Section 3

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Technical Memorandum

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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

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FUELS DIVISION

TECHNICAL MEMORANDUM 5/58-CG

DEVELOPMENT AND PROGRESS OF THE CARBONIZATION SECTION

By

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THE DEVELOPMENT AND PROGRESS OF THE CARBONIZATION SECTION

The Carbonization Section had its inception early in the development of the Division of Fuels*. Projects dealing with the manufacture and testing of coke and producer gas trials were reported in 1912. The lack of the laboratory facilities at this time, necessitated the reporting of this work as investigations carried out at McGill University. Although intensive studies on carbonization and gasification were not undertaken prior to 1927, pilot plant scale projects on the processing of peat and small scale tests on bituminous coals, mainly for low temperature assays, were reported during this early period in the annual "Investigation of Fuels and Fuel Testing" Mines Branch Reports.

In 1927, with the world wide interest in low temperature carbonization for the production of a smokeless domestic fuel, the Carbonization Section extended its interests from the various bench scale forms of assay equipment to large scale tests. Field studies were made to examine the possibility of the many different types of pilot plants as well as the performance of the developed commercial units. These studies resulted in plant scale tests being undertaken

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* Swinnerton A. A. Fifty Years of Fuel Testing and Research. Mines Branch Memorandum Series No. 136, 1957.

in an investigation of the application of the Illingworth Low-temperature Carbonization Process to Canadian bituminous coals. The coal used in these tests was supplied by the Dominion Coal Company of Sydney Nova Scotia and the carbonization tests were made at the commercial scale plant of the Illingworth Company at Pontypridd, Wales. The domestic fuel produced by this process appeared quite satisfactory when tested in central heating equipment for solid fuels of the type commonly used in Canada for domestic heating. However attempts to adopt processes which have been successful in one country to conditions in another country have rarely succeeded: the best processes are liable to fail in any but the most favourable locations. The success of any low temperature carbonization process in Canada will depend on low capital cost of the plant per ton year -- materially lower than the present cost of either by-product oven or gas plants -- and on the ability to utilize a low grade and inexpensive raw fuel.

The carbonization industry in Canada, in the late 1920's, included fairly extensive developments in the production of manufactured gas for distribution in urban centres across the country. The type of carbonization equipment generally in use was that of the continuous vertical retort type. These units have since been completely superceded by other methods of gas production, or replaced by natural gas. A few plants were constructed to produce by-product

coke as domestic fuel and manufactured gas for urban distribution from standard by-product coke ovens. The major production of coke was mainly for metallurgical use from both by-produce coke ovens and beehive ovens with a smaller tonnage of by-product coke being used as domestic fuel mostly in the central provinces.

With the increase in staff in the Fuels Division preliminary sampling was undertaken to provide detailed information on the carbonization properties of various Canadian coals. Paralleling the laboratory tests in carbonization at high and low temperatures, it was decided to erect a semi-industrial scale size coking unit at these laboratories. This decision resulted from several attempts to obtain reliable data on yields and quality of coke from Canadian coals in small scale apparatus. The by-product yields for coals and coal blends, it was concluded, could be determined in the laboratory with reasonable accuracy and the results duplicated in plant operation, but coke quality can only be determined by tests on coke produced on a relatively large scale. Box coking tests were not considered entirely satisfactory although they were employed to make a preliminary survey of Western Canadian coals for the manufacture of coke. The high temperature carbonization equipment constructed at these laboratories in 1930 consisted of a by-product coke oven of slightly more than two tons capacity, an exhauster, a "P. and A." tar extractor, a bubble type washer, a gas meter and a small gas holder. The auxiliary equipment for controls and temperature recording, etc.,

included a Thomas calorimeter. The carbonizing chamber proper measured 8.5 ft. in height, 11.5 feet in length and had a uniform width of 12 inches. The carbonization unit included a pushing and leveling machine, a one hundred cu. ft. charging car and coke quenching equipment. The oven was heated by producer gas from a built-in producer. Car load lots of Canadian coking coals from Western Canada were obtained and tested, during the period 1930-1933. Several reports were prepared from the data collected from these tests and attempts were made to demonstrate the advantages of by-product coke as a smokeless domestic fuel.

The expense of operating the large 2 ton capacity unit did not appear to justify the investigations without preliminary work on a smaller scale. In the early 1930's two ovens having a capacity of approximately 500 lbs. of coal were built and experimental tests were made in them, these ovens being known as the high temperature 16 in. wide oven operating at 2200°F and the other the mid-temperature 12 in. oven operating at 1400°F. The feature of these ovens was that sufficient coke was produced from the 500 lb. coal charges for examination as to structure, physical properties and chemical analysis. The coke obtained was considered to be similar in quality to that produced in commercial ovens.

At the time these investigations were continuing tests were also being made in commercial coke oven plants at Montreal, Hamilton, Winnipeg and Ottawa in order to demonstrate the practical

application of Canadian coals to the industry in the production of coke for metallurgical and domestic use. In Ontario, considerable effort was made to expand the use of coke as domestic fuel and a proposal to encourage the construction of by-product coke plants for the distribution of manufactured gas and coke was supported by field investigations and the collection of statistical data.

Laboratory and small scale tests were continued on various phases of the work on carbonization and, up to the period which ended with the commencement of hostilities in 1939, a considerable proportion of this work was devoted to the study of coal expansion and the development of equipment for its measurement. The problems of coal expansion in coke ovens reached serious proportions when it was indicated that the deterioration of coke oven walls of several plants on this continent might be laid to the wall pressures developed during carbonization.

The first practical application of the measurement of expansion of Canadian coals was made for the plant of the Winnipeg Electric Company, Winnipeg Manitoba. It was intimated that the coal in use at this plant was highly damaging to the oven wall structures, despite the fact that the coke was readily discharged from the ovens.

Most of the types of equipment in use for the measurement of expansion at the time of the investigation were constructed and a series of tests were made. To further the information available on

coal expansion in Canada, cooperation was obtained between other laboratories and other investigators known to be working on the problem. The result of this work was the exchange of samples and information, and later the formation of a committee for the standardization of test equipment and methods of testing coal expansion. This committee is now a sub-committee of Committee D5 on Coal and Coke of the A.S.T.M.

From the earlier types of equipment developed on this continent, the unit designed by Mr. W.T. Brown of the Bethlehem Steel Company's research organization was selected as a tentative standard for conducting routine tests on samples being tested for expansion properties. This experimental unit which carbonizes 25 pounds of coal and known as the sole heated Bethlehem Tester or Brown oven has also been used by the Fuels Division to indicate the physical quality of coke that can be made, alone or in blends. Since this time several units have been developed which incorporate a movable wall oven with both walls heated; and in this connection cooperation has been obtained with the Montreal Coke and Manufacturing Co. (now Quebec Natural Gas Corp.) at LaSalle P.Q. and on several occasions tests on selected Canadian coals have been made in the Russel movable wall unit installed at that plant. This oven designed by the Koppers Company has been proposed by the A.S.T.M. Committee D5 on Coal and Coke, as a method for measurement of pressure developed during carbonization ("A.S.T.M. Standards on Coal and Coke".

Appendix V, Sept. 1951).

In 1939 a request was received from the Crow's Nest Pass Coal Company of British Columbia for co-operation in a series of tests to be conducted at the Curran Knowles plant West Frankfort, Illinois, U.S.A., on the processing of representative samples of their coals. These tests were observed and reported upon, allowing a more detailed study of the process which had been previously considered for its probable application to the demand for relatively small capacity coke oven plants which had occurred in areas where the urban population could not support a normal capacity standard type by-product coke plant. The Curran Knowles ovens were originally designed to treat petroleum still residues and and to carbonize coal tar to pitch, but were later adapted to the carbonization of coal by Mr. D. M. Curran. The design of the Curran Knowles ovens is a radical departure from that of other types of carbonization equipment. In general form they are arched rectangular chambers approximately 40 feet in length, 9 feet in width, the height of the arch from the sole of the oven being 4 feet at the key and 2 feet at the buttresses. The heat for carbonization is supplied from flues below the sole of the oven. The installation at Michel was successfully undertaken and the original 10 ovens, built for the first battery, have now been extended to 52 units. However several other plants of this type, constructed elsewhere on this continent, have failed for various reasons.

With the expansion of Canada's war effort the carbonization staff was diverted to other work more closely allied to the war effort and much of the work done was confined to field investigations and inspection of industrial plant operations with a view in most cases to conservation of fuels.

In addition an intensive study was undertaken at the early part of the war period in the possible production of activated charcoal in Canada and the necessary process steps to produce an acceptable product for gas masks from coconut shell, peach stones or selected low ash coals.

The programme was divided into three parts:-

(a) Carbonization tests on samples of anthracite, bituminous splint coal and natural splint coal from Alberta.

(b) Activation tests on the chars from the above coals, and also on samples of coconut shell chars produced by the Standard Chemical Company.

(c) The investigation of other possible raw materials for charring and activation such as briquettes made at high pressures from finely pulverized splint coals.

At the inception of this investigation it was considered probable that these laboratories would be required to meet the demands of the National Defence Department for activated charcoal. With this possibility in mind a considerable amount of work was done on the testing of raw material and the collection of data pertinent to

the design of equipment suitable for the production of gas mask charcoal on the scale required for the Canadian war effort.

In the post war period gradual recovery was made in the field of coking studies and the depleted staff rebuilt to its present status. One of the earlier investigations of this period included contributions to the Royal Commission on Coal in 1946, the completed report of this commission being published in 1947.

In a project which began in 1948 to study the possibility of improving the structure of the blast furnace coke made from Nova Scotia coals, blends were prepared using Drummond coal (Intercolonial Coal Co.) and the Sydney area coals. A decided improvement in the coke structure was indicated with the addition of Drummond coal to the washed Sydney slack. The same trend of improvement was also obtained with additions of coal from the seams of the Acadia Coal Company. However these conclusions were drawn from tests made in a Bethlehem Tester. This small quantity precluded the use of standard A.S.T.M. Shatter and Tumbler tests for evaluation, and it was suggested that pilot scale tests should be run in order to obtain sufficient quantities of coke for testing by standard methods used for the evaluation of the physical properties of cokes. Arrangements were then made with the Montreal Coke and Manufacturing Company, to process four coal blends in the 480 pounds test oven installed at their plant. From these tests it was demonstrated that 25 percent of Drummond coal in the blend increased the shatter index about 20

percent and the abrasion index 10 percent.

Recently, a special Mines Branch research group, comprising metallurgists of the Mineral Dressing and Process Metallurgy Division and fuel technologists of the Fuels Division was formed with the objective of compiling information for the efficient utilization of fuels in pyrometallurgical processes. The Carbonization Section, which is represented in this group, is charged with the task of collecting such data as the preferred range of quality merits of coke in relation to blast furnace conditions; properties of charges in foundries and smelting plants of the conventional type as well as other heat processes such as sintering, roasting etc. This study will include visits to various plants over a period of years in order to provide the proper reliable background information essential to develop an information service on the uses of fuels in the metallurgical industry. Currently this group is investigating the use of coal from the Canmore Mines Ltd. alone or processed for pyrometallurgical processes.

The problems of gas production have been studied by this section both as the basic source of city gas when manufactured from coal or alternatively derived from other source fuels such as coke. An important field of study has been the investigation of means of producing hydrogen and other synthesis gases both as to methods and costs. Recent advances in the extensive distribution of natural gas were made with the introduction of more grid distribution systems for methane from the main pipe line into many parts of Ontario and

Quebec. This has materially reduced the demand for manufactured gas which was previously obtained from by-product coke ovens and other coal gasification processes. However synthesis gas from natural gas and other raw material such as oil and coke has been continually in demand for processing in the ammonia and other chemical industries.

In 1947, the Cupola Research Committee of the American Foundryman's Association requested the assistance of the Canadian Mines Branch as well as the U.S. Bureau of Mines in developing tests to evaluate coke quality for cupola use. This investigation stemmed from the responsibility of this committee to instruct and guide foundrymen to utilize fuels appropriate to specific conditions. The Canadian representative on this committee, a metallurgist of the Physical Metallurgy Division, proposed that the Fuels Division develop a simple test for indicating the reactivity of foundry coke. In this investigation a test, which measured the electrical conductivity of coke, was developed to indicate the extent of the graphitization the coke had undergone during carbonization. This study was based on the premise that the electrical conductivity would be proportional to the extent of graphitization which the sample had undergone, and in turn would be indicative of coke reactivity. From 1948 to 1951, samples submitted by the A.F.A. Committee were tested and the results reported to the Canadian representative on this committee*.

* A report covering the development of this project is in the process of preparation.

In the early 1930's interest in coal classification in Canada and the United States had increased owing to the activities of the Sectional Committee on the Classification of Coal, under the sponsorship of the American Society for Testing Materials and also due to the activities of the Canadian Associate Committee on Coal Classification and Analysis. A scheme or relatively simple method of establishing the rank of a coal without resorting to the use of ultimate analysis data for classification was proposed by the Carbonization Section. This method known as the Specific Volatile Index although designed for coals in the by-product coking industry and originally considered applicable only to bituminous coals appears to offer a means of classifying all coals and may therefore be employed as a basis for general classification. The original report of this work is now out of print, and has been re-issued, in 1958, in a more concise form as result of the experience obtained over the intervening years in the application of this method for the classification of coal.

In view of the importance of the coking coal resources of Canada and, more particularly, the current interest shown in export possibilities of western coking coal, considerable emphasis is presently placed on the importance of evolving the most significant laboratory methods for predicting the coking properties of coals and coal blends processed in standard industrial ovens. This work has been in progress for approximately two years and is in addition to the work on the evaluation of specific coals for the production of suitable

cokes of acceptable metallurgical properties. The cooperation of the U.S. Bureau of Mines was given in laboratory tests wherein coals from three Canadian coking plants were carbonized in the Bureau of Mines - American Gas Association experimental retort. The same coals were also carbonized in the Fuels Division Bethlehem test oven. The properties of these laboratory produced cokes were compared with the cokes made from the same coals in industrial ovens referred to. The results of this co-operative work, with one of the authors an officer of the U.S. Bureau of Mines, was published in a recent report. Arrangements were made with the Steel Company of Canada for periodic submission to Fuels Division of plant data and samples of coal carbonized in the standard ovens. These coal samples are carbonized in laboratory scale equipment and comparisons are made with the cokes produced industrially.

The accompanying appendices are a reference guide to the published reports and memoranda on carbonization, gasification and uses of fuels in metallurgy prepared by members of the Fuels Division from its inception to the present time.

JCB/EJB/Jg

APPENDIX I

REPORTS OF INVESTIGATIONS CONDUCTED AT MCGILL UNIVERSITY, MONTREAL, UNDER THE AUTHORITY OF THE DOMINION GOVERNMENT

(these reports issued as "Coal of Canada: An Economic Investigation", published by the Government Printing Bureau, 1912)

	Title	Authors
Volume 1, Part VI	Manufacture and Testing of Coke	Edgar Stansfield and J.B. Porter
Volume II, Part VIII	Gas Producer Tests	R.J. Durley
Volume V	Detailed Results of the Gas Producer Trials	R.J. Durley
Volume VI, Appendix IV	Manufacture and Testing of Coke	Edgar Stansfield and J.B. Porter

APPENDIX II

INVESTIGATIONS REPORTED IN "INVESTIGATION OF FUELS AND FUEL TESTING", DEPT. OF MINES, MINES BRANCH, CANADA, PUBLISHED BY KINGS PRINTER, OTTAWA, FROM 1910 TO 1936

Mines Branch Report No.	Part Year	Title	Authors
509	IV (1918)	Lignite Carbonization	Edgar Stansfield R. E. Gilmore assisted by J. H. H. Nicolls, T. W. Hardy, R. C. Cantelo and others
542	III (1919)	Lignite Carbonization	Same
577	II (1920)	Carbonization of Peat	E. Stansfield and J. H. H. Nicolls
590	I (1920)	Lignite Carbonization	J. H. H. Nicolls and Harry Kohl
609	I (1922)	Carbonization of peat in commercial hardwood distillation ovens	R.E. Gilmore and Harold Kohl
618	I (1923)	The carbonization of lignite and sub-bituminous coals	Harold Kohl
644	I (1924)	Coking experiments on coals from the Maritime Provinces	B. F. Haanel and R. E. Gilmore
644	VI (1924)	Report of carbonization and washing experiments on sub-bituminous coal from Coal Valley, Alberta	R. A. Strong
671	I-I (1925)	Examination of typical cokes sold in Canada as household fuels	R. E. Gilmore, C. B. Mohr and others

Mines Branch Report No.	Part Year	Title	Authors
671	I-III (1925)	Low-temperature carbonization of bituminous coals	R.A. Strong
689	I-II (1926)	Low-temperature carbonization -- Continuation of tests on Canadian bituminous coals	R.A. Strong
696	I-II (1927)	Coking tests on coals from western Canada 1. Box coking tests in commercial by-product ovens 2. Laboratory by-product carbonization tests	R.E. Gilmore and R.A. Strong
696	I-III (1927)	Low-temperature carbonization -- continuation of tests on Canadian bituminous coals	R.A. Strong
712	I (1928)	Report of preliminary carbonization and briquetting tests on lignite from northern Ontario	R.A. Strong
721	I (1929)	Report of tests on Sydney coal by the Illingworth low-temperature carbonization process	R.A. Strong and E.J. Burrough
721	II (1929)	Notes on methods for the laboratory assay of coals for carbonization and for coking properties: (1) Comparison of low-temperature carbonization results by the "lead bath" and the Gray-King methods (2) Relation of caking indices and agglutinating values of coals to their laboratory	R.E. Gilmore

Mines Branch Report No.	Part Year	Title	Authors
		and plant scale coking properties	
721	III (1929)	Caking indices of typical Canadian coals	J.H.H. Nicolls
725	III (1930 and 1931)	Classification of coals using the Specific Volatile Index	E.J. Burrough E. Swartzman R.A. Strong
737	III (1932)	A Laboratory test on coals to predict the physical properties of the resultant by-product coke	E. Swartzman E.J. Burrough and R.A. Strong

APPENDIX III

REPORTS OF INVESTIGATIONS CARBONIZATION SECTION 1930 - 1944 (R.I.C.S. Series)

R.I.C.S. No.	Date	Title	Authors
1	Sept. 1930	Report of coking tests on Nova Scotia coals in the by-product plant of the Montreal Coke and Manufacturing Company, Ville LaSalle, Montreal July 8th to August 17, 1930	R.A. Strong and E.J. Burrough
2	Feb. 26 1931	Report of coking tests on Allison and Michel coals for gas and domestic coke manufacture	R.A. Strong and E.J. Burrough
3	Oct. 29 1931	Report of coking tests on British Columbia coals for manufacture of by-product oven coke	R.A. Strong E.J. Burrough E. Swartzman
4	June 10 1931	Report of coking tests on Greenhill and Bighorn coals for gas and domestic coke manufacture	R.A. Strong and E.J. Burrough
5	Dec. 8 1931	Report of coking test on washed Princess coal	R.A. Strong and E.J. Burrough
6	Jan. 26 1932	Report of coking tests on washed Princess coal in the by-product plant of the Montreal Coke and Manufacturing Company, Ville LaSalle, Montreal, November 21st, 1931	B.F. Haanel and R.A. Strong
7	May 17 1932	Report of coking tests on Alberta coals for domestic coke manufacture	R.A. Strong E.J. Burrough E. Swartzman

R.I.C.S. No.	Date	Title	Authors
9	June 7 1932	Report of coking tests on British coals in the by-product plant of the Montreal Coke and Manufacturing Co. Ville LaSalle, Montreal, Feb. 1932	R.A. Strong E.J. Burrough E. Swartzman
10	May 18 1932	Report of coking tests on Nova Scotia coals in the plant of the Ottawa Gas Co.	R.A. Strong E.J. Burrough E. Swartzman
13	July 21 1932	Report of tests on British gas coals, Part I	R.A. Strong E.J. Burrough E. Swartzman
14	Aug. 1932	Classification of coals and other solid fuels, using specific volatile index	E.J. Burrough E. Swartzman R.A. Strong
16	Oct. 17 1932	Report of coking tests on Glapwell coal in the plant of the Ottawa Gas Company	R.A. Strong E.J. Burrough E. Swartzman
17	Oct. 23 1932	Report of tests on British gas coals, Part II	R.A. Strong E.J. Burrough E. Swartzman
19	Dec. 1932	Report of coking tests on Dinnington and Kinneil coals in the plant of the Ottawa Gas Company, November 22 to 29, 1932	R.A. Strong E.J. Burrough E. Swartzman
20	Feb. 23 1933	Report of tests on British Gas coals, Part III, February 24th, 1933	R.A. Strong E.J. Burrough E. Swartzman
21	May 23 1933	A laboratory test on coals for predicting the physical properties of the resultant cokes	E. Swartzman E.J. Burrough R.A. Strong

R.I.C.S. No.	Date	Title	Authors
24	July 29 1933	Report of coking tests on Canadian coals in gas plant of the British Columbia Power and Gas Co. Ltd., Vancouver, B.C.	R.A. Strong E.J. Burrough E. Swartzman
25	July 22 1933	Report of coking tests on Michel and Champion coals in the gas plant of the Manitoba Power Commission Brandon, Manitoba	R.A. Strong E.J. Burrough E. Swartzman
32	May 15 1934	Report of coking tests on Cadomin coal for the manufacture of domestic coke	R.A. Strong E.J. Burrough E. Swartzman
33	July 28 1934	Report of coking tests on various coals for the manufacture of domestic coke for the Ottawa market	R.A. Strong E.J. Burrough E. Swartzman
35	Aug. 23 1934	Report of an investigation on the method now in use at the Fuel Research Laboratories for determination of apparent specific gravity of coke	E.J. Burrough R.A. Strong E. Swartzman
36	Oct. 1934	Report of field investigations on briquetting, coal preparation and carbonization	E. Swartzman
46	Dec. 1935	Report on washing and coking study of coals from five independently operated mines in Nova Scotia	R.A. Strong E.J. Burrough E. Swartzman
47	Dec. 1935	Report of Field Investigations at Sydney Nova Scotia, 1935	E. Swartzman R.A. Strong E.J. Burrough

R.I.C.S. No.	Date	Title	Authors
48	Dec. 1936	Report of Washing and Coking Study of Coals from the Minto Coal Basin, New Brunswick	E. J. Burrough R.A. Strong E. Swartzman
52	March 1936	Report on Reactivity of Coke	E. J. Burrough R.A. Strong E. Swartzman
54	May 1936	Study of the Washing Characteristics and Coking Properties of Slack Coal (- 1/2") from the Minto Coal Co. Ltd. Minto, N.B.	R.A. Strong E. J. Burrough E. Swartzman
57	Sept. 1936	Investigation on Minto Coal from the Minto Coal Co. Ltd. Minto, New Brunswick	R.A. Strong E. J. Burrough E. Swartzman
59	Nov. 1936	Report of Coking Tests on Nova Scotia coal at the plant of the Hamilton By-Product Coke Ovens, Ltd.,	R.A. Strong E. J. Burrough E. Swartzman
60	Dec. 1936	Report of Laboratory Tests on Coals supplied from the British Columbia Electric Railway Co. Ltd.	R.A. Strong E. J. Burrough E. Swartzman
65	April 1937	Preliminary report of an investigation of Michel coal at the coke ovens of the Winnipeg Electric Company	
66	June 1937	Report of Field Investigations re (1) coal expansion tests at Philadelphia, Pa., (2) description of Philadelphia coke plant, and (3) description of Koppers Seabord coke plant	E. J. Burrough
68	July 1937	Report of investigation of Michel coal, Part I	R.A. Strong E. J. Burrough E. Swartzman

R.I.C.S. No.	Date	Title	Authors
71	Sept. 1937	Preliminary report of expansion tests on Michel coal	R.A. Strong E.J. Burrough E. Swartzman
75	Dec. 1937	Report of Investigation of Michel coal, Expansion tests in a standard sample by various laboratories	R.A. Strong E.J. Burrough E. Swartzman
78	Jan. 1938	Investigation of Coals for Use in the By-product Coke Oven Plant of the Winnipeg Electric Co.	R.A. Strong E.J. Burrough E. Swartzman
84	Feb. 1938	Discussion on Coal Expansion Testing, Presented at the Conference on Coal Expansion held at Johnstown Pa. Feb. 18th, 1938	B.F. Haanel R.A. Strong E.J. Burrough E. Swartzman
86	April 1938	Report of Field Investigations on Coal Expansion	B.F. Haanel R.A. Strong E.J. Burrough
87	April 1938	Report of Coking Tests on Michel Coal at the Plant of the Radiant Heat Corporation West Frankfort, Ill.	R.A. Strong E.J. Burrough E. Swartzman
100	Oct. 1938	Investigation of Factors Affecting the Determination of the Bulk Density of Coal	R.A. Strong E.J. Burrough E. Swartzman
103	Nov. 1938	A Laboratory Study on the Use of Petroleum Pressure Coke in the Manufacture of Metallurgical and Domestic Coke	R.A. Strong E. Swartzman E.J. Burrough
108	Jan. 1939	Field Investigations of the Curran-Knowles Carbonization System at the Plant of the Owen Sound Public	E.J. Burrough

R.I.C.S. No.	Date	Title	Authors
		Utilities Commission	
111	Feb. 1939	Field Investigations in Western Canada Oct. 11 to Nov. 23, 1938	E. J. Burrough
125	Aug. 1939	Field Investigations on Coal Washeries and Coke Oven Plants of Nova Scotia	E. J. Burrough
145	April 1940	A Study on Coal Expansion with Reference to Western Canadian Coals	R. A. Strong E. J. Burrough E. Swartzman
151	July 1940	"Report on Laboratory Coking Tests Conducted on Various Western Canadian Coals with Reference to Use at Winnipeg Electric Company Gas Plant	E. Swartzman
153	Oct. 1940	"Report on Various Western Canadian Bituminous Coals at the Gas Plant of the Winnipeg Electric Company.	E. Swartzman
156	Jan. 1941	"Report of Coking Tests on Comox Colliery Coals for the Production of Blast Furnace Coke"	E. J. Burrough
158	Feb. 1941	"Investigation of No. 4 Seam Coal from the Greenhill Colliery, West Canadian Collieries, Ltd., Blaimore, Alberta.	E. J. Burrough
167	July 1941	Field Investigations Re the Collection of samples of Commercial Grades of Coal from selected collieries in Nova Scotia, and a Survey of the Carbonization Plants of	E. J. Burrough

R.I.C.S. No.	Date	Title	Authors
		of Eastern Canada	
170	Aug. 1941	Report of Field Investigations July and August 1941	E. Swartzman
189	May 1944	Investigation of the Coking Coals from Elk River colliery, Crows Nest Pass Coal Co. - May 1944	E. J. Burrough

APPENDIX IV

CARBONIZATION SECTION MEMORANDA
1939 - 1942 (C.S.M. Series)

C.S.M. No.	Date	Title	Authors
3	June 1939	Field Investigations of Coal Washeries and Coke Ovens in Nova Scotia	E.J. Burrough
5	June 1941	"Report of Tests on Beehive Coke Prepared from Comox Coal mined in the Cumberland Area, Vancouver Island, B.C.	E.J. Burrough
7	Nov. 1941	Report on the Coking Properties of Coal from the Aveling Coal Co. Ltd. Bulkley Valley Area B.C.	E. Swartzman
10	April 1942	Report on the Coking Properties of Coal from the Aveling Coal Co. Ltd. Bulkley Valley Area B.C.	E. Swartzman

APPENDIX V

REPORTS ISSUED BY THE FUEL RESEARCH LABORATORIES 1945 to 1956 (F.R.L. Series)

F.R.L. No.	Date	Title	Authors
6	March 1945	Separation and Properties of the Petrographic Constituents of Michel No. 3 Seam coal	E. Swartzman
11	May 1945	Coke and Gas Industry of Canada - submission prepared for the Royal Commission on coal	E.J. Burrough
27	Nov. 1945	Report on Carbonization Tests on a Sask. Lignite and Drumheller Coal in the Travelling Grate Coking Plant of the Shawinigan Chemicals Ltd.	E.J. Burrough
45	June 1946	Coke and Gas Properties of Coal from the Betty Seam B.C.	E. Swartzman
47	July 1946	Report of P and C Tests of Michel and Elk River coals for Coke Making	E.J. Burrough
52	Oct. 1946	Report of Tests on the Production of Carburetted Water using bituminous coal as generator Fuel at the Vanc. Gas Plants of the B.C. Power and Gas Co.	E.J. Burrough
60	Feb. 1947	Report on the Application of the Fluidization Process to the Production of a Carbonized Char from Canadian coals	E.J. Burrough H.P. Hudson
8	April 1945	Report on the Heavy Media Separation Processes, National Fuel Carbonization Process and the Batelle Smokeless Stove	E. Swartzman

F.R.L. No.	Date	Title	Authors
17	July 1945	Report of Inspection of Travelling Grate Carbonization Process as designed and operated by Shawinigan Chemical Co.	E. J. Burrough
114	Feb. 1949	Report of Carbonization Tests on Coal from Hasler Mine Hasler Creek Area B. C.	J. C. Botham E. J. Burrough
137	March 1950	Report of Tests for Obtaining a Coke Product from Blends of Non-Coking and Coking Coals	J. C. Botham E. J. Burrough
164	March 1952	Report on Carbonization tests Drummond Coal from Intercolonial Coal Company, Westville, N. S. and Blends with Dosco washed Coal from Dominion Steel and Coal Corp. Sydney, N. S.	E. J. Burrough J. C. Botham
180	Aug. 1953	Report of Carbonization Tests of Blends of Dominion Coal and Acadia Coal for the Production of Metallurgical Coke	E. J. Burrough J. C. Botham
229	Jan. 1956	Coking Properties as indicated by Free Swelling Index of Strip Mine Coal from Luscar Coals Ltd., Luscar, Alta.	J. C. Botham
229A	April 1956	The Pattern of Variability of the Swelling Indices of Luscar Strip Coal	J. Visman
240	March 1956	The Conversion of Coal to Chemicals and other Products	E. J. Burrough

F.R.L. No.	Date	Title	Authors
261	July 1957	Preliminary Study of the Relation Between Certain Physical Properties of Bituminous Coal and the Resulting Coke Produced under Laboratory and Industrial Conditions	E. Swartzman J.C. Botham G.W.I. Birge T.E. Tibbetts E.J. Burrough

APPENDIX VI

UNCLASSIFIED REPORTS ON CARBONIZATION AND GASIFICATION 1950 to 1955

Date	Titles	Authors
March 1950	Report on Electrical Resistivity of Graphitic Shale and on Blends of Graphitic Shale and Graphite Electrode	J. C. Botham and T. R. Skerry
Oct. 1950	Memorandum Re Foundry Coke Samples from International Coal and Coke Company Coleman, Alberta	E. J. Burrough J. C. Botham
Oct. 1950	Results of Coking Tests on Seam Samples of Coal from Crow's Nest Pass Coal Co. Ltd.	E. J. Burrough J. C. Botham
March 1951	Report of Laboratory Coking Tests on Samples of Crowsnest Pass Coals from Michel Colliery of the Crows Nest Pass Coal Co.	E. J. Burrough J. C. Botham
June 1951	Carbonization Investigations of the Washed Coal Processed at the Sydney Plant of the Dominion Steel and Coal Co. Ltd. Sydney, N. S.	E. J. Burrough J. C. Botham
Sept. 1951	Effect of Ash Contents of Coal Blends of "Drummond" coal and washed "Dosco" coal upon the resultant coke	E. J. Burrough J. C. Botham
Jan. 1951	Tests of Coal Blends Proposed for Use at the Hamilton Coke and By-products Plant, Hamilton, Ontario.	E. J. Burrough J. C. Botham
Nov. 1951	Report on the Use of Hematite Ore as an Inert Blending Material in Metallurgical Coke Production	E. J. Burrough J. C. Botham
Dec. 1951	Expansion Tests on Blends of Coals for LaSalle Foundry Cokes	E. J. Burrough J. C. Botham
July 1952	Report of Field Investigations at the LaSalle Foundry Cokes	E. J. Burrough

Date	Title	Authors
Sept. 1952	Report of Coking Tests on Coals from West Canadian Collieries Ltd., Blairmore Alta.	E. J. Burrough J. C. Botham
Jan. 1953	Report on Tests on Carbonization of Luscar Coal from Luscar Collieries, Alta.	E. J. Burrough J. C. Botham
Oct. 1954	P. D. and P. Char Process and Its Application to Drumheller Alt. Coal Based on letter from Lloyd Berg -- Montana State College to S. G. McMullen Midland Coal Mining Co. Ltd.	E. J. Burrough
Aug. 1955	Report of Field Work at the Institute of Gas Technology, Chicago Illinois, and Western Canada, (July 3 to 23)	J. C. Botham
Dec. 1955	"Carbochar Process" designed by Daniel Petit	E. J. Burrough

APPENDIX VII

TECHNICAL MEMORANDA 1955 - 1958 (T.M. Series)

Technical Memorandum T.M. No.	Date	Title	Authors
15/55	March 31 1955	Relationship of Free Swelling Index, Plasticity, Loss of Volatile Matter and Compactness to the Quality of Coked Briquettes made from mixtures of coals and Inert Materials	E. Swartzman
16/55	April 1955	Abstract of Address by Sir Charles Ellis, F.R.S. Subject "Smokeless Solid Fuels"	E.J. Burrough
22/55	May 4, 1955	Field Visits to Hamilton Coke Oven Plants	E.J. Burrough
23/55	May 5, 1955	Visit to Welland plant of American Cyanamid Company and notes on C.I. M.M. meeting	E.J. Burrough
27/55	May 1955	National Carbonizing Company Ltd. of London England Low Temperature Carbonization Process	E.J. Burrough
30/55	May 12 1955	Proposed Study of British Columbia and Alberta Crowsnest Area Coking Coals	E. Swartzman E.J. Burrough
43/55	July 21 1955	The Chemical Industry of the Dutch State Mines	E.J. Burrough
59/55	Nov. 16 1955	The Coking Properties of A Seam Michel Channel with Special Reference	

Technical Memorandum T.M. No.	Date	Title	Authors
		to the Plasticity (Gieseler Test)	
10/56	Feb. 15 1956	Calorific Values, Hardness and Apparent Specific Gravities of Canadian Coals, Cokes and Charcoals	E. Swartzman
17/56 CG	--	Sampling of Coal and Coke for F.R.L. _____ U.S. Bureau of Mines Co-Operative Programme Re: Correlation of physical quality of coke of B.M. - A.G.A. test with commercial coke	E. Swartzman E.J. Burrough
19/56 PREP	April 4 1956	Programme of Investigations on the coking coals of Canada.	E. Swartzman
25/56 PREP	May 1956	Certain Developments concerning the possible conversion of Coal, Under dhe influence of Temperature, Pressure and Solvents into Plastics and Binders	E. Swartzman
39/56 CG	June 30 1956	Metallurgical Coke Production in Eastern Canada	E.J. Burrough
40/56 PREP	June 1956	Canadian Coking Coals Their Occurrence, Quality and Availability	E. Swartzman

Technical Memorandum T.M. No.	Date	Title	Authors
41/56 CG	June 1956	Results from Field Testing Core Samples of Coal for Residual sorbed Gas Content at No. 3 Mine of the Canmore Mines Ltd., during the period of July 25 to August 5 1955	J. C. Botham
43/56 CG	July 1956	Results from Field Testing Core Samples of Coal for Residual Sorbed Gas Content at the No. 2 Mine of the Cumberland Railway and Coal Co. at Springhill N. S. during the period of May (14-19) 1956	E. J. Burrough
44/56 CG	July 19 1956	Coking Coal Sources in Western Canada and production of coke in Western Canada	E. J. Burrough
53/56 CG	August 1956	Clarification of the Method of Sampling and Further Data on the Rate of Evolution of Residual Sorbed Gas from Coal Samples Taken from No. 2 Mine, Cumberland Railway and Coal Company	J. C. Botham
65/56 PREP		Coal Cleaning, Coal Briquetting and Coke Plants in Canada (1945 and 1956)	E. Swartzman E. J. Burrough

Technical Memorandum T.M. No.	Date	Title	Authors
61/56 CG		A detailed study of the use of coal and other fuels in Canadian Metallurgical Industry and the creation of the Mines Branch Smelting Unit	A. Ignatieff
5/57 CG	Dec. 21 1956	Fuel Requirements in the Smelting of Nickel bearing ores with reference to the possible requirements of the International Nickel Company's proposed development of Mystery-Moak Lakes Manitoba	J. C. Botham
7/57 CG	Feb. 1957	Application of the Dietrich-Humbolt Process for the Recovery of Alumina from Canadian Coal Ash	J. C. Botham
16/57 PREP	Feb. 1957	Discussion with Mr. W. L. Morriss Jr. Director of Preparation, U.S. Steel Corp. Pittsburgh Pa., on Dec. 5, 1957, Re: Petrography in Coal Preparation as related to carbonization	Ed Swartzman
20/57 CG	Feb. 1957	Visit to Eldorado Mining and Refining Co. Ltd. Port Hope, Ont., to Analyse Recycle Gas From Greensalt Process	J. C. Botham R. J. Offord
23/57 CG	March 1957	Petrographic Preparation of Coking Coals - Meeting with Members of Steel Company of Canada Ltd.	E. Swartzman
24/57-MECH-CG	April 1957	An Analysis of Coal Gasifier - Gas Turbine -	

Technical Memorandum T.M. No.	Date	Title	Authors
		Steam Boiler Combinations for Generating Power	E.R. Mitchell E.J. Burrough
28/57 CG	April 1957	The Use of Coal in the Smelting of Iron Ore with particular reference to Novel Techniques	J.C. Botham
34/57 CG	April 1957	Metallurgical Coke in Western Canada	E.J. Burrough
35/57 PREP	April 10 1957	Visit of T.C. Hirst, Sogemines Ltd., Discussion of Sources and Quality of Coking Coals in Canada in relation to Prospective Steel Industry Developments	E. Swartzman
50/57	June 1957	Appraisal of Proposed High Temperature Test for Physical Quality of Coke In Relation to the Generally Accepted Test Methods	J. C. Botham
75/57 CG	Nov. 1957	Association of Gases with Coal Part 5 - Laboratory Outburst Test on Solid Coal Specimens	J. C. Botham
77/57 PREP	Nov. 1957	Interim Report on the Coking and other Characteristics of Coal from Vicary Creek Mine	E. Swartzman
82/57 PREP	Nov. 1957	Interim Report on the Study of the Coking Properties of Mine Run Coal from Bellevue No. 1 Seam West Canadian	E. Swartzman

Technical Memorandum T.M. No.	Date	Title	Authors
		Collieries Limited, Crowsnest Area, Alta.	
88/57 PREP	Dec. 1957	Meeting with a Representative of and Consultants to the CUMCO Corporation Ltd. Toronto Re: Availability of Coals for Reduction of Low Grade Iron Ore in the Port Arthur District	E. Swartzman
5/58	Nov. 1958	The Development and Progress of the Carbonization Section	E.J. Burrough J.C. Botham
7/58	April 1958	Present and Potential Uses of Coal in the Canadian Metallurgical Industry	J.H. Walsh J.C. Botham H.P. Hudson
23/58	Jan. 1958	Continuous Fluidized Carbonization Process - United Engineers and Constructors Inc.	E.J. Burrough E.R. Mitchell
26/58 PREP	Feb. 1958	The Coking and Other Characteristics of Coal from Vicary Creek Mines Coleman Collieries Ltd. Crowsnest Area, Alta. - Second Interim	E. Swartzman T.E. Tibbetts
34/58 CG	Feb. 1958	Tokyo Gas Company - Plants and Equipment	E.J. Burrough
37/58 CG	Feb. 26 1958	Review on the Direct Use of Coal for the Reduction of Ores 1956-57 (C.C.F.R.)	J.C. Botham

Technical Memorandum T.M. No.	Date	Title	Authors
42/58 PREP	Feb. 26 1958	Blending Low Volatile Coking Coals and Inert Materials to Improve Coke Quality of High Volatile Bituminous Coking Coals	E. Swartzman
45/58 PREP	Feb. 28 1958	Interview with Mr. Masaaki Sanda Re: Canadian Coking and Anthracite Coals for Possible Export to Japan - Feb. 28/58	E. Swartzman
49/58 S.F.	March 4 1958	Devolatilization of Canmore Buckwheat Coal	W.J. Montgomery
51/58 CG	March 6 1958	Carbonization Tests on Western Canadian Coals in Russell Movable-Wall Test Oven	J.C. Botham E.J. Burrough
61/58 PREP		Study of the Coking Properties of Alberta Crowsnest Area coals, from Bellevue Mine No. 1 Seam, Greenhill No. 2 Seam and Grassy Mountain Strip No. 4 Seam - Part 2. Quality of Bethlehem Tester Coke Expansion Characteristics and Carbonization Yields	E. Swartzman T.E. Tibbetts
62/58 CG		Association of Gases with Coal Part 4 - Permeability Tests	J.C. Botham
66/58 PREP	April 1958	41st Conference of Blast Furnace Coke Oven and Raw Materials Committee and National Open Hearth	E. Swartzman J.C. Botham

Technical Memorandum T.M. No.	Date	Title	Authors
		Steel Committee of the AIME Cleveland Ohio April 14 to 16 1958	
72/58 CG	May 1958	Attendance at the 41st Conference of the Blast Furnace, Coke Oven and Raw Materials Committee and the National Open Hearth Committee of the AIME, Cleveland Ohio, April 14 to 16, 1958	J. C. Botham
73/58 CG	May 1958	Visit to the Steel Company of Canada, Hamilton, Ont. April 17, 1958	J. C. Botham
74/58 CG	May 1958	Visit to Dominion Foundries and Steel Co. Ltd., Hamilton, Ontario, April 18, 1958	J. C. Botham
86/58 CG	June 1958	Memorandum Re: Study of Carbonization Units of the Shawinigan Chemicals Co. Ltd.	E. J. Burrough
94/58 CG	June 1958	Visit to Algoma Steel Corporation, Sault Ste. Marie Ontario and Algoma Ore Properties, Jamestown, Ontario June 10 - 12 1958	J. C. Botham
97/58 CG	Sept. 1958	Classification of Coals Using Specific Volatile Index	E. J. Burrough E. Swartzman

Technical Memorandum T.M. No.	Date	Title	Authors
105/58 CG	July 1958	Coking Characteristics of the Marker Seam, No. 5 (Stewart) Seam and No. 4 Seam, Canmore Mines Ltd., Canmore Alberta	J. C. Botham E. J. Burrough
109/58 CG	July 1958	Study of Pilot Plant Methods for Assessing Coal Expansion During Carbonization	E. J. Burrough
145/58 SF	Aug. 18 1958	A Comparison of the Relative Stability of Small Sized Canmore Coals from Two Seams	J. G. Jorgensen
151/58 CG	Sept. 1958	Memorandum Re: Study of the Coking Techniques Followed at the Steel Company of Wales and the plants of the South Western Section of the British Coal Board	E. J. Burrough
152/58 PREP	Sept. 1958	Review of Small and Semi Commercial Scale Experimental Methods Used in Europe for Assessing the Metallurgical Coke Making Characteristics of Coals	E. Swartzman
157/58 CG	Sept. 30 1958	Report of Field Studies of Canmore Mines Ltd. Canmore Alberta, Aug. 1 - 20, 1958	J. C. Botham
158/58 SF	Sept. 1958	An Empirical Test to Determine the Ignition Temperature of Metallurgical Coke	G. C. Behnke and W. J. Montgomery

Technical Memorandum T.M. No.	Date	Title	Authors
160/58 SF	Sept. 30 1958	Devolatilization and Agglomeration Tests of Canmore Coal	W.J. Montgomery
162/58 PREP	Sept. 1958	Progress Report - Cooperative Study of the Correlation of the Quality of Cokes Produced Industrially and by Laboratory Methods	E. Swartzman E.J. Burrough
165/58 CG	Oct. 8 1958	Memorandum Re: Estimates of By-product Coke Plant Costs in Canada	E.J. Burrough J.C. Botham
167/58 CG	Sept. 30 1958	Possible Uses of Canmore Coal in the Metallurgical Industry	J.C. Botham
171/58 PREP	Sept. 1958	Evaluation of the Coking Characteristics of a Sample of Coal from the Nordegg Area, Alta.	E. Swartzman T.E. Tibbetts
177/58 CG	Oct. 1958	Occluded Gas Study, Canmore Mines Ltd., August 1958	J.C. Botham
190/58 CG	Nov. 1958	Coking Characteristics of Samples from the Stewart Seam, Granger Seam and Georgetown Prospects Canmore Mines Ltd.	J.C. Botham

APPENDIX VIII

REPORTS PUBLISHED IN TECHNICAL JOURNALS

Journal	Title	Authors
Proc. 22nd Annual Meeting (1929) Canadian Gas Association	The Status of Low-Temperature Carbonization in Europe	B. F. Haanel
C.I.M. Trans. Vol. XXXVI, 1933	Recent Investigations on The Nature, Storage and Coking of Typical Coals from the Sydney Area, Nova Scotia.	R. E. Gilmore R. A. Strong
A.I.M.E. Coal Division, 1934	Agglomerating and Agglutinating Tests for Weakly Caking Coals	R. E. Gilmore G. P. Connell J. H. H. Nicolls
C.I.M. Trans. Vol. XXXIX, 1936	Review of Investigations on Coals and other Fuels of Western Canada	B. F. Haanel R. A. Strong
Eng. Journal, Vol. XX No. 7, 1937	Investigations of Canadian Coals including their testing, classification and utilization	B. F. Haanel R. E. Gilmore
Fuel Economy Conference of the World Power Conference The Hague, 1947	Canadian Coals, Their Characteristics and Utilization	R. E. Gilmore E. J. Burrough
C.I.M. Transactions Vo. LIV. 1951	Metallurgical Coals of the Crownest Area	E. J. Burrough
Can. Mining Jr. Sept. 1952	The By-product Coking Industry in Canada	E. J. Burrough
Can. Mining Jr. Nov. 1953	Manufactured Gas	E. J. Burrough
International Conference on complete gasification of mined coal LIEGE May 3-5, 1954	Gasification of Coal Relative to the Canadian Fuels Economy	A. Ignatieff E. J. Burrough R. B. Toombs

Journal	Title	Authors
C.I.M. Transactions Vol. LXI, 1958 PP. 57-64	Present and Potential Uses for Coal in the Canadian Metallurgical Industry	J.H. Walsh J.C. Botham H.P. Hudson
Royal Commission on Coal, Chapter XI, pp. 479-519 published by Kings Printer, 1946	Products and By-Products	W.F. Carroll Chairman of the Commission

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