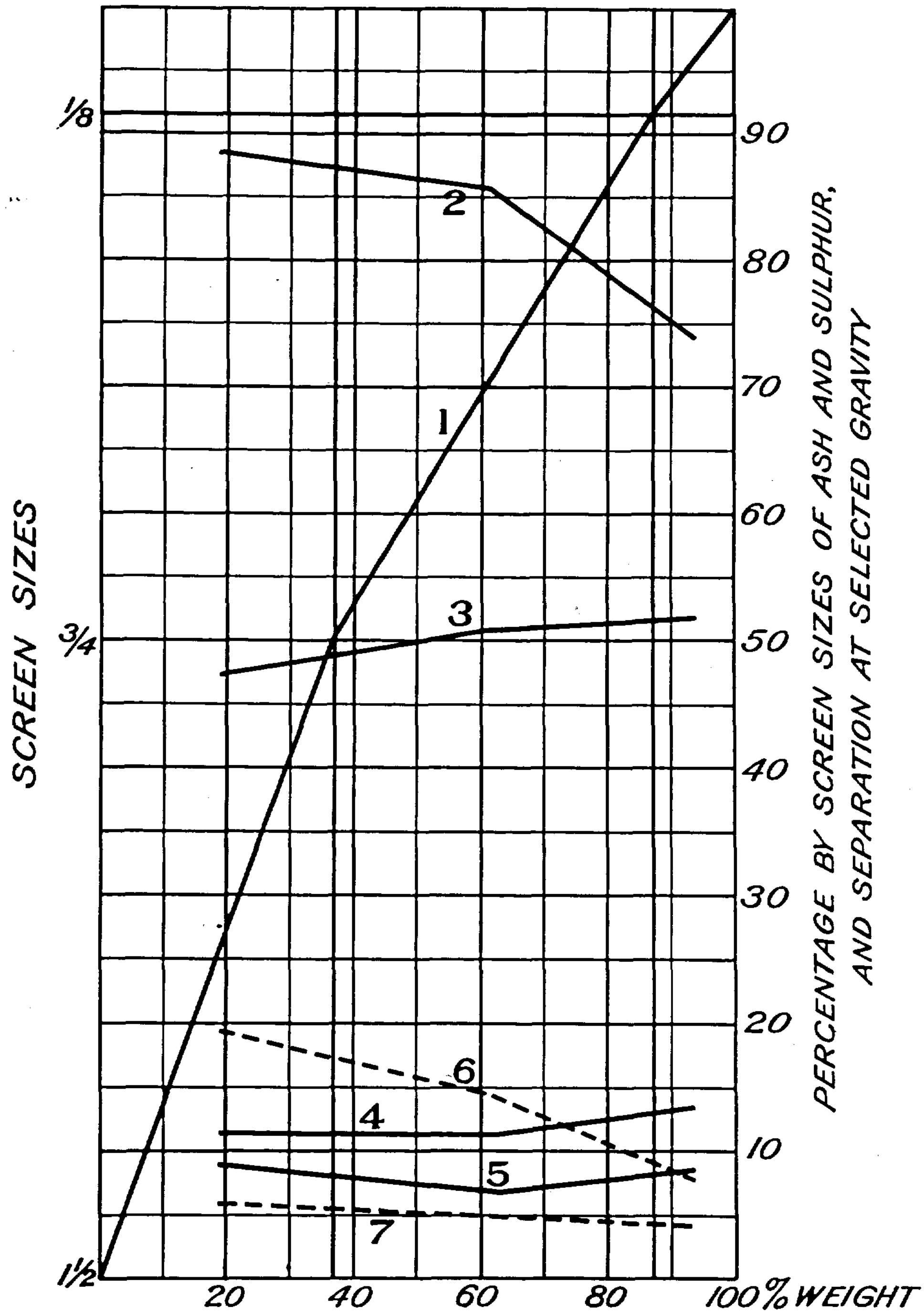

Fig. 8 - Curves showing screen analysis and washing data on screen sizes for Inverness No. 1 Mine.

Curve 1 - Sizing curve.
Curve 2 - Percentage float at 1.60 specific gravity.
Curve 3 - Percentage ash in sinks at 1.60 specific gravity.
Curve 4 - Percentage ash in screen sizes.
Curve 5 - Percentage ash in floats at 1.60 specific gravity.
Curve 6 - Percentage sulphur in sinks at 1.60 specific gravity.
Curve 7 - Percentage sulphur in floats at 1.60 specific gravity.

TABLE XI

Chemical Analyses of Raw Coal, Clean Coal, and Refuse

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight.......................%	100.0	83.2	16.8
Proximate Analysis (dry basis)			
Ash.......................%	14.1	7.2	40.8
Volatile Matter..........%	38.0	41.9	26.7
Fixed Carbon.............%	47.9	50.9	32.5
Sulphur..................%	6.3	5.1	13.8
Calorific Value B.t.u./lb	11,925	12,985	6,690*
Fusion Point of Ash.....°F	2025	2200	2010
Melting Range of Ash....°F	140	450	160
Coking Properties.........	Poor	Fair	Slightly agglomerating

*Calculated

TABLE XII

Sulphur Forms and Fusain of Raw Coal, Clean Coal and Refuse

	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure coal
1½" Slack (raw)...	6.00	0.14	2.3	3.70	61.7	2.16	36.0	2.67
Clean coal: floats	4.91	0.06	1.2	2.60	53.0	2.25	45.8	2.50
Refuse: sinks.....	13.47	0.26	1.9	10.15	75.4	3.06	22.7	7.04

TABLE XIII

Screen and Chemical Analyses of Sizes Prepared from 1½" Slack for Washing Tests -- Dry Basis

Screen Sizes (round holes)	Weight %	Cumulative Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - 1½"	36.9	36.9	11.5	6.9	2075
1/8" - 3/4"	49.9	86.8	11.3	5.7	2010
0 " - 1/8"	13.2	100.0	19.2	6.7	2100

TABLE XIV

Analyses of Clean Coal and Refuse of Screened Sizes (Washed at Selected Gravity of 1.50)

Screen Sizes (round holes)	Floats				Sinks			
	Weight %	Ash %	Sulphur %	F.P.A. °F.	Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - 1½"	88.6	8.9	6.0	2140	11.4	47.2	19.3	2030
1/8" - 3/4"	85.5	6.7	4.9	2170	14.5	50.7	14.2	2020
0 " - 1/8"	73.8	8.6	4.2	2030	26.2	51.7	8.0	2130

TABLE XV

Physical Properties of By-product Coke
as Indicated by the "Swelling Index" Test

	1½" Slack	
	As received	After washing
Volatile matter at 600°C. (dry basis)..%	31.1	34.5
Swelling index...........................	-161	-116
Section--Coke classification chart......	XIII opposite VI	
Specific volatile index.................	139.7	138.9
Section--Coal classification chart......	C Sub-bituminous	
Ash per cent in coal (dry basis).......%	14.1	7.2
Physical properties of by-product coke:		
Size on wharf (% on 3" screen.........	25.0	
Size on wharf (Breeze: % -1/2"........	4.0	
Shatter test. (Index: % on 2" screen..	30.0	
Shatter test. (Breeze: % -1/2"........	20.0	
Abrasion test. (Index: % on 1½" screen.	50.0	
Abrasion test. (Dust: % -1/16".........	15.0	
Density...... (App. specific gravity..	0.85	
Density...... (Lb. per cubic foot.....	23.5	
Transverse shrinkage..................	Good	
Appearance of natural surface.........	Dull grey, grannular	
Shape.................................	Irregular	
Strength..............................	Very friable	
Cross fracture........................	Medium amount, irregular	
Longitudinal fracture.................	Medium amount	
Cell structure........................	Practically none	
Sponge................................	Grannular ends	
Pebbly seam...........................	Very pebbly	
Remarks...............................	Practically non-coking. Residue on carbonization is more like a char than coke.	

Caking Properties

	Caking index by Gray's method
Run-of-mine sample.....................	18

THIRTEEN-FOOT SEAM

INVERNESS BASIN

NO. 4 MINE, INVERNESS COAL MINE, GOVT. CONTROL

INVERNESS, NOVA SCOTIA

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TABLE I

Screen Analyses, Bulk Density and Apparent Specific Gravity

Screen Sizes*	Screen Analyses				Bulk Density	Apparent	Void	Ash
	As received		As mined		---	Specific Gravity		
	% Weight	% Cumulative	% Weight	% Cumulative	lb. per cu. ft.			
Plus 4 "	25.4	25.4	41.2	41.2	.....	....	....	....
2 " - 4 "	22.9	48.3	17.0	58.2	44.50	1.48	51.8	10.7
1½" - 2 "	5.4	57.3	6.8	65.0	43.00	1.45	52.6	10.8
1 " - 1½"	12.2	65.9	8.9	73.9	43.25	1.43	51.6	11.4
3/4" - 1 "	7.3	73.2	5.6	79.5	45.00	1.41	48.9	10.0
1/2" - 3/4"	8.0	81.2	6.3	85.8	45.00	1.39	48.2	10.3
1/4" - 1/2"	9.1	90.3	6.9	92.7	45.25	1.38	48.3	9.5
1/8" - 1/4"	4.2	94.5	3.2	95.9	46.50	1.40	47.9	12.4
No. 48 - 1/8"	4.0	98.5	3.2	99.1	} 51.00	....	....	....
0 " - No. 48	1.5	100.0	0.9	100.0		....	....	....
Mine run		100.0		100.0	60.00	....	....	....
0 " - 4 "		74.6		58.8	54.00	....	....	....
1/8" - 4 "		69.1		54.7	50.75	....	....	....
3/4" - 4 "		47.8		38.3	47.50	....	....	....
0 " - 3/4"		26.8		20.5	50.50	....	....	....
0 " - 1½"		46.3		35.0	54.00	....	....	....
0 " - 1/8"		5.5		4.1	51.00	1.43	42.9	20.2

	As mined	As received
Average size of run-of-mine coal............in.	3.314	2.582
Size stability during handling from mine to Ottawa..................................%		77.9

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh, with nominal aperture of 0.295 mm.

TABLE II

Size Stability

	Screen Analyses Before and After Drop-shatter Test									
	Single sizes				Mixed sizes					
	2" - 3"		3" - 4"		3/4" - 4"			0" - 4"		
	Before Test %	After 2 drops %	Before test %	After 2 drops %	Before test %	After 2 drops %	After 4 drops %	Before test %	After 2 drops %	After 4 drops %
3 " - 4 "			100.0	40.0	16.1	10.8	7.7	10.3	6.2	2.3
2 " - 3 "	100.0	60.8		24.5	31.8	15.3	13.3	20.4	18.7	18.9
1½" - 2 "		12.2		10.0	11.3	19.0	17.3	7.2	7.7	8.1
1 " - 1½"		9.5		8.0	25.5	21.7	19.7	16.4	17.7	16.5
3/4" - 1 "		4.5		4.0	15.3	14.7	15.0	9.8	10.0	10.1
1/2" - 3/4"		4.8		4.0		7.7	10.0	10.7	12.0	12.1
0 " - 1/2"		8.2		9.5		10.8	17.0	25.2	27.7	32.0
Average size In.	2.500	1.942	3.500	2.372	2.010	1.569	1.389	1.417	1.265	1.084
Size stability %		77.7		67.8		78.1	69.1		89.3	76.5

TABLE III

Grindability

Screen Size of Coal Tested	Hardgrove Index
0" - 4 "	60.9
0" - 3/4"	65.7
0" - 1/8"	67.6

TABLE IV

Proximate Analyses, Sulphur, and Calorific Value

Screen Sizes*	Moisture --- (as rec'd)	Dry basis				
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.
Plus 4 "	7.9	12.5	38.7	48.8	8.9	......
2 " - 4 "	7.8	10.7	39.5	49.8	7.6	......
1½" - 2 "	7.6	10.8	39.5	49.7	7.5	......
1 " - 1½"	7.6	11.4	39.0	49.6	7.5	......
3/4" - 1 "	7.5	10.0	39.4	50.6	6.8	......
1/2" - 3/4"	7.7	10.3	39.4	50.3	6.9	......
1/4" - 1/2"	7.6	9.5	39.9	50.6	6.6	......
1/8" - 1/4"	7.2	12.4	38.3	49.3	7.0	......
No. 48 - 1/8"	5.3	16.4	36.4	47.2	7.0	......
0 " - No. 48	3.2	29.9	27.7	42.4	7.3	9,215
Mine run	7.6	12.2	38.5	49.3	8.0	11,870
0 " - 4 "	7.6	12.0	38.5	49.5	7.9	11,835
1/8" - 4 "	7.6	10.8	39.4	49.8	7.5	12,060
3/4" - 4 "	7.6	11.1	39.2	49.7	8.0	11,985
0 " - 3/4"	7.5	13.1	38.1	48.8	7.0	11,825
0 " - 1½ "	7.5	12.8	37.9	49.3	7.5	11,785
0 " - 1/8"	6.3	20.2	33.7	46.1	7.0	10,735

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE V

Ultimate Analyses

Sample	Dry basis					
	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %
1/8" - 4 "	67.7	4.7	7.5	1.3	8.0	10.8
0 " - 1/8"	61.1	4.1	7.0	1.2	6.4	20.2

TABLE VI

Sulphur Forms and Fusain

Screen Sizes	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
0 " - 4 "	7.27	0.24	3.3	4.31	59.3	2.72	37.4	2.14
1/8" - 4 "	6.96	0.22	3.2	4.07	58.4	2.67	38.4	1.86
3/4" - 4 "	7.37	0.24	3.3	4.34	58.9	2.79	37.8	1.75
0 " - 3/4"	6.50	0.22	3.4	3.96	60.9	2.32	35.7	2.32
0 " - 1½"	6.96	0.23	3.3	4.30	61.8	2.43	34.9	2.48
0 " - 1/8"	6.58	0.32	4.9	4.56	69.3	1.70	25.8	8.32

TABLE VII

Fusibility of Ash

Screen Sizes*	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.	Ash
Plus 4 "	2200	2300	2500	300	100	200	12.5
2 " - 4 "	2040	2430	2450	410	390	20	10.7
1½" - 2 "	2040	2430	2450	410	390	20	10.8
1 " - 1½"	2040	2430	2450	410	390	20	11.4
3/4" - 1 "	2100	2430	2450	350	330	20	10.0
1/2" - 3/4"	2100	2430	2450	350	330	20	10.3
1/4" - 1/2"	1960	2240	2310	350	280	70	9.5
1/8" - 1/4"	2000	2200	2470	470	200	270	12.4
No. 48 - 1/8"	2000	2150	2460	460	150	310	16.4
0 " - No. 48	1870	1950.	2050	180	80	100	29.9
Mine run	2000	2350	2450	450	350	100	12.2
0 " - 4 "	2100	2260	2450	350	160	190	12.0
1/8" - 4 "	2040	2350	2410	370	310	60	10.8
3/4" - 4 "	2040	2200	2440	400	160	240	11.1
0 " - 3/4"	1900	2000	2200	300	100	200	13.1
0 " - 1½"	1930	2140	2330	400	210	190	12.8
0 " - 1/8"	1890	1915	2010	120	25	95	20.2

TABLE VIII

Chemical Analysis of Ash ≠

Screen Sizes*	SiO_2	Fe_2O_3	Al_2O_3	CaO+MnO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	Total
1/8" - 4 "	14.4	67.2	8.7	4.4	0.5	1.6	0.4	0.3	0.4	1.5	99.4
0 " - 1/8"	27.8	35.2	15.7	9.4	0.7	1.6	1.2	0.4	0.2	8.4	100.6

≠ Analysis made in chemical laboratory, Division of Metallic Minerals, under the direction of J.A. Fournier, Chief Chemist.

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE IX

Float and Sink Data on 1½" Slack -- Ash and Sulphur

Specific Gravity		Weight	Ash	Sul-phur	Cumulative						±.10 Specific Gravity Distribution	
					Floats			Sinks				
					Weight	Ash	Sulphur	Weight	Ash	Sulphur	Gravity	Calculated Ordinate
Sinks	Floats	%	%	%	%	%	%	%	%	%		
											1.35	75.8
	1.30	8.9	3.2	3.0	8.9	3.2	3.0	100.0	11.3	6.9	1.40	73.2
1.30	1.40	53.2	5.3	4.4	62.1	5.0	4.2	91.1	12.1	7.3	1.45	48.0
1.40	1.50	17.2	12.1	8.4	79.3	6.5	5.1	37.9	21.7	11.3	1.55	20.4
1.50	1.60	10.6	16.9	11.9	89.9	7.8	5.9	20.7	29.7	13.7	1.65	8.9
1.60		10.1	43.2	15.6	100.0	11.3	6.9	10.1	43.2	15.6	1.75	3.1
Curve No.		4	2	2	1,2,4	1	1	3	3	3	5	5

TABLE X

Chemical Analysis of Coal and Fusibility of Ash on Float and Sink Portions of 1½" Slack

Specific Gravity		Ash %	Vola-tile Matter %	Fixed Carbon %	Coking Properties	Sul-phur %	Initial Deform-ation °F.	Soft-ening Point °F.	Fluid Tempe-rature °F.	Melt-ing Range °F.	Soften-ing In-terval °F.	Flow Inter-val °F.
Sinks	Floats											
	1.30	3.5	43.6	52.9	Fair	3.2	2050	2160	2200	150	110	40
1.30	1.40	5.7	42.1	52.2	Fair to Poor	4.7	2020	2320	2420	400	300	100
1.40	1.50	12.9	39.4	47.7	Poor	8.9	2200	2420	2450	250	220	30
1.50	1.60	18.0	35.6	46.4	Poor	12.7	2200	2430	2500	300	230	70
1.60		45.0	25.1	29.9	Non-coking	16.2	1930	2030	2070	140	100	40

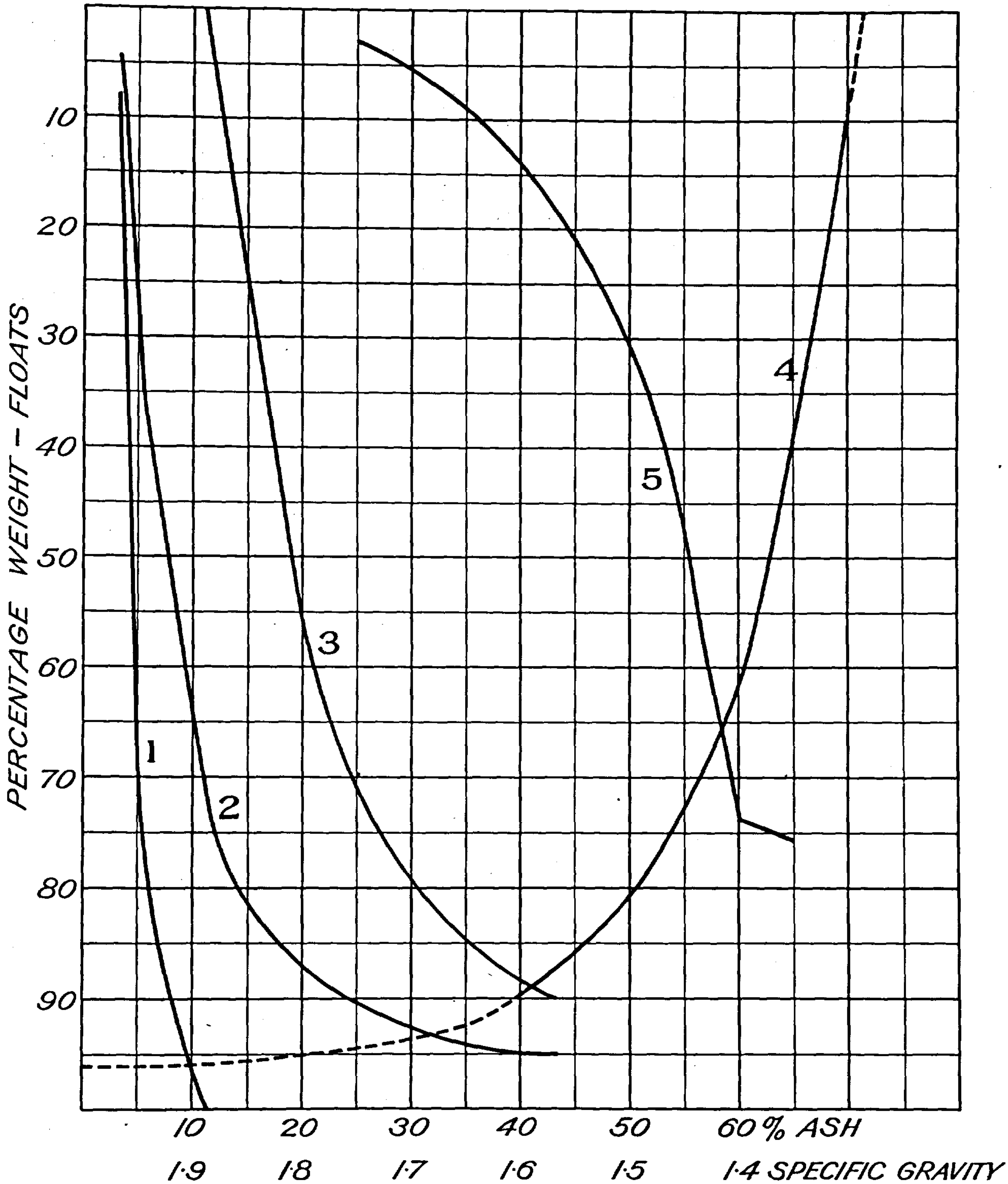

Fig. 9 - Washability Curves for Inverness No. 4 Mine - Ash

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

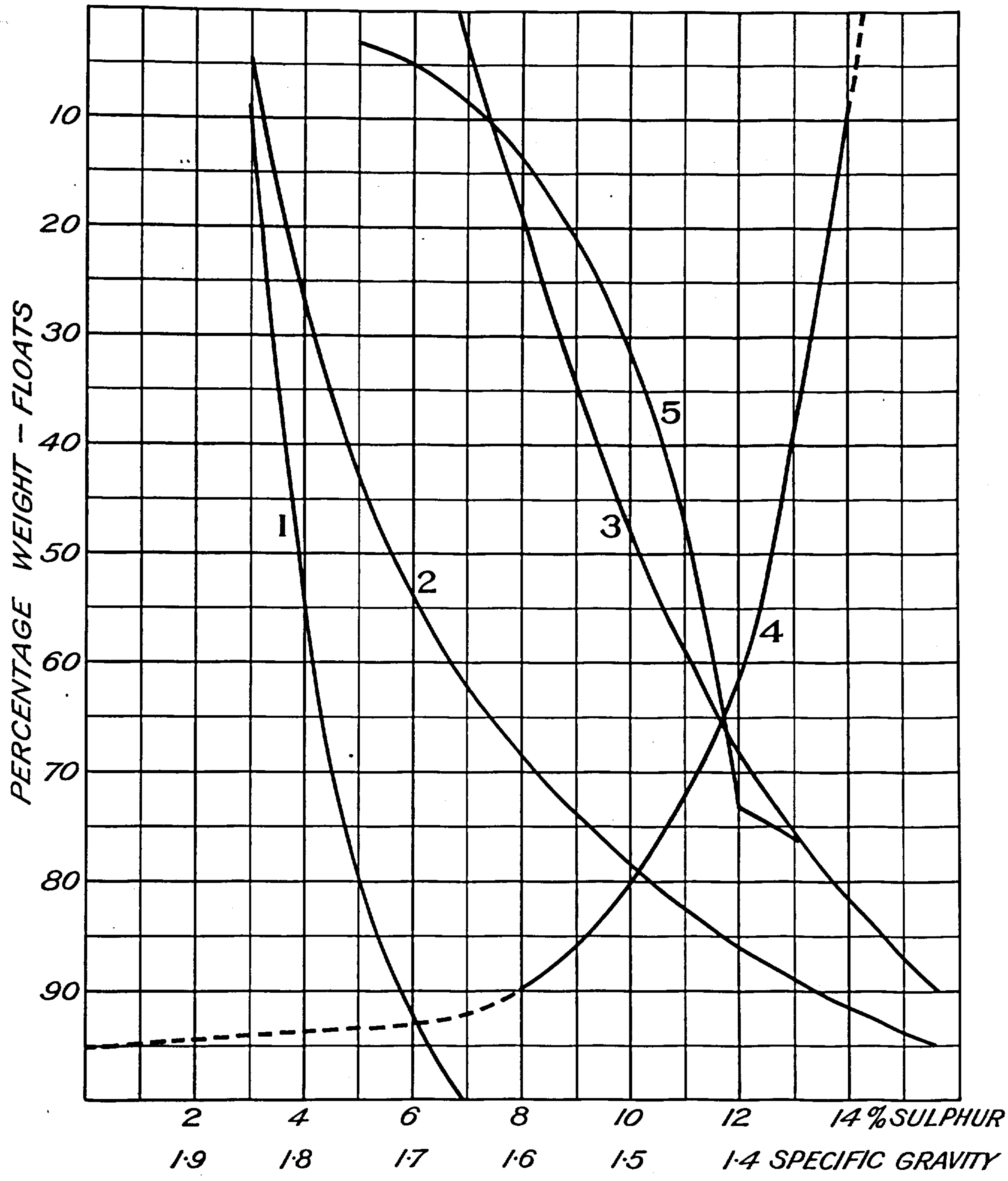

Fig. 10 - Washability Curves for Inverness No. 4 Mine - Sulphur

Curve 1 - Cumulative coal-sulphur percentage (float).
Curve 2 - Actual sulphur percentage.
Curve 3 - Cumulative refuse-sulphur percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ±.10 specific gravity distribution.

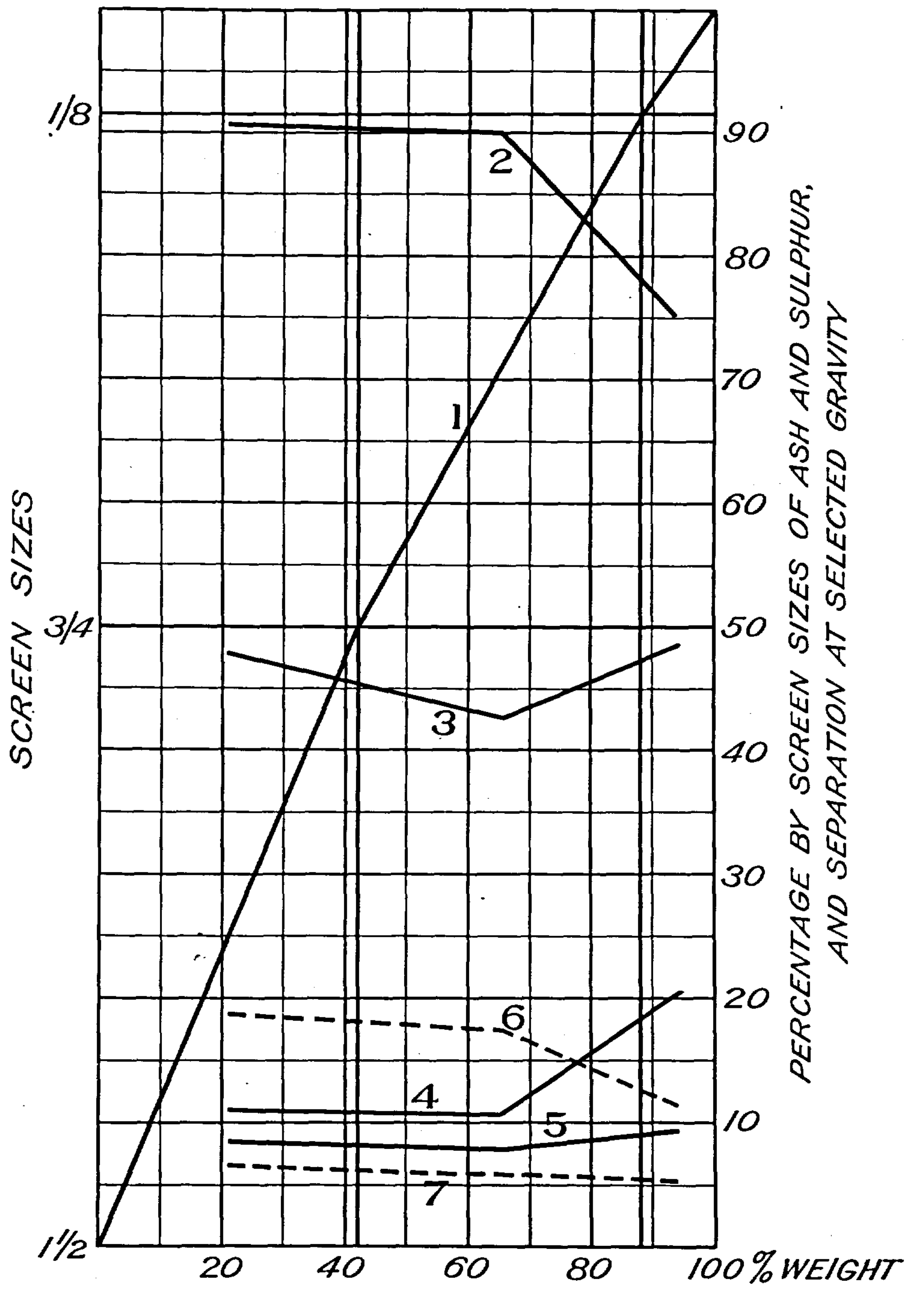

Fig. 11 - Curves showing screen analysis and washing data on screen sizes for Inverness No. 4 Mine.

Curve 1 - Sizing curve.
Curve 2 - Percentage float at 1.60 specific gravity.
Curve 3 - Percentage ash in sinks at 1.60 specific gravity.
Curve 4 - Percentage ash in screen sizes.
Curve 5 - Percentage ash in floats at 1.60 specific gravity.
Curve 6 - Percentage sulphur in sinks at 1.60 specific gravity.
Curve 7 - Percentage sulphur in floats at 1.60 specific gravity.

TABLE XI

Chemical Analyses of Raw Coal, Clean Coal, and Refuse

	Raw Coal	Clean Coal Floats 1.60	Refuse Sinks 1.60
Weight....................%	100.0	91.0	9.0
Proximate Analysis (dry basis)			
Ash.....................%	12.8	8.3	41.7
Volatile matter..........%	37.9	40.9	25.1
Fixed carbon.............%	49.3	50.8	33.2
Sulphur..................%	7.5	6.3	15.7
Calorific value.....Btu/lb	11,785	12,660	5,810 *
Fusion point of ash....°F.	2140	2540	2130
Melting range of ash...°F.	400	190	320
Coking properties.........	Poor	Poor to Fair	Slightly Agglomerates

* Calculated.

TABLE XII

Sulphur Forms and Fusain of Raw Coal, Clean Coal and Refuse

	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
$1\frac{1}{2}$" Slack (raw)...	6.96	0.23	3.3	4.30	61.8	2.43	34.9	2.48
Clean coal: floats	5.93	0.14	2.4	3.23	54.5	2.56	43.1	2.24
Refuse: sinks.....	15.29	0.56	3.7	11.97	78.3	2.76	18.0	12.36

TABLE XIII

Screen and Chemical Analyses of Sizes Prepared from $1\frac{1}{2}$" Slack for Washing Tests -- Dry Basis

Screen Sizes (round holes)	Weight %	Cumulative Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - $1\frac{1}{2}$"	42.1	42.1	10.9	7.2	2430
1/8" - 3/4"	46.0	88.1	10.4	6.8	2300
0 " - 1/8"	11.9	100.0	20.2	7.0	1915

TABLE XIV

Analyses of Clean Coal and Refuse of Screened Sizes (Washed at Selected Gravity of 1.60)

Screen Sizes (round holes)	Floats				Sinks			
	Weight %	Ash %	Sulphur %	F.P.A. °F.	Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - $1\frac{1}{2}$"	90.4	8.3	6.5	2440	9.6	47.7	18.9	2070
1/8" - 3/4"	90.0	7.7	6.0	2350	10.0	42.3	17.3	2030
0 " - 1/8"	75.1	9.4	5.2	2170	24.9	48.5	11.2	2080

TABLE XV

Physical Properties of By-product Coke
as Indicated by the "Swelling Index" Test

		1½" Slack	
		As received	After wasing
Volatile matter at 600°C. (dry basis)...		31.5	34.7
Swelling index...........................		-174	-125
Section--Coke classification chart......		XIII opposite VI	
Specific volatile index.................		130.1	135.4
Section--Coal classification chart......		C Sub-bituminous	
Ash per cent in coal (dry basis).......%		12.8	8.3
Physical properties of by-product coke:			
Size on wharf	% on 3" screen.........	25.0	25.0
	Breeze: % -1/2"........	4.0	4.0
Shatter test	Index: % on 2" screen..	30.0	30.0
	Breeze: % -1/2"........	20.0	20.0
Abrasion test	Index: % on 1½" screen.	50.0	50.0
	Dust: % -1/16".........	15.0	15.0
Density......	App. specific gravity..	0.85	0.85
	Lb. per cubic foot.....	23.5	23.5
Transverse shrinkage.................		Good	Good
Appearance of natural surface.........		Dull grey, granular	
Shape................................		Irregular	
Strength.............................		Very friable	
Cross fracture.......................		Medium amount, irregular	
Longitudinal fracture................		Medium amount	
Cell structure.......................		Practically none	
Sponge...............................		Granular ends	
Pebbly seam..........................		Very pebbly	
Remarks..............................		Practically non-coking. Residue on carbonization is more like a char than coke.	

Caking Properties

	Caking index by Gray's method
Run-of-mine sample..............................	10

SIX-FOOT SEAM

ST. ROSE BASIN

ST. ROSE MINE, ST. ROSE, NOVA SCOTIA

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TABLE I

Screen Analyses, Bulk Density and Apparent Specific Gravity

Screen Sizes*	Screen Analyses As received % Weight	% Cumulative	Bulk Density --- lb. per cu. ft.	Apparent Specific Gravity	Void %	Ash %
Plus 4 "	12.8	12.8	.....	....	....	11.5
2 " - 4 "	19.7	32.5	43.50	1.38	49.5	12.7
1½" - 2 "	9.7	42.2	43.25	1.40	50.6	11.3
1 " - 1½"	13.4	55.6	43.50	1.38	49.5	10.5
3/4" - 1 "	8.6	64.2	43.75	1.38	49.2	10.5
1/2" - 3/4"	9.6	73.8	44.00	1.37	48.6	10.0
1/4" - 1/2"	10.0	83.8	45.00	1.39	48.2	11.1
1/8" - 1/4"	7.0	90.8	42.75	1.39	50.8	12.0
No. 48 - 1/8"	6.6	97.4	51.00	1.39	41.3	15.7
0 " - No. 48	2.6	100.0				22.4
Mine run		100.0	54.50	....	....	12.4
0 " - 4 "		87.2	52.25	....	....	12.7
1/8" - 4 "		78.0	49.00	....	....	11.3
3/4" - 4 "		51.4	48.50	....	....	11.4
0 " - 3/4"		35.8	50.00	....	....	12.8
0 " - 1½"		57.8	54.50	....	....	11.9
0 " - 1/8"		9.2	51.00	1.39	41.3	15.9

	As received
Average size of run-of-mine coal..........in.	1.927

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh, with nominal aperture of 0.295 mm.

TABLE II

Size Stability

	Screen Analyses Before And After Drop-shatter Test			
	Single Sizes			
	2" - 3"		3" - 4"	
	Before test %	After 2 drops %	Before test %	After 2 drops %
3 " - 4 "			100.0	32.0
2 " - 3 "	100.0	61.1		25.6
1½" - 2 "		13.0		12.4
1 " - 1½"		9.3		11.7
3/4" - 1 "		4.9		5.1
1/2" - 3/4"		4.5		4.4
0 " - 1/2"		7.2		8.8
Average size..in.	2.500	1.962	3.500	2.219
Size stability..%		78.5		63.4

TABLE III

Grindability

Screen Size of Coal Tested	Hardgrove Index
0" - 4 "	62.7
0" - 3/4"	64.7
0" - 1/8"	68.1

TABLE IV

Proximate Analyses, Sulphur, and Calorific Value

Screen Sizes*	Moisture (as rec'd) %	Dry Basis				
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.
Plus 4 "	5.8	11.5	36.9	51.6	7.3	......
2 " - 4 "	4.7	12.7	36.6	50.7	7.6	......
1½" - 2 "	3.9	11.3	36.8	51.9	7.1	......
1 " - 1½"	4.9	10.5	37.5	52.0	6.8	......
3/4" - 1 "	4.5	10.5	37.4	52.1	6.6	......
1/2" - 3/4"	4.7	10.0	37.6	52.4	6.8	......
1/4" - 1/2"	5.2	11.1	37.3	51.6	7.4	......
1/8" - 1/4"	5.3	12.0	36.9	51.1	7.6	......
No. 48 - 1/8"	4.5	15.7	36.7	47.6	7.4	......
0 " - No. 48	3.5	22.4	34.9	42.7	6.9	......
Mine run	5.1	12.4	36.8	50.8	7.6	12,300
0 " - 4 "	4.8	12.7	36.8	50.5	7.4	12,100
1/8" - 4 "	5.0	11.3	37.2	51.5	7.3	12,380
3/4" - 4 "	4.7	11.4	36.9	51.7	7.1	12,415
0 " - 3/4"	5.4	12.8	37.0	50.2	7.3	12,145
0 " - 1½"	4.7	11.9	37.4	50.7	7.2	12,245
0 " - 1/8"	5.4	15.9	36.4	47.7	7.1	11,455

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE V

Ultimate Analyses

Sample	Dry Basis					
	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %
0" - 4"	67.8	4.5	7.4	1.4	6.2	12.7

TABLE VI

Sulphur Forms and Fusain

Screen Sizes	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
0 " - 4 "	7.03	0.42	6.0	3.84	54.6	2.77	39.4	3.74
3/4" - 4 "	6.74	0.40	5.9	3.39	50.3	2.95	43.8	3.25
0 " - 3/4"	6.88	0.42	6.1	3.96	57.6	2.50	36.3	3.96
0 " - 1½"	6.86	0.40	5.8	3.82	55.7	2.64	38.5	3.89
0 " - 1/8"	6.68	0.62	9.3	4.16	62.3	1.90	28.4	5.84

TABLE VII

Fusibility of Ash

Screen Sizes*	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.	Ash %
Plus 4 "	1840	2015	2180	340	175	165	11.5
2 " - 4 "	1930	2070	2100	170	140	30	12.7
1½" - 2 "	1950	2100	2125	175	150	25	11.3
1 " - 1½"	1920	2060	2100	180	140	40	10.5
3/4" - 1 "	1900	2010	2070	170	110	60	10.5
1/2" - 3/4"	1900	2010	2070	170	110	60	10.0
1/4" - 1/2"	1930	2030	2080	150	100	50	11.1
1/8" - 1/4"	1820	1995	2130	310	175	135	12.0
No. 48 - 1/8"	1890	2030	2110	220	140	80	15.7
0 " - No. 48	2110	2160	2210	100	50	50	22.4
Mine run	1910	2030	2070	160	120	40	12.4
0 " - 4 "	1950	2050	2090	140	100	40	12.7
1/8" - 4 "	1880	2030	2070	190	150	40	11.3
3/4" - 4 "	1870	1980	2050	180	110	70	11.4
0 " - 3/4"	1830	1950	2030	200	120	80	12.8
0 " - 1½"	1890	2030	2050	160	140	20	11.9
0 " - 1/8"	1830	1900	1970	140	70	70	15.9

TABLE VIII

Chemical Analysis of Ash ≠

Screen Sizes*	SiO_2	Fe_2O_3	Al_2O_3	CaO+MnO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	Total
0" - 4"	23.8	58.7	9.5	2.4	0.1	nil	2.8	0.6	0.2	2.3	100.4

≠ Analysis made in chemical laboratory, Division of Metallic Minerals, under the direction of J.A. Fournier; Chief Chemist.

* All screens 1/8" and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE IX

Float and Sink Data on 1½" Slack -- Ash and Sulphur

Specific Gravity		Weight	Ash	Sulphur	Cumulative						±.10 Specific Gravity Distribution	
					Floats			Sinks				
					Weight	Ash	Sulphur	Weight	Ash	Sulphur	Gravity	Calculated Ordinate
Sinks	Floats	%	%	%	%	%	%	%	%	%		
											1.35	85.7
	1.30	10.4	3.8	3.6	10.4	3.8	3.6	100.0	12.4	7.1	1.40	81.0
1.30	1.40	53.6	7.4	5.5	64.0	6.8	5.2	89.6	13.4	7.5	1.45	44.7
1.40	1.50	23.3	13.3	7.9	87.3	8.5	5.9	36.0	22.3	10.5	1.55	11.5
1.50	1.60	4.1	18.7	8.9	91.4	9.0	6.0	12.7	38.9	15.3	1.65	3.7
1.60		8.6	48.6	18.3	100.0	12.4	7.1	8.6	48.6	18.3	1.75	2.2
Curve No. 4			2	2	1,2,4	1	1	3	3	3	5	5

TABLE X

Chemical Analysis of Coal and Fusibility of Ash on Float and Sink Portions of 1½" Slack

Specific Gravity		Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Sinks	Floats											
	1.30	3.9	38.7	57.4	Good	3.7	1900	1980	2010	110	80	30
1.30	1.40	7.7	38.4	53.9	Good	5.7	1910	1980	2010	100	70	30
1.40	1.50	13.7	34.9	51.4	Fair	8.1	1850	1980	2010	160	130	30
1.50	1.60	19.4	32.0	48.6	Poor	9.2	1830	1975	2010	180	145	35
1.60		49.7	26.9	23.4	Agglomerates	18.7	2140	2180	2240	100	40	60

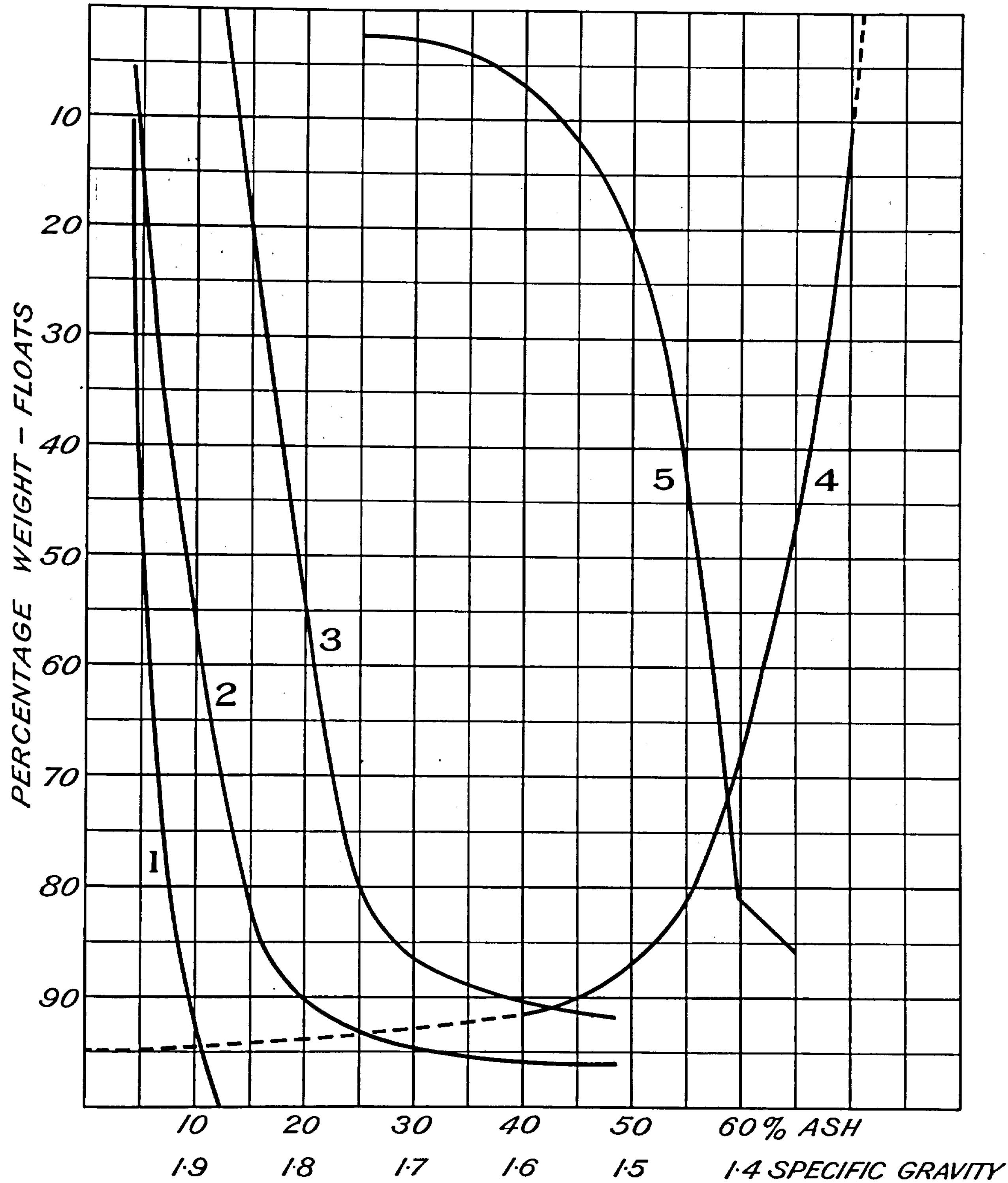

Fig. 12 - Washability Curves for Six-Foot Seam, St. Rose Mine - Ash

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

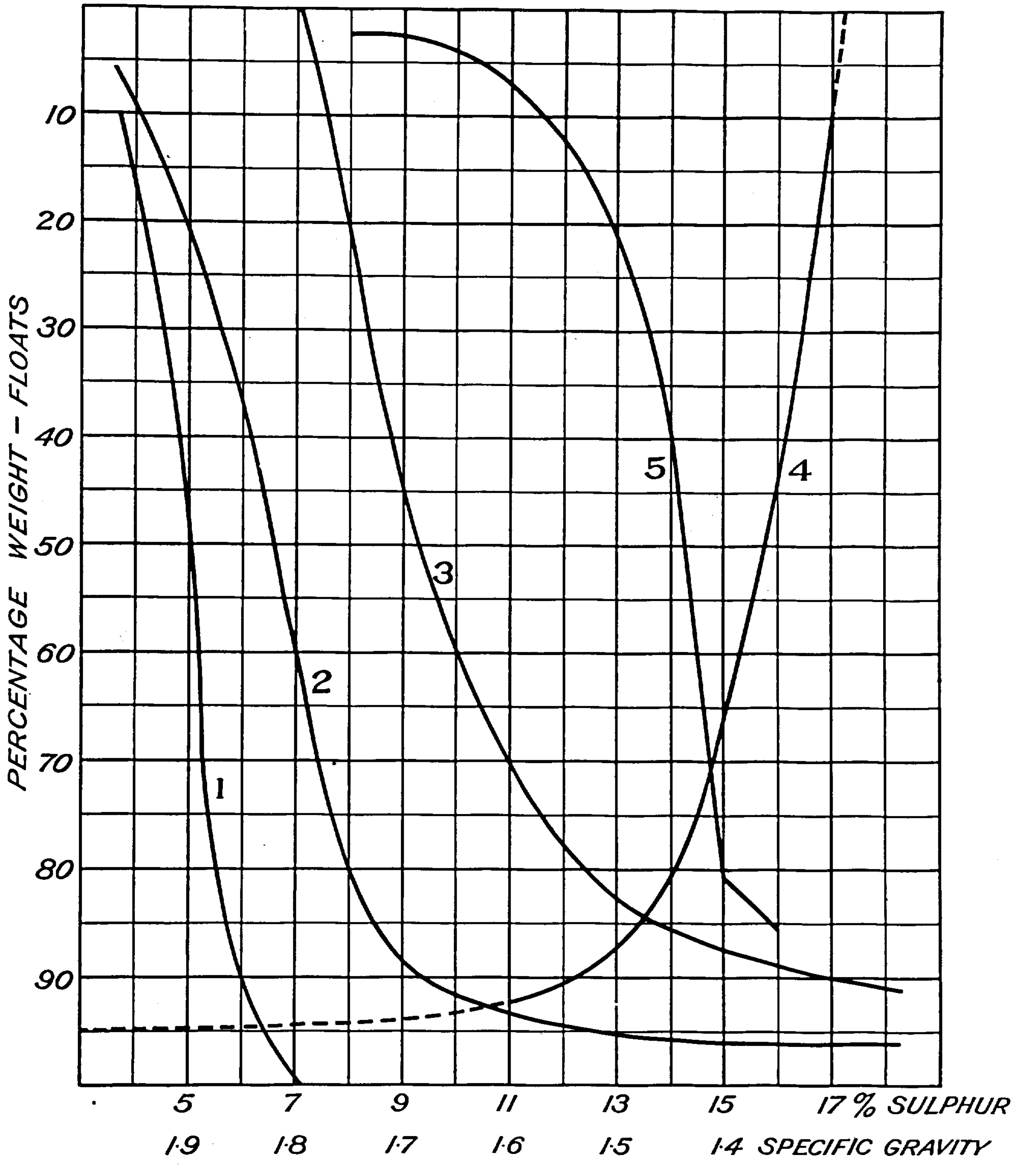

Fig. 13 - Washability Curves for Six-Foot Seam, St. Rose Mine - Sulphur

Curve 1 - Cumulative coal-sulphur percentage (Float).
Curve 2 - Actual sulphur percentage.
Curve 3 - Cumulative slate-sulphur percentage (Sink).
Curve 4 - Specific Gravity.
Curve 5 - ±.10 specific gravity distribution.

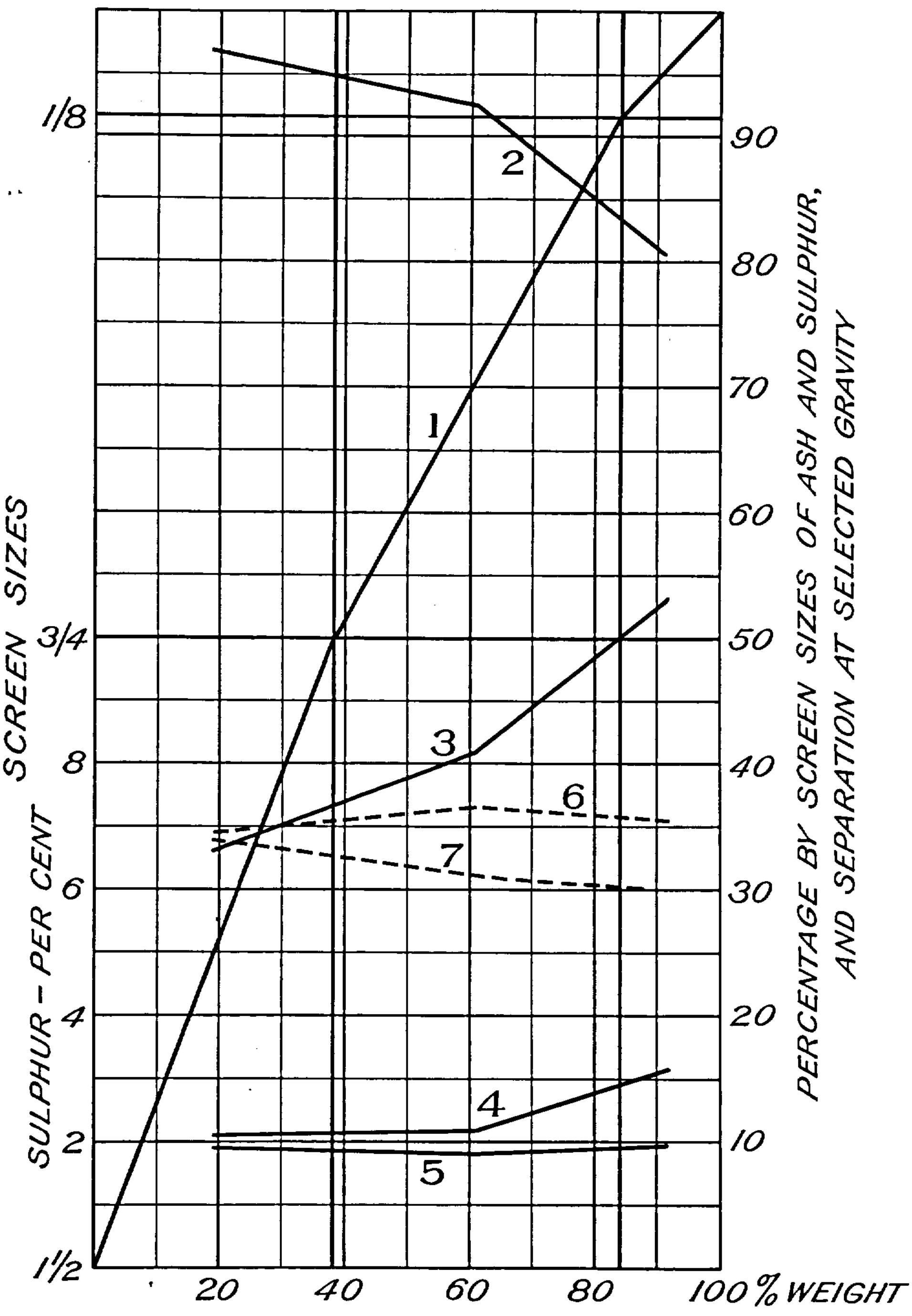

Fig. 14 – Curves showing screen analysis and Washing Data on Screen Sizes for Six-Foot Seam, St. Rose Mine.

Curve 1 – Sizing curve.
Curve 2 – Percentage float at 1.60 specific gravity.
Curve 3 – Percentage ash in sinks at 1.60 specific gravity.
Curve 4 – Percentage ash in screen sizes.
Curve 5 – Percentage ash in floats at 1.60 specific gravity.
Curve 6 – Percentage sulphur in screen sizes.
Curve 7 – Percentage sulphur in floats at 1.60 specific gravity.

TABLE XI

Chemical Analyses of Raw Coal, Clean Coal, and Refuse

	Raw Coal	Clean Coal Floats 1.60	Refuse Sinks 1.60
Weight.....................%	100.0	92.6	7.4
Proximate Analysis (dry basis)			
Ash.......................%	11.9	9.8	55.4
Volatile matter..........%	37.4	37.8	26.1
Fixed carbon.............%	50.7	52.4	18.5
Sulphur..................%	7.2	6.5	20.9
Calorific value.....Btu/lb	12,245	12,650	....
Fusion point of ash....°F.	2030	2030	2210
Melting Range of ash...°F.	160	165	210
Coking properties.........	Poor to Fair	Poor to Fair	Non-coking

TABLE XII

Sulphur Forms and Fusain of Raw Coal, Clean Coal and Refuse

	Total Sulphur	Sulphate Sulphur		Pyritic Sulphur		Organic Sulphur		Fusain
	% of Coal	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Coal	% of Sulphur	% of Pure Coal
1½" Slack (raw)...	6.86	0.40	5.8	3.82	55.7	2.64	38.5	3.89
Clean coal: floats	6.33	0.32	5.0	3.22	50.9	2.79	44.1	3.04
Refuse: sinks.....	20.47	1.34	6.5	17.59	85.9	1.54	7.6	14.06

TABLE XIII

Screen and Chemical Analyses of Sizes Prepared from 1½" Slack for Washing Tests -- Dry basis

Screen Sizes (round holes)	Weight %	Cumulative Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - 1½"	38.1	38.1	10.5	6.7	2040
1/8" - 3/4"	46.0	84.1	11.0	7.3	2020
0 " - 1/8"	15.9	100.0	15.9	7.1	1900

TABLE XIV

Analyses of Clean Coal and Refuse of Screened Sizes (Washed at Selected Gravity of 1.60)

Screen Sizes (round holes)	Floats				Sinks			
	Weight %	Ash %	Sulphur %	F.P.A. °F.	Weight %	Ash %	Sulphur %	F.P.A. °F.
3/4" - 1½"	96.8	9.6	6.8	2020	3.2	33.1	18.9	2100
1/8" - 3/4"	92.4	9.0	6.2	2030	7.6	41.0	21.7	2190
0 " - 1/8"	80.2	9.9	6.0	1950	19.8	53.1	12.3	2330

TABLE XV

Physical Properties of By-product Coke as Indicated by the "Swelling Index" Test

	$1\frac{1}{2}$" Slack	
	As received	After washing
Volatile matter at 600°C. (dry basis)...%	30.7	31.6
Swelling Index..........................	-195	-190
Section--Coke classification chart.......	XIII	
Specific volatile index..................	139.5	141.4
Section--Coal classification chart.......	C Sub-bituminous	
Ash per cent in coal (dry).............%	11.9	9.8
Physical properties of by-product coke:		
Size on wharf (% on 3" screen..........	....	
(Breeze: % thru 1/2".....	....	
Shatter test. (Index: % on 2" screen...	....	
(Breeze: % thru 1/2".....	....	
Abrasion test (Index: % on $1\frac{1}{2}$" screen..	....	
(Dust: % thru 1/16"......	....	
Density...... (App. specific gravity...	....	
(Lb. per cubic foot......	....	
Transverse shrinkage.....................	Good	
Appearance of natural surface..........	Dull grey, granular	
Shape..................................	Blocky, irregular	
Strength...............................	Very friable	
Cross fracture.........................	Medium amount, irregular	
Longitudinal fracture..................	Medium amount	
Cell structure.........................	Very little to none	
Sponge.................................	Granular ends	
Pebbly seam............................	Pebbly to non-coking	
Remarks................................	This coal is practically non-coking insofar as use in by-product ovens is concerned. Washing does not improve the coking properties.	

Caking Properties

	Caking index by Gray's method
0" - 4" sample..................................	17

Chapter IV

SUMMARY AND DISCUSSION OF RESULTS

The four coal seams in Inverness County, which are discussed in this report, occur in three different basins, but as they are all in the same major coalfield, they may be compared on the basis of their physical and chemical characteristics as below.

Physical Properties

Size Distribution

The screen analyses of the coals from these mines, after shipment to Ottawa, are shown in the first table under the respective mine designations. The results of these analyses have been plotted on a cumulative basis as shown in Figure 15. It will be noted that the coal from Inverness No. 1 and the St. Rose mines is definitely smaller in size than that from the Inverness No. 4 and Port Hood mines. This is clearly indicated by the following table which compares the average screen sizes of these coals "as received", calculated in accordance with the method referred to in the Appendix.

Port Hood..........	inch	3.427
Inverness No. 1....	inch	2.074
Inverness No. 4....	inch	2.582
St. Rose...........	inch	1.927

The proportion of smaller sizes produced from the run-of-mine coal from these mines is practically directly related to the average screen size, as indicated by the following tabulation. It will be noted that the coal from the St. Rose mine is slightly more friable than that from the others, as indicated by the excess percentage of fines and dust.

	1½ inch slack	3/4 inch slack	Fines thru 1/8 inch	Dust thru 48 mesh
Port Hood........%	40.9	23.4	5.6	1.5
Inverness No. 1..%	55.1	34.5	6.8	1.6
Inverness No. 4..%	46.3	26.8	5.5	1.5
St. Rose.........%	57.8	35.8	9.2	2.6

In order to obtain information on the commercial handling properties of the coal, screen analyses were made at the mine on samples which had been subjected to the minimum possible handling. These were later compared to similar analyses made on the same samples after shipment to the Fuel Research Laboratories at Ottawa (screen analyses were not made at the mime in the case of St. Rose). These data are presented in Table I under the respective mine designations, and in order to facilitate comparison, the results have been calculated to the average screen size. The following tabulation shows the average size of the coals as mined,

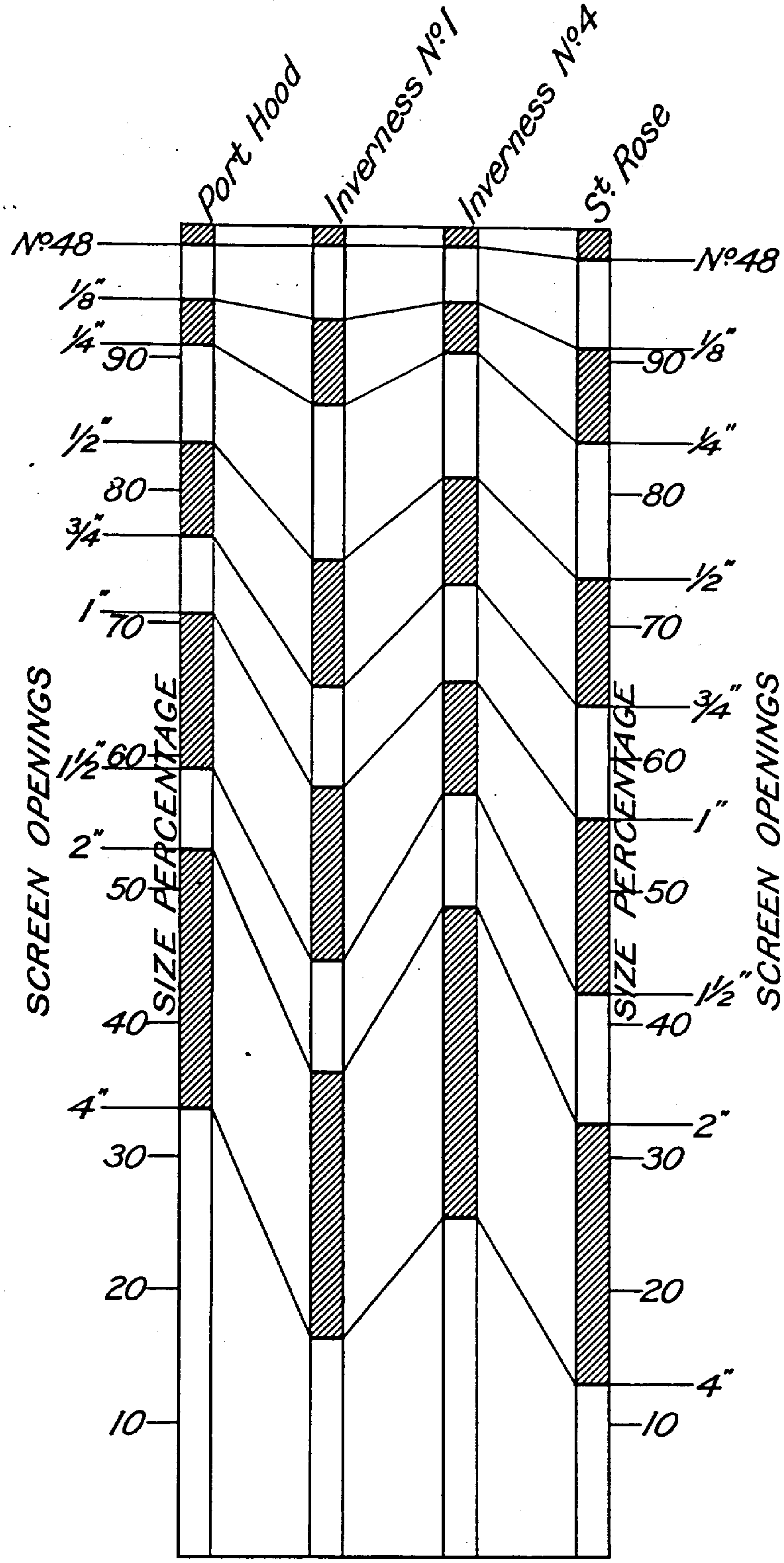

Fig. 15 Comparative screen analyses (as received)

and as later received at Ottawa. It also includes the "size stability during handling", which represents on a percentage basis the relationship of the size of the coal "as received" at the laboratories to that "as mined".

	As mined inches	As received inches	"Size stability during handling"
Port Hood........	4.536	3.427	75.6 %
Inverness No. 1..	2.284	2.044	89.5 %
Inverness No. 4..	3.314	2.582	77.9

With reference to the above table, it should be taken into consideration that the method employed for the determination of size stability does not allow of a true comparison of coals, inasmuch as the results are much more favourable in the case of a small coal than in the case of a large one. In this connection, it should be noted that the size of the coal from Inverness No. 1 mine was only 50.4 per cent of that from the Port Hood mine, and that the coal from Inverness No. 4 mine was 73.1 per cent of that from Port Hood. Despite the lower size stability, as shown in the above table, it must be pointed out that Port Hood coal is much stronger than that produced from either of the Inverness mines in view of its larger size "as mined". It should furthermore be realized that machine mining, which usually results in smaller coal, is employed at Port Hood, as opposed to hand methods used in the other two mines with which it is compared.

Density

The apparent specific gravity, bulk density, and "void" for the various screen sizes of the four coal seams examined are also shown in Table I under the respective mine designations. The minimum and maximum results obtained for these characteristics have been tabulated as follows.

	Apparent specific gravity	Bulk density lb./cu.ft.	Void %	Ash %
Port Hood......	1.41 - 1.45	42.3 - 48.5	46.1 - 53.0	12.5 - 18.8
Inverness No. 1	1.35 - 1.39	43.5 - 49.0	42.8 - 48.6	9.7 - 13.5
Inverness No. 4	1.38 - 1.48	43.0 - 46.5	47.9 - 52.6	9.5 - 12.4
St. Rose.......	1.37 - 1.40	42.8 - 45.0	48.2 - 50.8	10.0 - 12.7

From an examination of the above data, it is evident that although the average ash content of the Inverness No. 4 coal is lower than that of the Inverness No. 1 coal, the apparent specific gravity is higher. This may be due to the fact that the No. 4 coal contains approximately 2 per cent more inherent moisture than the No. 1 coal, thus resulting in more compact lumps. The higher average apparent specific gravity of the Port Hood coal is undoubtedly due to the higher average ash content.

Since bulk density varies with particle size and shape, as well as with the total quantity of moisture and mineral-matter, it is evident from the above data that the limits of the bulk density values for the screen sizes of the four coals are practically the same. Table I indicates that, in the case of three of the coals, the smaller sizes have a lower bulk density. This condition is reversed in the case of Inverness No. 4 coal, where the bulk density tends to decrease with increase in size. The reason for these variations is not apparent.

"Void", which is the volume of free space between the particles of coal in a bed, depends upon the lump density of the coal as well as its bulk density, thus implying the influence of size, shape, total moisture, and ash. It is apparent, from the above data, that the average "void" is lowest for Inverness No. 1 coal and highest for the Port Hood coal. It should be noted, however, that the "void" increases with decrease in size for both Port Hood and Inverness No. 1 coals, and decreases with a decrease in size for Inverness No. 4. The "void" of the St. Rose coal is fairly uniform for the various sizes, with the exception of the fines, in which case it is lower.

Blending of the various sizes in different proportions results in mixtures having different bulk densities. This is shown in the following table which compares the bulk densities of various composites of the coals from the four seams.

	Bulk density (lb./cu.ft.)			
Size Mixture	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Mine run........	63.50	53.75	60.00	54.50
0 - 4 in....	57.00	56.50	54.00	52.25
0 - 1½ in....	53.00	54.25	54.00	54.50
0 - 3/4 in....	52.00	51.75	50.50	50.00
0 - 1/8 in....	48.00	49.75	51.00	51.00
1/8 - 4 in....	56.50	52.75	50.75	49.00
3/4 - 4 in....	49.00	47.25	47.50	48.50

Normally, the bulk density of various size mixtures decreases with a decrease in the amount of the top size, and, as shown above, these four coals conform in this respect, as indicated by their screen sizes previously referred to.

Size Stability

The size degradation, after handling, of the various single sizes and size mixtures of the four coals, is shown in Table II under the respective mine designations. Shatter tests on the 2 to 3 inch and the 3 to 4 inch sizes were made in order to obtain a comparison of the relative size stability of the four coals. The following table summarizes these data.

	Size Stability Per Cent (2-drop shatter)	
	2 - 3 inch coal	3 - 4 inch coal
Port Hood.........%	77.6	73.6
Inverness No. 1...%	79.5	74.2
Inverness No. 4...%	77.7	67.8
St. Rose..........%	78.5	63.4

The above tabulation indicates that, based on the calculated average size of the coal, both before and after the standard shatter test, the 2 to 3 inch sizes for the four coals studied have practically the same stability factor. While Inverness No. 1 coal shows a slightly higher figure in this regard than the other three coals, the difference is not considered sufficient to definitely indicate a greater stability. The difference in the stability of the size mixtures tested is shown below.

	Size Stability Per cent (after 4 drops)	
	4 - 3/4 inch coal	4 - 0 inch coal
Port Hood.........%	78.0	82.9
Inverness No. 1...%	79.4	91.3
Inverness No. 4...%	69.1	76.5

As will be noted, the coal from the Inverness No. 1 mine has the highest stability factor for both the individual sizes tested and the mixed sizes. According to the results of the three coals tested, the coal from Inverness No. 4 mine may be considered as the least stable.

Grindability

The Hardgrove grindability indices for various size mixtures of the Inverness County coals are shown in Table III. As the higher figures represent less resistance to grinding, the comparative results tabulated below indicate that the Inverness No. 4 coal and the St. Rose coal should react to pulverizing slightly better than either of the other two coals.

	Hardgrove grindability index 0 - 1/8 inch slack
Port Hood...........	59.7
Inverness No. 1.....	61.3
Inverness No. 4.....	67.6
St. Rose............	68.1

The maximum difference, however, between the coals is so small, in comparison to the difference between their average value and that of the standard easily-ground coal having an index of 100, that it may be concluded that the four coals are uniformly difficult to grind under the same conditions. There is no doubt that the high mineral matter content of these coals is partially responsible for their low grindability indices, but experience has also shown that generally lower rank coals containing a high inherent moisture are less easily pulverized than those of higher rank which contain a lower inherent moisture.

Chemical Properties

Proximate Analyses

The proximate analyses of the various screened sizes and composites of the screen sizes for the Inverness County coals are shown in Table IV under the respective mine designations. As the values obtained for the 0 to 4 inch composites may be considered to be representative of the coals, these results may be used for comparative purposes as below.

	Proximate Analyses			
	Moisture as received %	Dry basis Volatile Matter %	Dry basis Fixed Carbon %	Dry basis Ash %
Port Hood......	4.5	35.3	49.4	15.3
Inverness No. 1	5.2	38.6	47.6	13.8
Inverness No. 4	7.6	38.5	49.5	12.0
St. Rose.......	4.8	36.8	50.5	12.7

In all cases, the fines, i.e.: material through the 1/8 inch screen, are highest in ash content, whereas the top sizes, i.e.: the plus 4 inch coal and the 2 to 4 inch coal, are next in order, with the intermediate sizes uniformly lowest in ash. It is rather interesting to note that the 1/4 to 1/2 inch size, in all cases except St. Rose, has the lowest ash content. On the dry, ash-free basis the proximate analyses of the minus 4 inch composites are as follows.

	Volatile Matter %	Fixed Carbon %
Port Hood......	41.7	58.3
Inverness No. 1	44.8	55.2
Inverness No. 4	43.8	56.2
St. Rose.......	42.2	57.8

Calorific Value

The calorific values of the various composites for the four Inverness County coals are shown in Table IV, referred to above. All the four coals have relatively low calorific value, varying of course with the content of ash and moisture. It should be noted that generally the finer coal is lower in calorific value than the coarser lumps. Calculated to the dry, ash-free basis, these values are as shown in the following table.

Calorific Value--B.t.u./lb.
(Dry, ash-free basis)

	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Mine run.....	13,700	13,535	13,520	14,040
0 - 4 in.	13,910	13,715	13,450	13,860
1/8 - 4 in.	13,830	13,770	13,520	13,960
3/4 - 4 in.	13,725	13,685	13,480	14,015
0 - 3/4 in.	13,770	13,860	13,610	13,930
0 - 1½ in.	13,790	13,885	13,510	13,900
0 - 1/8 in.	13,725	13,515	13,455	13,625
Average......	13,780	13,710	13,510	13,905

The average values indicate that Inverness No. 4 coal on the dry, ash-free basis, is lower in calorific value by 200 B.t.u. than either the Inverness No. 1 or Port Hood coal, and that the St. Rose coal is higher by about 200 B.t.u., thus indicating a variation in rank. On the "as received" and on the dry bases, the average calorific values for the coals are as follows.

	Calorific Value (B.t.u./lb.)		Moisture	Ash
	As received	Dry basis	%	%
Port Hood.....	11,011	11,542	4.6	16.2
Inverness No. 1	11,153	11,740	5.0	14.4
Inverness No. 4	10,860	11,728	7.4	13,2
St. Rose.......	11,542	12,149	5.0	12.6

From the above, it is evident that "as received", which in this case is the air-dried basis, the Inverness No. 4 coal has the lowest calorific value. This, of course, is due to its high inherent moisture content, as the values on the dry basis indicate.

Ultimate Analyses

The ultimate analyses of the four Inverness County coals are shown in Table V under the respective mine designations. The values obtained for the composite of screen sizes passing a 4 inch round hole screen and retained on a 1/8 inch screen are shown in the following table.

Ultimate Analyses (dry basis)

	1/8 - 4 inch			0 - 4 inch
	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Carbon.....%	64.3	67.0	67.7	67.8
Hydrogen...%	4.3	4.8	4.7	4.5
Sulphur....%	8.0	6.9	7.5	7.4
Nitrogen...%	1.4	1.2	1.3	1.4
Oxygen.....%	5.3	7.3	8.0	6.2
Ash........%	16.7	12.8	10.8	12.7

For comparative purposes, the ultimate analyses on the dry, ash- and sulphur-free basis are more revealing as shown in the following table.

	Ultimate Analyses (dry, ash- and sulphur-free)			
	Port Hood	Inverness #1	Inverness #4	St. Rose
Carbon....%	85.4	83.4	82.8	84.9
Hydrogen..%	5.7	6.0	5.8	5.6
Nitrogen..%	1.9	1.5	1.6	1.8
Oxygen....%	7.0	9.1	9.8	7.7

From the above, it is quite evident that the high ash and sulphur contents of the Port Hood coal masks its superiority insofar as carbon, hydrogen and oxygen contents are concerned. On the "as received" basis, the ultimate analyses of the four coals are as follows.

	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Carbon.....%	61.3	63.6	62.5	64.6
Hydrogen...%	4.7	5.2	5.2	4.8
Sulphur....%	7.6	6.6	7.0	7.0
Nitrogen...%	1.4	1.2	1.2	1.4
Oxygen.....%	9.1	11.3	14.2	10.1
Ash........%	15.9	12.1	9.9	12.1
Moisture...%	4.6	5.1	7.6	4.8

Fusibility of Ash

The fusibilities of ash, which include the temperature of initial deformation, the softening temperature and fluid temperature, as determined by the gas furnace method, are shown in Table VII under the respective mine designations. The temperature intervals between the above empirical points, namely: the softening interval, flow interval and melting range for the various ashes, are also shown in Table VII of each coal. For comparison of the Inverness County coals, the results obtained on the composite samples, 0 to 4 inch, are shown below.

	Ash Fusibility			
	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Initial deformation.. °F.	1890	1900	2100	1950
Softening temperature °F.	1965	2020	2260	2050
Fluid temperature.... °F.	2000	2040	2450	2090
Softening interval... °F.	75	120	160	100
Flow interval....... °F.	35	20	190	40
Melting range....... °F.	110	140	350	140

The variation in ash fusibility of the different sizes is indicated in the following table, which shows the values for the 1/8 to 4 inch composites and the 0 to 1/8 inch composites.

	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.
Port Hood...... 1/8 - 4 in.	1900	1950	2000
0 - 1/8 in.	1840	1900	1950
Inverness No. 1 1/8 - 4 in.	1970	2070	2080
0 - 1/8 in.	1980	2100	2200
Inverness No. 4 1/8 - 4 in.	2040	2350	2410
0 - 1/8 in.	1890	1915	2010
St. Rose....... 1/8 - 4 in.	1880	2030	2070
0 - 1/8 in.	1830	1900	1970

It should be noted that, in the case of the Inverness No. 1 coal, the fines show a slightly higher ash fusibility than the same size from the other three coals. It should also be noted that, although the Inverness No. 4 coal has as high a sulphur content as the other coals, the ash fusibility of the 1/8 to 4 inch size is materially higher than those of the other coals.

Chemical Analysis of the Ash

Table VIII for each of the four Inverness County coals shows the chemical analyses of the ashes. For comparative purposes and in studying the relationships of the various ash constituents, the four-component SiO_2-Al_2O_3-Fe_2O_3-CaO system has been found to yield the most valuable information. Consequently, the ash analyses for the coals studied are presented in the following table calculated on this basis.

	Ash Analyses			
	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
SiO_2..........%	35.8	28.1	15.2	25.2
Al_2O_3.........%	12.6	15.8	9.2	10.1
Fe_2O_3.........%	45.8	53.5	71.0	62.2
CaO...........%	5.8	2.6	4.6	2.5
$SiO_2 + Al_2O_3$...%	48.4	43.9	24.4	35.3

It will be noted that, although the Inverness No. 4 coal ash has the lowest content of refractory material, i.e.: $SiO_2 + Al_2O_3$, its softening temperature is the highest. Based on the "free silica" method developed by Estep* for predicting the softening temperature of an ash from its analysis, the predicted values as compared to those determined for the coals are as follows.

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* Estep, T.G., Seltz, H., Bunker, H.L., and Strickler, H.S. -- "The Effect of Mixing Coals on the Ash Fusion Temperature of the Mixture" Cooperative Bulletin 62, Mining & Metallurgical Advisory Boards and Carnegie Institute of Technology, 1934.

	Softening Temperature	
	Predicted	Determined
Port Hood.......°F.	1950	1965
Inverness No. 1 °F.	2020	2020
Inverness No. 4 °F.	2060	2260
St. Rose........°F.	1950	2050

The unusually high iron content of the ash of Inverness No. 4 results in a product which should slag less easily than the other ashes, this being indicated not only by the higher softening temperature of the ash, but by the much higher fluid temperature as shown below.

	Fluid Temperature
Port Hood.......°F.	2000
Inverness No. 1 °F.	2040
Inverness No. 4 °F.	2450
St. Rose........°F.	2090

Sulphur Forms

The distribution of the forms in which the sulphur occurs in the coal, that is, the sulphate, pyritic and organic sulphur, is shown in Table VI under the respective mine designations. The results as obtained for the composite of screen sizes passing a 4 inch screen are shown below for comparative purposes.

	Sulphur Forms			
	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
	As Percentage of Coal			
Total sulphur....%	7.40	6.51	7.27	7.03
Sulphate sulphur.%	0.23	0.12	0.24	0.42
Pyritic sulphur..%	3.91	3.99	4.31	3.84
Organic sulphur..%	3.26	2.40	2.72	2.77
	As Percentage of Total Sulphur			
Total sulphur....%	100.0	100.0	100.0	100.0
Sulphate sulphur.%	3.1	1.8	3.3	6.0
Pyritic sulphur..%	52.8	61.3	59.3	54.6
Organic sulphur..%	44.1	36.9	37.4	39.4

It will be noted that the percentage of pyritic sulphur in all of these coals is very high, and, as is usual in such cases, the organic sulphur is also high, indicating the practical impossibility of materially lowering the sulphur content of the coals by washing.

Examination of Table VI referred to above indicates that in all cases, with the exception of Inverness No. 1, the pyrite is concentrated in the fine sizes. This is demonstrated by a comparison of the quantity of pyritic sulphur as a proportion of the total sulphur present in the sizes passing a 4 inch screen and retained on a 1/8 inch screen, and in the material passing a 1/8 inch screen as shown below.

	Pyritic Sulphur As Per Cent of Total Sulphur	
	4 - 1/8 inch	1/8 - 0 inch
Port Hood......	50.4	56.3
Inverness No. 1	44.3	50.0
Inverness No. 4	58.4	69.3
St. Rose.......	....	62.3

Fusain

The distribution of fusain is also shown in Table VI of the four different coals. The following table indicates the fusain content and its distribution between the various sizes of the four coals studied.

	Fusain as Per Cent of Pure Coal		
	Composite 0 - 4 inch	Composite 1/8 - 4 inch	Composite 0 - 1/8 inch
Port Hood......	2.26	1.94	7.24
Inverness No. 1	2.01	1.73	5.92
Inverness No. 4	2.14	1.86	8.32
St. Rose.......	3.74	3.25*	3.96**

The above table shows that the fusain content of the coals is low, and that it is fairly uniform for three of the seams studied. Owing to the nature of its occurrence, it is concentrated to a greater degree in the fines. It should be noted, however, that the fusain in all cases is more heavily loaded with pyrite than are the other coal constituents.

Classification By Rank

The rank of the four Inverness County coals, according to both the S.V.I. (Specific Volatile Index) and the A.S.T.M. (American Society For Testing Materials) systems of classification, is shown in Table XV under the respective mine designations. The table presented below is a comparison of the rank of these coals by the two systems.

	S.V.I. Classification (1-1/2 inch Slack)		A.S.T.M. Classification (0 - 4 inch)
	S.V.I.	Group	Group
Port Hood......	138.7	B: Sub-bituminous	High Volatile Bituminous C
Inverness No. 1	130.1	B: Sub-bituminous	High Volatile Bituminous C
Inverness No. 4	139.7	B: Sub-bituminous	High Volatile Bituminous C
St. Rose.......	140.0	B: Sub-bituminous	High Volatile Bituminous C

* Composite 3/4 - 4 inch. ** Composite 0 - 3/4 inch.

The coals are all low rank bituminous bordering on the sub-bituminous class, with the Inverness No. 4 coal slightly lower in rank than the other three according to the A.S.T.M. classification. Coals of this rank are generally either weakly caking or non-caking, and produce either a poor coke or a char rather than a commercial coke on processing in gas retorts and by-product coke ovens.

Washing Characteristics

The laboratory washing tests on the four coals from Inverness County were conducted on the 1½ inch slack according to the standard method as described in the Appendix. The results are given in a series of tables and curves shown in Chapter III.

Float and Sink Data

The data obtained by the float and sink tests with respect to ash and sulphur are shown in Table IX under the respective mine designations. The inherent ash and sulphur, as indicated by the analysis of the fractions floating at a specific gravity of 1.30, are as follows.

	Inherent Ash and Sulphur		Coal recovery at 1.30 specific gravity per cent of total
	Ash Per cent	Sulphur Per cent	
Port Hood......	5.6	4.4	5.1
Inverness No. 1	2.7	2.5	9.3
Inverness No. 4	3.2	3.0	8.9
St. Rose.......	3.8	3.6	10.4

In all cases, the inherent sulphur is of such a quantity as to preclude any possibility of satisfactory reduction of sulphur content by washing. It is interesting to note that both the inherent sulphur and the inherent ash are much higher in the Port Hood coal than in the other three coals, and that the quantity of coal floating at 1.30 specific gravity is very low for all four coals, being more outstanding in this respect for Port Hood coal than for the others.

The complete chemical analyses of the fractions separated at the various gravities are shown in Tables IX and X under the respective mine designations, and reference to these tables indicates the following major differences between the four coals examined.

(a) The Inverness No. 1 and No. 4 coals are lower in inherent sulphur and ash than the Port Hood and St. Rose coals.

(b) The material floating at a specific gravity of 1.60 is much higher in ash fusibility in the case of Inverness No. 4 coal than for the other three coals, in which cases the ash fusibilities for the various fractions are uniformly low. In the case of the Port Hood coal, only the lightest and heaviest fractions are low in ash fusibility.

Washing at Selected Gravity

Simple wet washing, as indicated by the $\pm .10$ specific gravity distribution curves, was made at the following gravities.

Port Hood......	1.60
Inverness No. 1	1.50
Inverness No. 4	1.60
St. Rose.......	1.60

The results of washing the 1½ inch slacks at the above respective gravities are presented in Table XI under the respective mine designations, which shows the analyses of the clean coal and refuse fractions. The table below summarizes the analyses of the clean coal fractions, together with the quantities reclaimed.

	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
Weight reclaimed.........%	86.4	83.2	91.0	92.6
Proximate analysis (dry basis)				
Ash.....................%	10.7	7.2	8.3	9.7
Volatile matter........%	36.3	41.9	40.9	37.8
Fixed carbon...........%	53.0	50.9	50.8	52.5
Sulphur................%	6.7	5.1	6.3	6.5
Calorific value...Btu/lb	12,560	12,985	12,660	12,650
Fusion point of ash...°F	1930	2200	2540	2030

Referring to Table XI for each of the four coals, it will be noted that the ash reductions are quite substantial, but that the sulphur reduction is not very great. This is due to the high inherent sulphur, as well as to the fact that the inorganic sulphur occurs largely as finely disseminated pyrite. Table XII for each coal, showing the fusain and the sulphur forms of the clean coal, refuse, and unwashed coal, indicates that, although there is a concentration of "pyrite-loaded" fusain in the refuse, the pyrite remaining in the clean coal is probably finely divided material more or less uniformly distributed between the various petrographic constituents.

The results obtained by washing the various screened sizes at the selected gravities are shown in Table XIV under the respective mine designations, the following being a summary of this information for purposes of study of the four coals.

	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
		3/4 - 1½ inch coal		
Clean coal recovered...%	90.9	88.6	90.4	96.8
Ash..................%	11.2	8.9	8.3	9.6
Sulphur..............%	6.4	6.0	6.5	6.8
		1/8 - 3/4 inch coal		
Clean coal recovered...%	88.1	85.5	90.0	92.4
Ash..................%	10.3	6.7	7.7	9.0
Sulphur..............%	6.6	4.9	6.0	6.2

cont.

cont.	Port Hood	Inverness No. 1	Inverness No. 4	St. Rose
		0 - 1/8 inch coal		
Clean coal recovered...%	76.0	73.8	75.1	80.2
Ash...................%	9.5	8.6	9.4	9.9
Sulphur..............%	5.6	4.2	5.2	6.0

The data indicate that the finer sizes of these four coals are somewhat more amenable to washing, as judged by the "sink and float" test, than are the lump sizes, this being more marked in the case of the Port Hood coal. It is also evident that practically no improvement in the ash fusion temperature is obtained as a result of washing.

Coking Properties

The coking properties of the coals from Inverness County, as indicated by laboratory tests, are shown in Table XV under the respective mine designations.

Swelling Index Test

The results of the swelling index test, which is employed to predict the physical properties of the by-product coke made from a given coal, are shown in Table XV. The table below presents the comparative pertinent data on the raw $1\frac{1}{2}$ inch slacks.

	Volatile Matter at 600°C. (dry basis)	Swelling Index	Remarks
Port Hood......	28.6	-210	Practically non-coking
Inverness No. 1	31.5	-174	Practically non-coking
Inverness No. 4	31.1	-161	Practically non-coking
St. Rose.......	30.7	-195	Practically non-coking

The four coals are very similar in their reaction to the swelling index test. They show considerable contraction and are practically non-coking, which indicates that they would only yield a char on carbonization in standard by-product ovens. The data presented in Table XV referred to above show that washing does not improve the coking properties of these coals.

Caking Index (Gray method)

This test, which at present is of doubtful value, is included because it is felt that it may be shown to be related in some way to the reaction of fuels in combustion equipment. The results of the test on the run-of-mine (0 - 4 inch) samples of the Inverness County coals are also shown in Table XV for each of the four coals examined. The caking indices in all cases are considered low, but there is an appreciable difference between the coals tested, the Port Hood coal having the highest caking index as shown below.

	Caking Index
Port Hood......	24
Inverness No. 1	18
Inverness No. 4	10
St. Rose.......	17

Appendix

DESCRIPTION AND SIGNIFICANCE OF PHYSICAL AND CHEMICAL TESTS EMPLOYED

The various tests described below were used to evaluate the physical and chemical characteristics of the run-of-mine coals taken from the different working seams in Inverness County. The data obtained by subjecting the coals to these tests allow for a comparative scientific and economic evaluation of these coals.

Tests For Physical Properties

Size Distribution By Screen Analysis

The size distribution of the run-of-mine coal samples was determined, with slight modification where necessary, according to the Tentative Method of Test for Screen Analysis of Coal, A.S.T.M. Designation D 410-35T, as described in the A.S.T.M. publication "Standards on Coal and Coke" prepared by Committee D-5, October 1938. Screens from the following series were used:-

1. Round-hole screens:- Plate screens with 4, 3, 2, 1½, 1, 3/4, 1/2, 1/4 and 1/8 inch diameter openings; and
2. Sieves:- Wire-cloth Tyler sieves with square openings of 10, 20, 48, 60 and 100 meshes to the linear inch. The nearest equivalent A.S.T.M. designations for the above sieves are respectively: 1680, 840, 297, 250 and 149 microns (A.S.T.M. Designation E-11).

It is becoming increasingly evident that the performance of mechanical stokers, gas producers, and many other coal burning appliances are dependent not only on the absolute or the average size of the fuel used, but even more on the size distribution or range of sizes, and fuel technologists throughout the world are conducting exhaustive research on this subject. Bennett[3] has shown how the problem can be attacked quantitatively by studying the physical nature of the process of breakage, and by making use of Rosin and Rammler's law, which governs the distribution of size in the broken material obtained in the course of mining coal and during its subsequent treatment. However, as the application of the Rosin law is still a subject of discussion, the calculation of the size distribution according to this method has not been included, but, in order to compare the screen analyses of the different samples, the average size of the coal has been calculated according to the method proposed by Smith[4][7]. In this case, the percentage weight of each screen size is multiplied by its respective average screen hole diameter in inches, the sum total being the average size of the coal.

Density

Apparent Specific Gravity, or "lump" density, equals the weight of unit volume of the solid fuel as a lump, including cracks and fissures, ash and moisture. This physical property was determined by a modification of the A.S.T.M. method for coke as outlined under A.S.T.M. Designation D 167-24. The modified apparatus and procedure, as developed by the Fuel Research Laboratories, has been reported in R.I.C.S. 35[5], but is as yet unpublished.

Bulk Density equals the weight of the dry, or wet, fuel contained in a unit volume of packing space. This physical characteristic was determined according to the Standard Method of Test For Cubic Foot Weight of Crushed Bituminous Coal, A.S.T.M. Designation D 291-29.

The bulk density is a characteristic of coal which has a bearing upon the filling of such spaces as bunkers, freight cars, coke oven chambers, etc., and upon the storage of a given number of heat units within a given volume. According to Rosin[6] the bulk density of a coal depends upon various factors such as: apparent specific gravity, particle size distribution, shape of particles, moisture content, thickness of bed, relation between mean particle size and dimensions of layer, duration of storage, and mode of packing (height of fuel, shaking, stamping, etc.). Hence it is evident that bulk density is not a "property of substance and is no exact characteristic", but a resultant of various factors.

The bulk density of a coal will be equal to its lump density (apparent specific gravity), if the interspaces between the grains become so small that they are completely filled by the adherent water retained by the capillary forces acting in the minute interspaces.

"Void" is the interspace volume between the coal particles. It is calculated as a percentage from:

$$1 - \left(\frac{\text{Bulk Density}}{62.5 \times \text{apparent specific gravity}} \right) \times 100$$

and is highest for a bed consisting of particles of equal size. It increases, however, inversely with the volume factor.

The relations between particle size, moisture, bulk density, and "void" are of great significance, especially for carbonization, on account of their influence on packing, heat transfer, and formation of the plastic layer. These relations are also fundamental in considering the following: the de-watering of coal by drainage, shaking or centrifuging; the preparation of coal-oil mixtures; the dust-proofing of coal by oil spraying; the pitch consumption in briquetting; and the determination of the most economical compromise between the viscosity of a coal-oil mixture and the velocity of the reaction in the hydrogenation of coal.

Size Stability (and Friability)

Coal is a brittle heterogeneous material containing cracks and fissures. When a brittle material such as this, which varies in strength, is subjected to forces large enough to cause fracture, it breaks up into smaller pieces of varying sizes. This readiness of coal to break into smaller pieces is termed "friability", which is a complex physical characteristic implying size degradation. The antonym of "friability", as applied to coal, is "size stability", and this may be considered to be a measure of the handling properties or resistance to breakage of the coal, either as an aggregate of lumps of the same size, or as a mixture of sizes. Hence, in the foregoing chapters the term "size stability" rather than "friability" has been employed.

Methods for determining the comparative handling properties of coal were devised and tested at the Fuel Research Laboratories in connection with the programme of the "Coal Friability" Sub-committee of the American Society for Testing Materials(7). The Drop Shatter Test for Coal, which has been tentatively accepted as standard by the A.S.T.M.(8), has been used in this investigation for determining the comparative size stability (and friability) of certain sizes and mixtures of sizes. Friability per cent is 100 - size stability per cent.

Grindability

The grindability, or ease of pulverizing a material, is not a single physical property, but is a composite factor dependent upon a combination of such properties as strength, brittleness, hardness, etc. This factor was determined by the Tentative Method of Test for Grindability of Coal by the Hardgrove-machine Method, A.S.T.M. Designation D 409-35T. The method gives a measure of the relative grindability of any coal in comparison with a standard coal chosen as 100 grindability. The coal chosen as a standard is a low-volatile run-of-mine product from Jerome mine, Upper Kittanning bed, Somerset County, Pennsylvania. The method is based on Rittinger's law(9), which states: "The work done in pulverizing is proportional to the new surface produced". A sized sample receives a definite amount of grinding energy in a miniature pulverizer, and the new surface is determined by sieving, greater resistance to grinding being indicated by lower values.

Grindability figures refer only to any given or constant grinding system, and cannot be generalized to include other systems. Inasmuch as the term "grindability" implies a combination of a group of physical properties and technical factors, the latter prevailing to a marked extent, no absolute scale of grindability for all grinding machines can be established. According to Rosin(6) "certain relations exist between particle size, power consumption and throughput, but they are greatly modified and completely masked by the machine factor, 99 per cent of the power consumption in pulverizers not being utilized for disintegration".

Some of the factors, other than "grindability", that influence industrial capacity of pulverizers are moisture and size of coal. According to an article 'Factors in Economical Grinding and Pulverizing(10), when mills of any type are operated without air-drying of the coal "the effect of the surface moisture becomes important, as increase in moisture decreases the output disproportionately. The general effect is to cause clogging of the fine material and prevent its removal by the air current so that the efficiency of the mill is lowered." The effect varies with different types of mills, being greatest with slow-speed mills of the ball-mill type and smallest with the impact or beater pulverizers. Increasing the size of the feed normally tends to decrease the output and the efficiency of pulverizers.

Tests For Chemical (and Physico-chemical) Properties

The various screened sizes of coal and the so-called "composites" (re-assembled screened sizes) were subjected to chemical and physico-chemical analyses, as outlined below.

Proximate Analyses

According to Bone(11), "the usefulness of any given coal for a particular purpose depends largely upon the yield of combustible 'volatile' matter expelled when it is carbonized under certain specified conditions and upon the character of the resulting carbonaceous residue. From a properly conducted laboratory test (sometimes called a 'proximate analysis'), much valuable information may be gained respecting the economic value of a given coal". The third edition of the Methods of the Chemists of the United States Steel Corporation states that "the proximate analysis includes a direct determination of the ash and volatile matter, and the estimation of the 'fixed carbon' by difference". In addition, the proximate analysis of coal includes the determination of its moisture content. A.S.T.M. Designation D 121-30, Standard Definitions Of Terms Relating To Coal And Coke, defines proximate analysis as the determination, by prescribed methods, of moisture, volatile matter, fixed carbon, and ash.

The American Society For Testing Materials has devised standard methods for proximate analysis, which are published as Standard Methods Of Laboratory Sampling And Analysis Of Coal And Coke, under A.S.T.M. Designation D 271-33. The Fuel Research Laboratories, however, for various reasons, have retained slight modifications of these methods of analysis, but they do not vary to any great degree from the standards adopted by the A.S.T.M.

Moisture-- For determining the moisture of a coal, that is the moisture retained after sufficient drying to allow for crushing and grinding, one-gram quantities of the finely pulverized coal were dried for 105 minutes in small metal capsules. The drying was effected in a suitably constructed oven heated with toluene vapour at a temperature of between 105 and 108° C., with a current of pre-heated and dried carbon dioxide sweeping over the coal samples. The A.S.T.M. standard specifies air instead of CO_2, otherwise the method used correspond to the published standard.

In this survey, only the moisture, as determined above, has been included, although the influence of surface or extraneous moisture on the use of coal for various purposes is of real importance. As this extraneous moisture is, however, dependent upon many factors such as storage, drainage, change of atmospheric conditions, etc., a study of the surface moisture of the seam samples in a general survey would not be of any significance.

Ash-- The ash was determined according to the standard method described under A.S.T.M. Designation D 271-33. One gram of the finely pulverized coal is ignited in an electric muffle at a controlled temperature between 700 and 750° C. The residual incombustible matter, which is a complex mixture of compounds resulting from the dehydration and ignition of the inorganic impurities present in the coal, is reported as ash.

Volatile Matter-- The volatile matter of the coal was determined according to the A.S.T.M. method Designation D 271-33, with the exception that a Chaddock gas burner was employed in preference to either a Meker burner or a vertical electric furnace. The method consists of placing one gram of the sample in a covered platinum crucible, and heating it over the Chaddock burner for a period of exactly seven minutes, the flame being so regulated as to give a temperature of 950° C. $\pm$20° C. The loss of weight minus the moisture equals the volatile matter.

Fixed Carbon-- The fixed carbon, which is that material remaining after the evolution of the moisture and volatile matter, exclusive of ash, is calculated as follows:

100 - (moisture + ash + volatile matter) = percentage of fixed carbon

Ultimate Analyses

According to A.S.T.M. Designation D 121-30, ultimate analysis is defined as the "determination of carbon and hydrogen in the material, as found in the gaseous products of its complete combustion, the determination of sulphur, nitrogen, and ash in the material as a whole, and the estimation of oxygen by difference". The methods as outlined in the publication referred to where adhered to.

Total Sulphur-- The total sulphur content of the coals was determined according to the Eschka method as described under A.S.T.M. designation D 271-33, with the exception that the sample was ignited at 700 to 750° C. instead of at the specified 800° C. $\pm$25° C. with the Eschka mixture. The sulphates were then leached out and determined gravimetrically by precipitation with $BaSO_4$, as specified.

Carbon and Hydrogen-- The determination of carbon and hydrogen was made by a procedure corresponding to A.S.T.M. Designation D 271-33, using an electrically-heated combustion furnace.

Nitrogen-- The Kjeldahl-Gunning method, as recommend under A.S.T.M. Designation D 271-33, was employed for determining the nitrogen in the coals.

Oxygen-- As there is no satisfactory direct method for determining oxygen, it was estimated by subtracting the sum of the percentages of hydrogen, carbon, nitrogen, sulphur, and ash from 100. This result is, of course, affected by any errors incurred in the other determinations.

Calorific Value

The gross calorific value of coal, according to A.S.T.M. Designation D 407-35T, is "the heat produced by combustion of unit quantity, at constant volume, in an oxygen bomb calorimeter under specified conditions". This value was determined with the Emerson bomb according to the method described under A.S.T.M. Designation D 271-33.

The calorific value of a coal is an important factor in its evaluation for steam raising purposes, as well as for the determination of its rank. The purchase of coal on a heat basis for steam raising has generally given satisfaction, and according to Grumell(12) "the knowledge and experience acquired by systematic evaluation leads to better control of subsequent fuel deliveries and, in most cases, to more efficient performance in the boiler plant". The average calorific value of a coal seam, calculated to the dry, ash-free (or mineral-matter-free) basis, can be generally used as a check on commercial determinations. It should be noted, however, that calorific value alone is not entirely sufficient for comparative purposes, as the satisfactory use of a coal often depends upon other factors as well, such as: moisture, ash, volatile matter, coking properties, size, friability, and possibly the melting point of ash.

Fusibility of Ash

The fusibility of the ashes of the coals was determined by the standard method outlined in A.S.T.M. Designation D 271-33, using a modified Remmey fusion test furnace heated with acetylene and oxygen. By means of this method, three different physical states of the ash cone under the influence of increasing temperatures are recorded.

1. The Initial Deformation Temperature--the temperature at which the apex of the cone begins to round or bend;

2. The Softening Temperature--the temperature at which the cone fuses down to a spherical shape; and

3. The Fluid Temperature--the temperature at which the ash becomes fluid and spreads out over the plaque in a flat layer.

The ranges in temperature between these points have been defined as follows:

(a) Softening Interval--the range in temperature between the initial deformation and softening temperature;

(b) Fluid Interval--the range in temperature between the softening and fluid temperatures; and

(c) Melting Range--the range in temperature between the initial deformation and fluid temperatures.

Selvig and Fieldner(13) have arbitrarily sub-divided the range of ash softening temperatures into three groups, as follows:

Class 1: refractory ashes, softening above 2600°F.

Class 2: ashes of medium fusibility, softening between 2200° and 2600°F.; and

Class 3: easily fusible ashes, softening below 2200°F.

The relationship of ash fusibility to clinker formation has been studied for many years, and it is conceded that the tendency to form clinker is not definitely related to the softening temperature of the ash. The present status of the problem has been stated by Nicholls and Selvig(14) in discussing the results of their work. They conclude that "no simple measure of the nature of the ash, such as its fusibility determined by an arbitrary method, can be expected to predict closely, relative values of troubles resulting from a complex ash passing through a set of conditions in which the temperature, time of exposure to that temperature, and travel of the ash are undefined, uncertain and dependent on factors that are also variable". Recent investigations conducted at the Fuel Research Laboratories(15) corroborate the above general statement.

Chemical Analysis of the Ash

The mineral matter in coal is composed mainly of compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium, phosphorus and alkali compounds. According to Thiessen et al(16), "the minerals comprizing the inorganic matter in coals are pyrite, calcite, kaolinite, detrital clay, and silica".

Chemical analyses of the ash, however, show only the simple constituents present without indicating the manner in which they exist in the coal as minerals. In such analyses, the following compounds are usually determined and reported:- SiO_2, Al_2O_3, Fe_2O_3, CaO, MnO, MgO, Na_2O, K_2O, TiO_2, P_2O_5, and SO_3. These analyses, which were conducted in the chemical laboratory of the Division of Metallic Minerals of the Bureau of Mines, were made with certain modifications according to the methods outlined in the Third Edition of the "Methods Of The Chemists Of The United States Steel Corporation For The Sampling And Analysis of Coal, Coke And By-products" published by Carnegie Steel Co., Pittsburgh, Pa., and in "Methods For The Quantitative Analysis Of Coal Ash"--Physical and Chemical Survey of the National Coal Resources No. 28, Department of Scientific and Industrial Research, England.

Sulphur Forms

The sulphur in coal occurs in two principal forms, depending upon its origin, these being termed inorganic and organic. The inorganic sulphur appears in two forms known as sulphate sulphur and pyritic sulphur. The organic sulphur is composed of resinic and humic sulphur, which, for all practical purposes, may be considered as total organic sulphur. Powell's(17) methods for determining quantitatively these sulphur forms were employed, with slight modifications, for these determinations.

Sulphate sulphur was determined by treating the pulverized coal with 3 per cent hydrochloric acid for forty hours at 60°C., and estimating the sulphur in the filtrate by precipitation with $BaCl_2$.

Pyritic sulphur was determined by digesting the pulverized coal with 1.12 s.g. nitric acid for ninety-six hours at room temperature, the oxidized pyrite plus the original sulphate being determined by precipitation with $BaCl_2$, the pyritic sulphur being calculated by subtracting the percentage of sulphate sulphur from the total inorganic sulphur.

The organic sulphur was estimated by subtracting the total inorganic sulphur from the total sulphur.

Information with respect to the distribution of the forms of sulphur is useful, inasmuch as it indicates the degree to which the sulphur content of a coal may be reduced by washing processes.

Fusain

The importance of fusain with respect to its influence on the spontaneous combustion of coal, and its effect on the coking properties, necessitates a study of its quantitative distribution between the various coal sizes. The method adopted with certain modifications for this determination was that of Heathcoat(18). This method takes advantage of the fact that, in bituminous coals, fusain is more resistant to oxidation than the other coal constituents. Hence, after oxidizing the insoluble humic material to an alkali-soluble humic substance, the more resistant fusain is collected by filtration, dried and ignited, and reported as "per cent dry ash-free fusain in dry ash-free coal".

A great deal of information with respect to coal washing may be obtained by studying the distribution of fusain in conjunction with the distribution of the forms of sulphur. Inasmuch as fusain is usually very porous in structure, it is often loaded with pyrite, and by reason of its friable nature it is usually concentrated in the fine coal dust. Elimination of fusain, loaded with pyrite, by screening may result in a far greater reduction in the total sulphur content of the coal than would be obtained by a washing process.

The influence of fusain on coke structure is well known, and Mott and Wheeler[19] have shown that the addition of this constituent, in moderate amounts (usually about three per cent), to by-product oven charges of good coking coals, permits the production of a "blockier" stronger coke of larger size. For coals with poor caking strength, however, the addition of fusain results in a weaker and sootier coke, and its removal from the charge is considered to be beneficial.

The influence of fusain on spontaneous combustion of stored coals is rather uncertain. Experiments by Stopes and Wheeler[20] led them to consider it improbable that fusain had a preponderating influence in promoting the actual ignition of the coal after self-heating had begun. They, however, thought it possible that "the rapid absorption of oxygen by fusain at low temperatures might be attended by a sufficient evolution of heat to raise appreciably the temperature of the main mass of the coal, thereby causing the most inflammable ingredient vitrain to react more rapidly with oxygen".

Classification of Coal by Rank

A committee of the American Society For Testing Materials (A.S.T.M.) has been studying various methods of coal classification for a number of years, and has recently published standard specifications for classification of coals both by rank and by grade*. Prior to this, the Fuel Research Laboratories of the Canadian Bureau of Mines employed the "specific volatile index"[21] method of coal classification, and as this method serves to classify coals for specific purposes, the two methods have been used for the coals reported herewith.

A.S.T.M. Classification By Rank (Designation D 388-38)

This method classifies coals by rank according to their fixed carbon and calorific values, calculated to the mineral-matter-free basis. The higher rank coals are classified by their fixed carbon on the dry basis, whereas the lower rank coals are classified by their B.t.u. value on the moist basis. Agglomerating and slacking indices are used to differentiate between certain adjacent groups.

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* See A.S.T.M. Designations D 388-38 and D 389-38 in reference (8), also "Report On The A.S.T.M. Standard Specifications For Classification of Coals By Rank and By Grade and Their Application to Canadian Coals" N.R.C. No. 814--National Research Council of Canada.

A.S.T.M. Classification By Rank - As Per Designation D 388-38

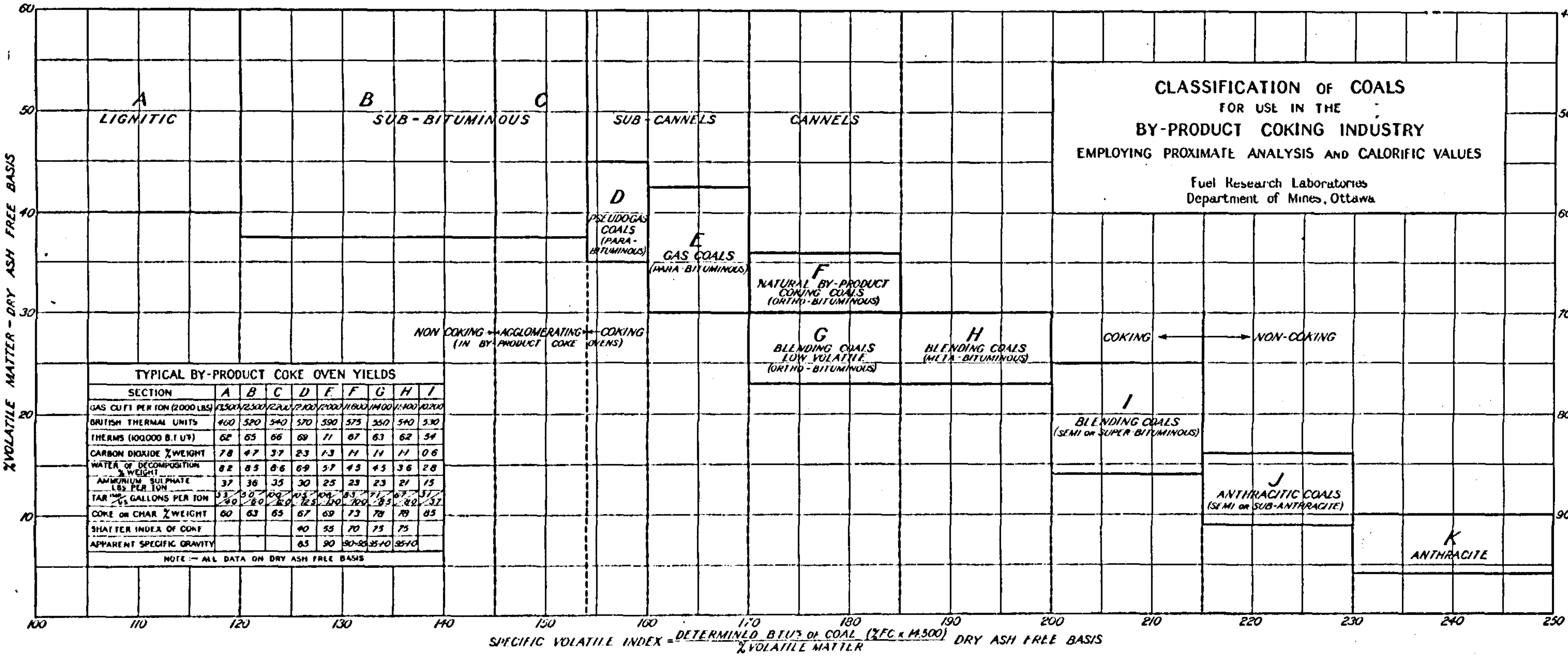
Classes and Groups	Limits of Fixed Carbon (f.c.) and B.t.u. (mineral-matter-free basis) and Requisite Physical Properties
I. Anthracitic class	
1. Meta-anthracite group..	Dry f.c., 98 per cent or more.
2. Anthracite group.......	Dry f.c., 98 to 92 per cent.
3. Semi-anthracite group..	Dry f.c., 92 to 86 per cent, non-agglomerating.
II. Bituminous class	
1. Low volatile group.....	Dry f.c., 86 to 78 per cent.
2. Medium volatile group..	Dry f.c., 78 to 69 per cent.
3. High volatile A group..	Dry f.c., less than 69 per cent, and moist B.t.u. 14,000 or more.
4. High volatile B group..	Moist B.t.u., 14,000 to 13,000.
5. High volatile C group..	Moist B.t.u., 13,000 to 11,000 either agglomerating or non-weathering.
III. Subbituminous class	
1. Subbituminous A group..	Moist B.t.u., 13,000 to 11,000 both weathering and non-agglomerating.
2. Subbituminous B group..	Moist B.t.u., 11,000 to 9,500.
3. Subbituminous C group..	Moist B.t.u., 9,500 to 8,300.
IV. Lignitic class	
1. Lignite group..........	Moist B.t.u., less than 8,300 (consolidated)
2. Brown coal group.......	Moist B.t.u., less than 8,300 (unconsolidated)

Specific Volatile Index (S.V.I.) Classification

This method is based on the heating value of the volatile matter, the values or indices obtained arranging coals in increasing value from peats to anthracites according to their rank. The index is calculated according to the following formula:-

$$\frac{\text{Determined B.t.u.} - (14{,}500 \times \text{weight of fixed carbon})}{\text{Per cent of volatile matter}} = \text{S.V.I.}$$

For ordinary purposes, the index is calculated on the dry, or dry ash-free, basis, but when the ash content is over 10 per cent and the sulphur over 1.5 per cent, the calculation is made on the "unit coal basis" (A.S.T.M. Designation D 388-36T). In accordance with this classification, coals are arbitrarily divided into the following groups.



TYPICAL BY-PRODUCT COKE OVEN YIELDS

SECTION	A	B	C	D	E	F	G	H	I
GAS CU. FT. PER TON (2000 LBS)	13500	12500	12200	12100	12000	11600	11400	11400	10200
BRITISH THERMAL UNITS	460	520	540	570	590	575	550	540	530
THERMS (100,000 B.T.U.'S)	62	65	66	69	71	67	63	62	54
CARBON DIOXIDE % WEIGHT	7.8	4.7	3.7	2.3	1.3	1.1	1.1	1.1	0.6
WATER OF DECOMPOSITION % WEIGHT	8.2	8.5	8.6	6.9	5.7	4.5	4.5	3.6	2.8
AMMONIUM SULPHATE LBS PER TON	37	36	35	30	25	23	23	21	15
TAR IMP/US GALLONS PER TON	33/40	50/60	100/120	105/125	104/120	83/100	71/85	67/80	31/37
COKE OR CHAR % WEIGHT	60	63	65	67	69	73	78	78	85
SHATTER INDEX OF COKE				40	55	70	75	75	
APPARENT SPECIFIC GRAVITY				.85	.90	.90-.95	.95-1.0	.95-1.0	

NOTE :— ALL DATA ON DRY ASH FREE BASIS

Chart I

	"Unit Coal" S.V.I. Limits	Volatile Matter Range Per cent
Brown lignites...	82 - 99	40 - 70
Black lignites...	99 - 125	36 - 55
Sub-bituminous...	125 - 160	35 - 50
Para-bituminous..	160 - 175	28 - 45
Ortho-bituminous.	175 - 190	21 - 35
Meta-bituminous..	190 - 210	21 - 28
Semi-bituminous..	210 - 230	14 - 24
Semi-anthracite..	230 - 255	9 - 16
Anthracites......	255 - 300	3 - 10

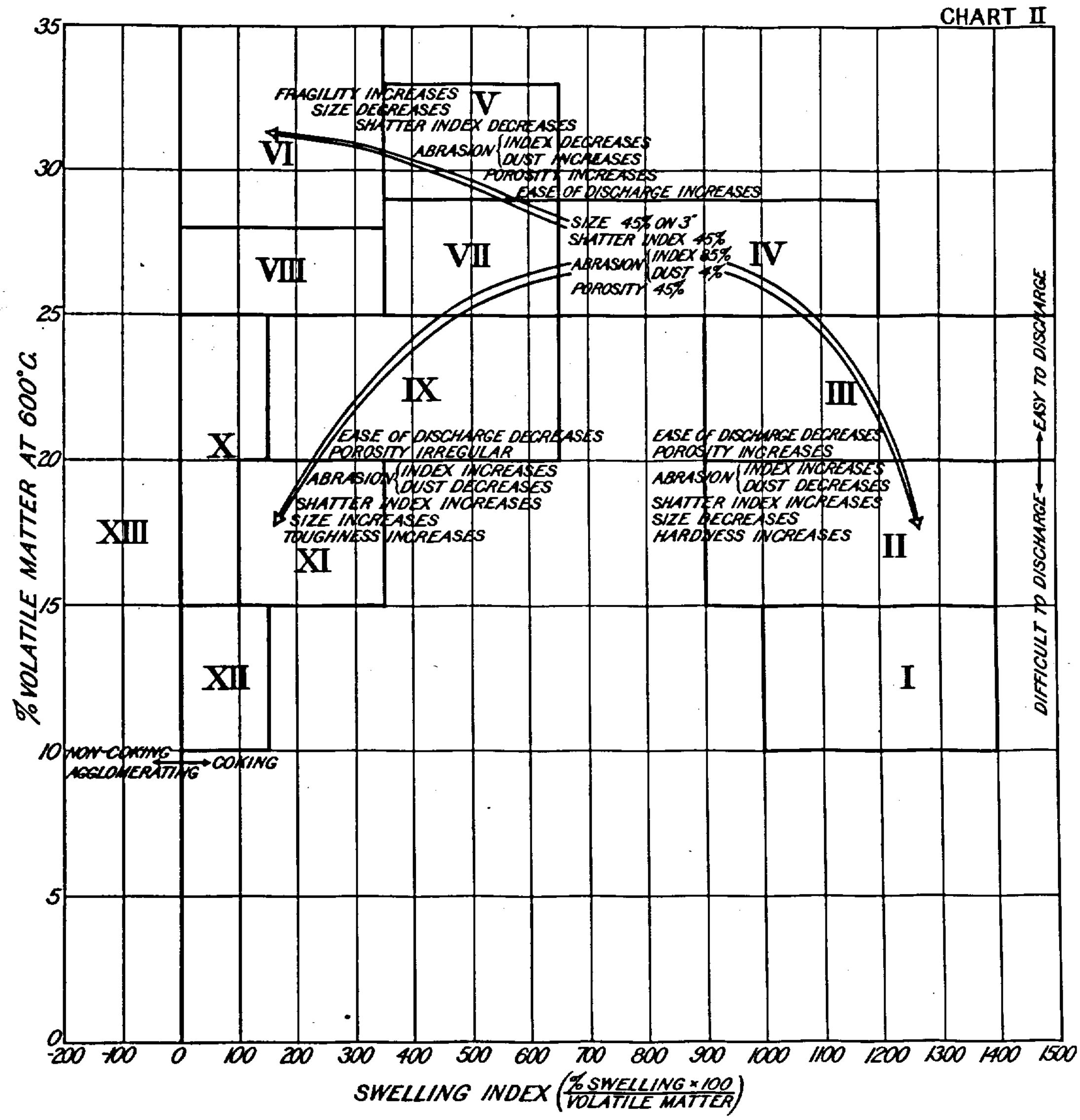
By noting the position of a coal on the chart, as per Chart 1, according to its S.V.I. and volatile matter, it is possible to predict, with a fair degree of accuracy, the characteristics of the coal with respect to its behaviour in a by-product coke oven, and the approximate yield of by-products to be expected.

Coking Properties

Swelling Index Test

In order to predict the physical properties of by-product coke made from any given coal, a laboratory test was developed at the Fuel Research Laboratories of the Canadian Bureau of Mines, which was published by the Mines Branch(22). This test consists of determining the volatile matter and the percentage swelling of the coke button at a temperature of 600°C. From these data, the swelling index is calculated, and, by the aid of a coke classification chart shown in Chart 2, 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 coals in these groups.

In addition to the use of this test for the by-product coke industry, its value is indicated in other fields. From a paper given at the A.I.M.M.E. meeting in 1937 by H.F. Hebley "Economics of Preparing Coal For Steam Generation", and reviewed in the Iron And Coal Trades Review, February 11, 1938, p. 277, the author may be quoted in part as follows:- "With coal of a highly-coking nature, the swelling characteristics often have a great influence on the ability of a stoker to maintain its load....... When the use of underfeed stokers is considered, the rate of combustion has a pronounced effect on the character of the coke produced during the operation of the stoker......... Some coals form hard dense coke masses, which fracture and break up much less readily than others. Other coals contract somewhat after initial coking, thereby causing fissures through the coke masses." It is obvious, therefore, that the evaluation of this property is very important in determining the suitability of coals for stoker use as well as for coke manufacture.



SECTION	ASH %	SIZE ON WHARF		SHATTER		ABRASION		DENSITY		TRANSVERSE	APPEARANCE OF NATURAL SURFACE	SHAPE	STRENGTH	CROSS FRACTURE	LONGITUDINAL FRACTURE	CELL STRUCTURE	SPONGE	PEBBLY SEAM
		% ON 3"	BREEZE	INDEX	BREEZE	INDEX	DUST	APP. S.G.	LB. C.F.	SHRINKAGE								
I		POCAHONTAS TYPE BLENDING COALS								NIL			HARD				VERY LITTLE	NONE
II		25-40	2·5-1·0	65-55	3·0-2·0	85-95	3·5 2·0	·85-·95	24-28	FAIR*	STEEL GREY AND SMOOTH	SQUARE	HARD	MEDIUM TO LARGE AMOUNT STRAIGHT	SMALL TO MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
III		30-45	2·5-1·0	50-65	3·0-2·0	85-95	3·5-2·0	·90-1·0	25-28	FAIR TO GOOD	STEEL GREY AND SMOOTH	SQUARE	HARD	MEDIUM AMOUNT, SQUARE	SMALL TO MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
IV		40-50	3·0-2·0	45-55	3·0-2·0	80-90	5·0-3·0	1·0-1·1	26-29	GOOD	STEEL GREY, FAIRLY SMOOTH	SLIGHTLY TRIANGULAR	HARD	MEDIUM AMOUNT, STEPPY	MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
V		30-50	4·0-2·0	40-50	6·0 4·0	75-85	5·0-3·0	1·0-0·9	26-29	GOOD	STEEL GREY, IRREGULAR	TRIANGULAR FINGERY	FRAGILE	MEDIUM TO LARGE AMOUNT STEPPY	MEDIUM TO LARGE AMOUNT	MEDIUM	SMALL TO MEDIUM AMOUNT	NONE
VI		30-50	2·0-5·0	25-40	6·0-4·0	55-80	7·0-3·0	·85-0·9	25	VERY GOOD	STEEL GREY, IRREGULAR	TRIANGULAR VERY FINGERY	VERY FRAGILE	MEDIUM TO LARGE AMOUNT STEPPY	LARGE AMOUNT	MEDIUM TO LARGE	MEDIUM AMOUNT	NONE
VII	0-5	40-50	4·0	55-70	3·0	80-95	2·5-5·0	·83	23·5	GOOD	STEEL GREY, IRREGULAR	BLOCKY; SLIGHTLY TRIANGULAR	HARD TO FRAGILE	SMALL TO MEDIUM. SLIGHTLY STEPPY	MEDIUM TO SMALL AMOUNT	MEDIUM TO SMALL	SMALL AMOUNT	NONE
	5-10 10-15	50-70 70-50	4·0 5·0	55-70 55-70	3·0 3·0	80-95 80-95	2·5-5·0 2·5-5·0	·83-·95 ·95	23·5-26 26	" "	" "	" "	" "	" "	" "	" "	" "	" "
VIII		50-70	2·0-5·0	45-65	4·0-5·0	60-80	2·5-7·0	·85-·95	24-26	GOOD	STEEL GREY, IRREGULAR	SLIGHTLY TRIANGULAR AND FINGERY	HARD TO FRAGILE; FRIABLE	MEDIUM AMOUNT; SLIGHTLY STEPPY	MEDIUM AMOUNT	MEDIUM; IRREGULAR	SMALL AMOUNT	NONE
IX	0-5	45-55	4·0	70	3·0	93	2·5	·80-·86	22-25	GOOD	STEEL GREY, SLIGHTLY IRREGULAR	BLOCKY; SLIGHTLY TRIANGULAR	TOUGH TO HARD	SMALL TO MEDIUM; SLIGHTLY STEPPY	SMALL TO MEDIUM AMOUNT	SMALL TO MEDIUM	SMALL AMOUNT	NONE
	5-10 10-15	55-80 80-55	2·0 2·0-4·0	70-80 70-80	3·0-5·0 3·0-5·0	90 90	2·5 2·5	·86-1·1 1·1-·92	25-31·5 31·5-25		" "	" "	" "	" "	" "	" "	" "	" "
X		70-80	3·0-5·0	65-80	10·0-5·0	70-80	10·0-7·0	·95-1·1	26-30	FAIR TO GOOD	DULL; GRANULAR	BLOCKY; IRREGULAR	TOUGH; FRIABLE	SMALL AMOUNT, SLIGHTLY STEPPY	SMALL AMOUNT	SMALL TO MEDIUM	GRANULAR ENDS	PEBBLY
XI		70-80	3·0	70-80	5·0	85-90	3·0-4·0	1·0-1·1	30-31	FAIR	DULL TO STEEL GREY; IRREGULAR	BLOCKY; SQUARE	TOUGH	SMALL AMOUNT; VERY SLIGHTLY STEPPY	SMALL AMOUNT	IRREGULAR	VERY LITTLE	NONE
XII		80	3·0	80	5·0	85	4·0	1·0-1·1	30-31	FAIR TO POOR	DULL GREY, IRREGULAR	BLOCKY; IRREGULAR	TOUGH; FRIABLE	VERY SMALL AMOUNT; IRREGULAR	VERY LITTLE	IRREGULAR	VERY LITTLE	NONE
XIII		25-70	4·0-3·0	30-70	20·0-5·0	50-80	15·0-5·0	·85-1·1	23·5-28	GOOD	DULL GREY, GRANULAR	BLOCKY; IRREGULAR	FRIABLE	SMALL TO MED. AMOUNT; IRREGULAR	SMALL TO MEDIUM AMOUNT	VERY LITTLE TO NONE	GRANULAR ENDS	PEBBLY TO NON COKING

*DIFFICULT TO DISCHARGE

Chart 2. Classification for By-product Cokes according to their physical properties, employing Volatile Matter and "Swelling Index" at 600° C. of the coal.

Caking Index

It has been shown that those coals, which are recognized as falling within the best coke-producing class, are more capable of withstanding a higher mixture of inert material and still yield a carbonized residue of definite crushing strength than are the inferior coals. This phenomenon of "caking" or "agglutination" has been thoroughly studied, and methods have been developed for the determination of the caking index. While these tests are of uncertain value for the purpose of assessing a wide range of coals in their application to the production of by-product coke, a knowledge of the caking index is of importance when it is desired to mix inert carbonaceous material, or non-coking coal, with coking coals.

The method developed by Gray(23), in which 25-gramme mixtures of coal and sand in varying proportion are carbonized in crucibles at 950°C., has been adopted as a standard at the Fuel Research Laboratories. The ratio of sand to coal, which on carbonization will form a sufficiently strong button to support a weight of 500 grammes, is designated as the "caking index". The higher the caking index, the greater the caking properties.

According to Malleis(24), the agglutinating value test has generally been found to have value for special investigation such as detecting deterioration of coking properties of coal due to storage, but it seems to have little value as a reliable index of the probable caking or coking properties of a coal.

The four coals studied in this publication were tested for their coking properties in accordance with the two tests outlined above.

Laboratory Washing Tests

Coal washing, generally speaking, depends on the difference in the specific gravities of the coal and refuse, and this difference has been used in the laboratory for many years by means of float-and-sink tests, to differentiate between these materials. By the successive separation of a coal at various gravities, washability curves may be constructed, which will indicate for any given coal the theoretical ash content and yield of both clean coal and refuse obtainable at any chosen gravity.

The data obtained from such tests on the 1½ inch slacks, the details of which are shown in a series of tables in Chapter IV, were plotted according to the method outlined by Campbell(25) of the American Rheolaveur Corporation. To these was added the "specific gravity distribution" curve as suggested by Bird(26) of the Battelle Memorial Institute. The curves, as constructed, contain the following information:-

Curve 1, the cumulative float ash per cent curve, represents the variation of the ash.

Curve 2, the variation in ash per cent of the material with variation in gravity at which the separation is made.

Curve 3, the cumulative sink per cent according to the recovery as in Curve 1.

Curve 4, the variation in recovery according to the specific gravity.

Curve 5, the ±0.10 specific gravity distribution curve, represents a measure of the comparative difficulty of separation according to specific gravity at the selected point of separation.

According to Bird, the degree of difficulty of west washing a coal may be predicted from the specific gravity distribution curve, and its application to standard processes is summarized in the following table.

±.10 Curve Per cent	Degree of Difficulty	Preparation
0 - 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.......	Efficient process: low tonnage
20 - 25	Exceedingly difficult	Very efficient process: low tonnage
Above 25	Formidable..........	Limited to a few exceptionally efficient processes

For the ordinary study of a bituminous coal, 10 per cent on the curve is used, and the specific gravity representing this point is usually selected for the washing of a composite sample, the clean coal and refuse fractions of which are studied for their various properties. If a horizontal line is drawn from this point on Curve 4 (specific gravity curve), the points at which it cuts the other lines represent the following:-

Curve 1, the average ash per cent of the separated coal;

Curve 2, the actual ash per cent of the heaviest piece of material left in the coal, and likewise the lightest piece of material in the refuse; and

Curve 3, the average ash per cent of the refuse extracted.

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