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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

FIFTY YEARS OF FUEL TESTING AND RESEARCH

by

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FUELS DIVISION

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PREFACE

The year 1957, coinciding with the holding in Canada of the Sixth Commonwealth Mining and Metallurgical Congress, is the Golden Jubilee of the organization of the Mines Branch. It is considered appropriate, therefore, to provide this review of the activities during the past fifty years of the Fuels Division, the senior division of the Mines Branch.

No research agency is built in a day and although, by the standards of larger nations, the results achieved by the Division are regarded by its staff as modest, much of the present success is due to the devoted efforts of the long service staff that have contributed so largely to the build-up of the Division over the years. In acknowledgment of their services, an appendix lists the names of those who have contributed to the history of the Fuels Division by more than twenty-five years of service.

A. Ignatieff,
Chief, Division of Fuels.

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FIFTY YEARS OF FUEL TESTING AND RESEARCH

by

A.A. Swinnerton

Early Years, 1907-1919

In 1906, the Director of the Geological Survey of Canada, Dr. A.P. Low, proposed an investigation of the coal deposits of Canada, somewhat along the lines of the investigation started by the United States Geological Survey, and as no Government department had the necessary laboratory facilities, it was decided to carry out this work at the Department of Mining Engineering at McGill University under the immediate supervision of Dr. J.B. Porter, head of the Mining Department.

Shortly after the commencement of this investigation the Department of Mines was created (April 27, 1907) and the responsibility for carrying out the work was transferred to the Mines Branch. The tests were continued at McGill University under the auspices of the Mines Branch and the directorship of Dr. Eugene Haanel who, previous to the formation of the Mines Branch, had been Superintendent of Mines, Department of the Interior. This investigation, which was the basis of a great deal of the future work of the Division of Fuels, was completed in November 1910 and the final report (1)* comprising seven volumes was published between 1912 and 1916.

This monumental work included:

Sampling in the field,
Crushing and preparation for treatment,
Washing and cleaning tests,
Coking trials,
Steam boiler trials,
Producer and gas engine trials, and
Chemical laboratory work and miscellaneous investigations.

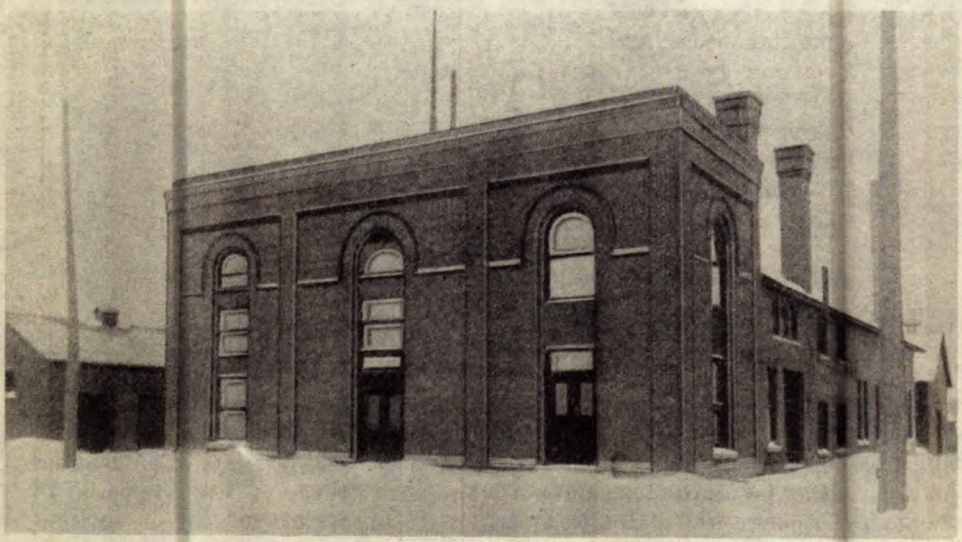
Sixty-seven different coals were tested, their sources ranging from Vancouver Island to Cape Breton Island.

During the course of this work an additional investigation was started by Dr. Haanel, this being an exhaustive study of the peat deposits of Ontario and Quebec and methods for their exploitation in order to develop a source of fuel for Central Canada owing to the "rapidly vanishing deposits of anthracite coal as well as the limited deposits of bituminous coal in the United States" (Summary Report of the Mines Branch 1907-1908). In the light of our present

* Numbers in brackets refer to the publications listed at the end of this report.

knowledge of the United States coal resources there would appear to have been undue alarm. However, an engineer from the Mines Branch was sent to Europe to study the peat methods successfully used there, and following his report (2) a peat bog of 300 acres at Alfred, Ontario (40 miles east of Ottawa) was bought by the Dominion Government for full-scale trials of peat machinery and equipment. The bog was drained, buildings and shops were erected, and peat machinery installed. Experimental operations were conducted during the 1912 and 1913 seasons and it was expected that commercial operations would start in 1914, but the outbreak of the First World War caused cancellation of the plans. In 1912, with growing interest in gaseous and liquid hydrocarbons and strong indications that Canada might possess oil and gas fields of considerable value, Mr. F.G. Clapp, a leading petroleum expert of that date, was engaged by the Mines Branch to prepare a report on the petroleum and natural gas resources of Canada. The report, completed in 1915 (3), was very comprehensive and included a history of developments, statistics of the industry, descriptions of drilling methods, markets, and methods of development. It is still a valuable source of information on the early developments of petroleum and natural gas which date back to the 1860's.

It soon became obvious that for the Mines Branch to function satisfactorily proper laboratory facilities were essential, and the first of the new laboratory units to be built was the Fuel Testing Station completed in 1910. This was situated in Ottawa at the corner of Dolly Varden and Division Streets (the original names of Plymouth and Booth Streets) and an ore-dressing laboratory was later built in 1911 on an adjoining site. The Fuel Testing Station (4), as it was then called, was equipped with Korting and Westinghouse gas producers (for peat and coal), a Korting gas engine , a Babcock and Wilcox marine water-tube boiler, chemical laboratories, grinding and crushing equipment, and was



Fuel Testing Station, 1911.

designed for the complete investigation of Canadian coals as well as for the distillation of petroleum and carbonaceous materials. This building also contained a well-equipped machine shop, the staff of which was part of the Division until 1931 when the Mechanical Section was set up as a separate unit of the Branch.

The staff consisted of 7 engineers and 3 laboratory assistants and was engaged in coal sampling and analysis, boiler trials, gas producer tests on various coals and peat, etc., and, later, mine air analyses and the testing of oil and petroleum products, oil shales, etc.

As a result of recurring shortages and interrupted supplies of American anthracite in the latter part of the First World War and in the post-war period, attention was turned to the development of native Canadian fuels for domestic heating purposes. In 1918 the Peat Committee, a joint enterprise of the Dominion and Ontario governments, was formed to develop a domestic fuel from peat and considerable experimental work was again carried out at the Alfred bog with the assistance of the Mines Branch from 1920 to 1924. Although large-scale equipment for digging and harvesting peat was developed, it was not found possible to produce a fuel that could compete economically with coal or coke (5).

In 1918 also, the Lignite Utilization Board was formed, as a joint enterprise of the Dominion, Manitoba and Saskatchewan governments, to try to produce a suitable domestic fuel from carbonized Saskatchewan lignite. Considerable preliminary investigation was carried out at the Fuel Testing Station on the carbonization and briquetting of this material. A plant that was built in 1921 by the Lignite Utilization Board at Bienfait in Saskatchewan was subsequently sold to private interests and since 1929 has been producing briquettes made from carbonized lignite (6).

The demand for and interest in liquid fuels as a result of the war, and the lack of domestic supplies, turned attention in 1919 to the oil shale deposits of New Brunswick, but the results of an investigation were somewhat disappointing as it was found that the quantity of high-grade material was not as extensive as had previously been supposed (7).

Middle Period, 1920-1945

Following the conclusion of the First World War, as more staff and equipment became available the investigations of the Division were extended.

In this period a comprehensive series of tests of Canadian coals for use in domestic hot-water heating equipment was carried out (8) with a view to the possible replacement of imported American anthracite by Canadian coals. In this same connection an investigation was conducted in cooperation with the Dominion Fuel Board of the possible substitution of by-product coke for anthracite by establishing coke industries at various points in the acute fuel area. The results were published in Mines Branch Report No. 630, Coke as a Household Fuel in Central Canada, by J.L. Landt,1925.

A series of low-temperature carbonization tests on various coals (9) was also conducted, since the interest at that time was the production of a more reactive coke for domestic use than that produced in by-product ovens. An additional feature was the increased yield of tars obtainable by low-temperature carbonization. In 1928 a shipment of Sydney coal went to South Wales for testing in the Illingworth low-temperature carbonization process, and although very satisfactory results were obtained it seemed impossible to develop any commercial low-temperature carbonization plants in Canada.

At this time also there was a revival of interest in the lignite of northern Ontario, but after extensive carbonization, briquetting and combustion tests were made it appeared that the deposits would not be an economic source of fuel even for northern Ontario (10).

As a result of increasing developments in the automotive field, annual surveys of the motor fuels and of the lubricating oils on the market were started and these were of considerable technical and popular interest.

In 1929 the Fuels Division was reorganized, provided with additional facilities, and moved into a new laboratory building, the "Fuel Research Laboratories", built to replace the original Fuel Testing Station which had become too small for the activities and staff. The new building, 56 by 144 feet with two floors and basement, provided office and laboratory space to undertake all types of small and pilot-plant investigations on solid, gaseous and liquid

Fuel Research Laboratories, 1957.

fuels. A third floor was added in 1938, to provide space for growing staff and equipment. Included in this building were a commercial-scale pulverized-fuel steam generating plant, experimental domestic heating equipment, and a briquetting and a coal washing plant. With the addition of a full-scale commercial-size by-product oven with scrubbing and by-product recovery equipment erected at the rear of the building, the Division became equipped to carry out full coking scale tests on Canadian and other coals. In the ensuing years, tests were made in this coking equipment for the production of gas and by-product cokes for domestic heating (9) (12). Continuing the high-temperature coking survey started in 1924, coking tests were made on coals from both United States and Canada with the objective of making reliable information available for the use of coal producers and providing a guide for operators of by-product coke plants on the choice of suitable coals for production of gas and coke.

Owing to the increasing use of pulverized fuel for steam raising, a comprehensive series of tests on Canadian coals was made in a commercial-sized pulverized-fuel-fired furnace to comparatively assess them and provide such data as would enable the use in the pulverized state of lower grade and smaller sized coals otherwise difficult to market (11).

The increasing development of the oil and gas resources of the western provinces brought requests for analyses and reports on these materials, and several reports have been issued on the natural gas and oil samples from western Canada (12). The results of the analyses of the gas from Turner Valley led to the installation of absorbers for the wet gas in this field to recover the light ends. The helium content of all gas samples was also determined to assist in locating a possible commercial source of this important element. In addition, a comprehensive list of analyses of domestic and imported coals and cokes (9) (12) was periodically published to assist both the producer and consumer of solid fuels. Annual gasoline surveys were continued, samples being taken at representative centres across the country (9) (12).

In this period before the Second World War, the chemical and physical survey of Canadian coals was undertaken, and the results presented in a series of reports, namely R.I.C.S. No. 1-199. Considerable laboratory investigational work was conducted on the following: grindability of coals, coal friability (13), tests on coal for predicting the physical properties of coke made in commercial ovens, briquetting (14), analysis of naphtha and natural gas from Alberta, an analytical survey of Canadian crude oils (15), and examinations of the more accessible oil shale deposits in Eastern Canada. Because of the lack of sources of natural petroleum, a study was undertaken of possible sources of substitute liquid fuels and this resulted in the installation of a laboratory for small-scale high-pressure experimental hydrogenation tests. This process produces gasoline of a high anti-knock rating and is applicable to such materials as bitumen as well as coal, and in addition, can also be used to make such products as benzene and toluene from coal. A whole series of Canadian coals were tested in order to determine their various oil yields by the hydrogenation technique (16). This work was subsequently extended on an increasing scale to include tests on crude oils and bitumen from the Alberta bituminous sands.

Considerable work was carried on also during this period on coal classification studies toward the eventual drawing up of a coal classification chart based on the examination of more than 1,000 coal analyses (17). The Division assisted in drawing up government specifications for the purchase of coal and in the anlyses of coal and coke purchased by various government departments. A gradual increase in the staff of the Division took place, and immediately prior to the Second World War there were 20 professional members and 14 technical assistants.

The Fuels Division, like other organizations, was naturally much affected by the Second World War. The ordinary activities gave way to war problems, and not only were there enlistments in the Armed Forces but several members of the staff were seconded to wartime organizations such as the Coal Controller's Office, Oil Controller's Office, Department of Munitions and Supply, etc. In addition to the large amount of work involved in the testing of solid and liquid fuels, and the preparation of certain materials of military significance for the Armed Services, several purely wartime investigations were conducted such as that concerning the production of an activated charcoal from the carbonized residues of peach nuts, anthracite, certain Canadian low-volatile coals, etc., as a substitute for the cocoanut charcoal used in Service gas masks.

Owing to the shortage of petroleum products, a diamond drill survey of the oil shale deposits of Albert county, New Brunswick, was carried out in 1942. A field laboratory was set up in which more than 3,000 drill-core samples were assayed, but the results indicated that these deposits would not be a possible source of oil even under war conditions (18).

As another emergency measure, a drilling program for evaluating a portion of the Alberta bituminous sand deposits was undertaken, and led eventually to the discovery of the Mildred-Ruth Lakes deposit with a bitumen content of almost a billion barrels. The Division's analyses of some thirty thousand core samples obtained between 1942 and 1947 formed the basis of a report subsequently issued by the Mines Branch (19). This wartime investigation has been a major factor in a recent decision of an important oil company to proceed with development of the bitiminous sands for oil production. The Mines Branch had been engaged as early as 1913 and over a period of many years in mapping and examination of the deposits which extend over a vast area.

On behalf of the Coal Emergency Production Board, the Division supervised the organizing and functioning of the various peat fuel projects sponsored by the Board in the Province of Quebec, whereby some 1,000 tons of air-dried peat fuel was manufactured in demonstration equipment. Another project was the development of methods for fluxing the ash of American buckwheat anthracite coals so that they could be used to better advantage in domestic blower installations to replace low-ash-fusion Welsh anthracite no longer available in the Canadian market. Owing to the critical shortage of toluene in the early part of the war, an extensive survey was conducted of all domestic and imported crude oils as possible sources of this essential material for explosives manufacture. A survey of deposits of peat moss was also made during the war period, having in view the possible use of this material in magnesium production and all the samples collected were analyzed in the Division.

Although the war years brought a wide variety of special problems to the Division, the main emergency work was connected with the supply and testing of solid and liquid fuels and the preparation of special products on a volume basis for the Armed Services.

Postwar Era, 1946-1957

After the war a gradual expansion of activities of the Division took place as more staff and equipment became available. The war had interfered with the program of fuel research, and past events had emphasized the importance of such research and the risk of too great a dependence on imported fuels. Owing to the increasing importance of liquid fuels, hydrogenation investigations were resumed on an extended scale and at much higher pressures than before because the quality of products obtained is improved by the use of higher pressures. Contact was maintained with the Office of Synthetic Fuels in the United States, and first-hand information on hydrogenation was obtained by investigations in Germany in 1945.

In 1944 a Royal Commission was set up to conduct "a full inquiry into the Coal Industry in Canada" and considerable assistance was given to the Commission by members of the Fuels Division in the preparation of its report (20).

Following the discovery of the Leduc oil field in Alberta in 1947 and the subsequent intensive drilling for oil, discoveries of natural gas increased, and it became evident that unless markets for the gas could be found there would be considerable wastage of gas and oil exploration would be adversely affected. Studies of the natural gas reserves of Alberta and British Columbia were carried out between 1947 and 1951 in cooperation with the Geological Survey of Canada. These studies resulted in the publication of the first quantitative estimates in Canada. They contributed also to the growing interest in developing Eastern markets for natural gas and have culminated in the construction of the Trans-Canada pipe line.

In the field of combustion engineering, Canadian coals were tested for use in industrial power plants. Another investigation which evaluated the important factors affecting the suitability of Canadian fuels for automatic domestic heating equipment indicated the suitability of certain Western Canadian high-ash-fusion, low-volatile coals for use in anthracite-type conversion stokers, and comparative tests were conducted of automatic oil-fired and coal-burning equipment for domestic use. A combustion project was undertaken in 1950 in collaboration with the Locomotive Development Committee of Bituminous Coal Research Inc. in the United States in which 27 Canadian coals were tested in a cyclone combustor to assess their suitability for the coal-fired open-cycle gas turbine. This work was completed in 1950, and was followed by a new project in collaboration with McGill University to develop an indirectly fired, exhaust-heated cycle, coal-burning gas turbine. Development and testing of this exhaust-heated cycle was completed as a research project by the end of 1956. It is hoped that the results of this work will stimulate industry to undertake the development of a prototype power unit.

Since 1946 a continuous physical and chemical survey of Canadian coals has been carried out. Commercial coal surveys in Eastern and Western Canada are also conducted periodically to provide information for the revisions of the Analysis Directory of Canadian Coals, a report first published in 1945. Coal-preparation and cleaning-performance tests have been conducted with commercial-sized equipment in the field and with small-scale equipment in the Division's laboratories.

A survey is being made of the coking properties of Western Canadian coals to provide information for metallurgical plants that may be established in the western provinces. Much attention has been paid to briquetting in order to aid the utilization of the small sizes of coals that are difficult to market in their natural state. This work has resulted in the development of briquettes suitable for stoker use. In addition, investigations are being made into the blending of fine coal with ore fines to produce briquettes for use as feed for smelters and reduction plants. Reports of this work are given in a series of FRL Reports, No. 1-263.

A major achievement has been the successful development of the 'cold water' process for separating the bitumen from the bituminous sands of northern Alberta. The Division in cooperation with the Mineral Dressing and Process Metallurgy Division demonstrated that this method, which may aid the eventual development of the bituminous sand resources, could be conducted at ordinary temperatures in standard ore-dressing equipment, and that high recoveries could be obtained (21). The diluted oil produced was used in hydrogenation, dehydration, and coking experiments (24). Considerable attention is being paid to the refining of oil from crude Alberta bitumen as this is a much more serious problem than is generally realized. In this connection, owing to the technical advantages of using ultra-high pressures, a pilot plant has been built for carrying out hydrogenation tests at 20,000 pounds per square inch, which is a considerable advance on anything attempted hitherto. In addition much work has been done on the chemical constitution of bitumen and on its probable origin.

Work is also being carried out on the improvement of the quality of the low-grade oils that are abundant in Western Canada, and assistance has been given to the small refineries that treat these oils. As the future economic development of these low-grade crude oils depends upon better knowledge of their chemical constitution, an absorption spectroscopic laboratory was established which has been the means of providing fundamental information on the classification of oils and bitumen and some clues as to their methods of origin.

In order to assist the coal producers in Western Canada, a western regional laboratory was created in Calgary in 1951 to work on problems of coal preparation, briquetting, and the collection and analysis of coal samples. This laboratory has been transferred recently to Edmonton where space has been provided in the new Coal Research Laboratories of the Research Council of Alberta. As a result, close cooperation will be maintained with the coal research activities of the Government of Alberta. A survey of coal mining methods in Canada was carried out from 1947 to 1951 (22) and included visits to mines in

the United States where conditions were considered to be somewhat similar to those in Canadian mines. This survey pointed to the importance of the problem of excessive stress conditions existing in several deep mines in Eastern and Western Canada, which adversely affect the future exploitation of coal reserves at depth. As a result of this survey, and in view of the concern of the provinces with this problem, a long-term investigation was undertaken to obtain precise information on the stresses present in underground workings. Studies of rock pressures were initiated in several coal mines in Western Canada, both in the Rocky Mountain and Alberta Plains regions (22). This fundamental research is directed toward the optimum recovery of Canadian coal resources at depths where the effects of increasing strata stresses restrict the orderly and economic extraction of the mineral (23). The effects range from violent manifestations of stress relief known as "bumps" and "outbursts of gas and coal" to more gradual closure of the workings. Large reserves of high-quality coking coal are affected by the phenomena. Included in the research is a study of methane contained in the coal 'in situ' and its effect on the outburst hazard. The work was extended later to Nova Scotia and Newfoundland, in the latter case for observing the stress pattern with reference to pillar mining methods in the iron ore mines at Wabana.

A recent development by the Division has been the setting up of a section which deals with certification of electric and other equipment for use in coal mines and explosive atmospheres. A Certification Officer has been appointed, specifications for the guidance of equipment manufacturers are being drawn up, and a schedule of fees for certification has been established by Order in Council. The new service will not specify what equipment may be used in coal mines -- which is a responsibility of the Provincial authorities -- but, by providing findings on what is, or is not, safe for use, the certification service should prove a great value to both manufacturers and users, particularly as hitherto there has been no Canadian authority, and equipment had to be certified by the Safety in Mines Research Establishment in the United Kingdom, the United States Bureau of Mines, or the Underwriters' Laboratories in Chicago.

As examples showing the variety of investigations currently being conducted by the Division, the following may be mentioned:

Maintainance of the Analysis Directory of Canadian Coals and reports on Canadian crude oils and natural gases.

Effect of mechanisation on the size distribution of coals.

Coal washing and preparation tests.

Thermal-power studies.

Investigation of pitch binders for briquetting coals and for electrode manufacture.

Evaluation by laboratory methods of the coking properties of coals.

Development of a coal-fired gas turbine and cyclone combustion for powdered fuels and for iron smelting.

Refining studies on bitumens and heavy crude oils by hydrogenation in batch autoclaves and on pilot-plant scale at elevated pressures. The use of gamma ray irradiation as an auxiliary energy source in the hydrogenation reaction will be investigated in a specially constructed laboratory.

Research on the chemical constitution and classification of naturally occurring bituminous substances such as bitumen, bituminous shales and like materials.

Mining problems: stress studies of rock pressures, including instrumentation and models for study of stress distribution in underground workings.

Mine air analysis and the certification of electrical equipment for underground use.

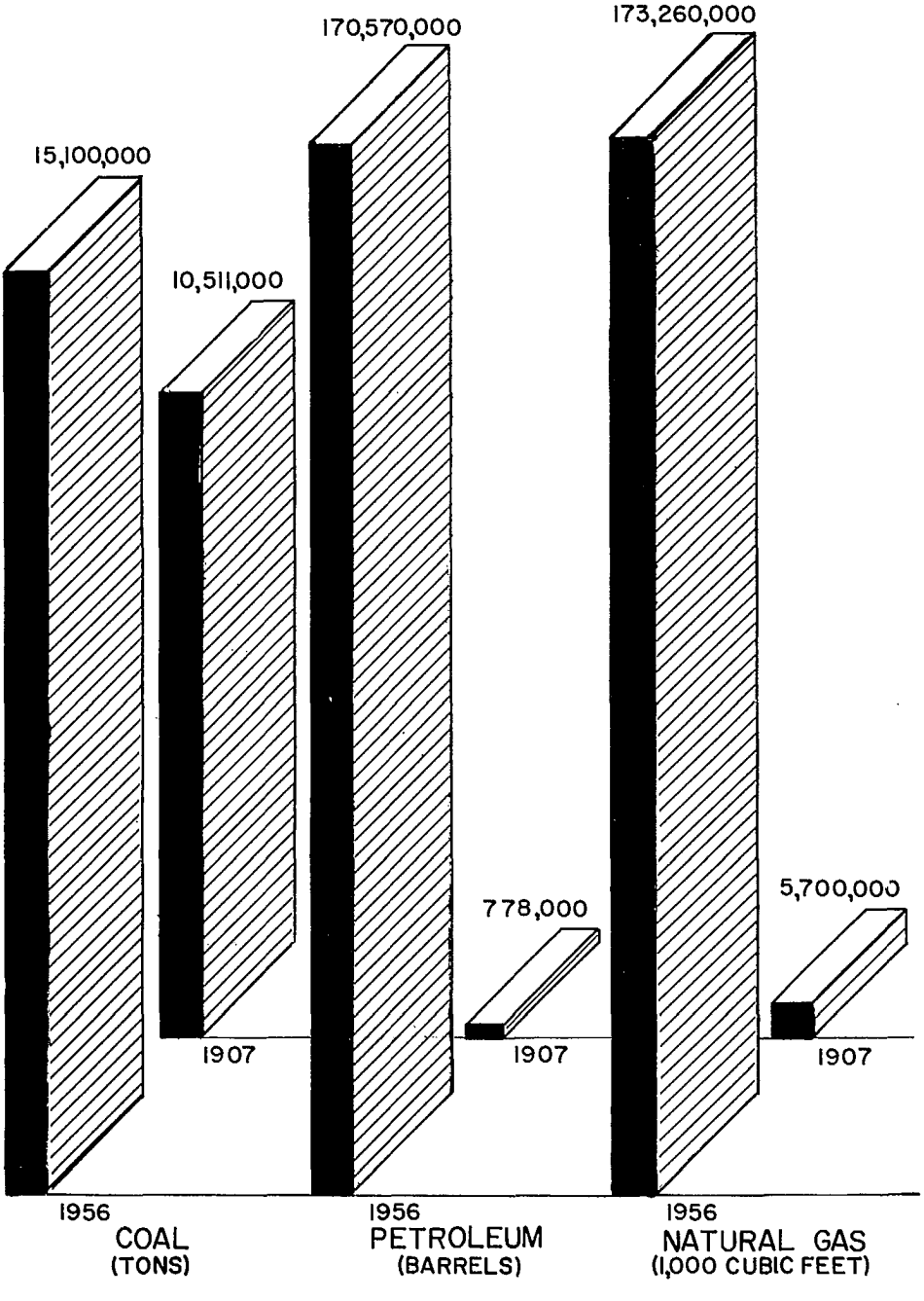
Many of these investigations constitute long-term research or studies from which no immediate results are expected, but they are planned with the hope of ultimately providing assistance to the fuel industries. In addition to the continuing projects, the Division, on request from industry, undertakes from time to time various small-scale investigations, these being concerned most often with coal. Furthermore, Divisional officers constantly provide consultation service to industry and to government departments on matters concerned with the use of fuels.

The Division has increased its technical staff over the years, especially since 1946, and now has 50 engineers and scientists as well as 24 technical assistants. The list of references selects only a few of the reports issued by the Fuels Division as it would be impracticable to include a full list. However, details of the various reports can be found by referring to the latest catalogue of Mines Branch reports and to FRL No. 246 "Investigations and Research on Fuels in Canada, 1950-1955".

Conclusion

In this brief historical account, an attempt has been made to describe the main activities and investigations carried out by the Fuels Division in its fifty years of existence. Many minor activities perforce have either been omitted or only superficially treated. At first glance it might seem that the efforts of the Division were sometimes directed towards solving problems that eventually solved themselves through the passage of time but any such view would be ignoring the importance or urgency of making Canada less dependent on foreign sources for a large part of her fuel supplies and would be overlooking the complex technical and economic problems that beset the domestic fuel industry. As Canada possesses large deposits of the lower grade fuels, such as peat, lignite, sub-bituminous coal, oil shales and bituminous sands, the efforts of the Division to a considerable extent have been devoted to research and investigations to aid

COMPARISON OF PRODUCTION OF COAL PETROLEUM AND NATURAL GAS 1907-1956



developpent of these potential resources. That these resources have not been commercially developed on a large scale is because so far Canada has been able through imports to make up its deficiencies in solid and liquid fuels.

In retrospect it is hard to realize the fuel famines that existed just after the First World War and the coal shortages during the Second. These conditions could recur if all the houses burning oil in Canada and the United States had to revert to burning solid fuel. There would probably not be any American anthracite available for Canada and there would be resort to all kinds of substitute fuels. The extent to which Canadian home owners have turned to the more convenient oil and gas heating may be understood when it is noted that of the one million houses built in Canada since 1945 only an insignificant number are equipped to burn solid fuel. The adequate supplies of oil and other fuels that are available today at reasonable prices have not solved but have only temporarily postponed the fuel problems. In perhaps a half century, when the higher grade fuel resources of this continent may have been depleted, the time may come when more serious attention will have to be given to developing Canada's lower grade resources. The work of the Fuels Division in its broader aspects has laid the foundations which can well serve the country in any fuel crises.

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Appendix

The following is a list of members of the staff of the Division of Fuels with more than 25 years of service.

B.F. Haanel, Chief of Division	1908-1946
A.W. Mantle	1914-1939
E.S. Malloch	1914-1947
J.H.H. Nicolls	1914-1949
F.W. Burstow*	1914-1940
W. Kritsch	1915-1956
R.E. Gilmore, Chief of Division (1946-54)	1917-1919; 1921-1954
A.A. Swinnerton	1919-
R.J. Offord	1921-
P.V. Rosewarne	1921-1955
C.E. Baltzer	1923-
H. McD. Chantler	1924-
L. Labelle	1925-
K.W. Bowles	1926-
E.J. Burrough	1927-
W.H. Harper	1927-
C.J. Coleman	1927-
E. Swartzman	1928-
F. Bess*	1928-1957
C.H. Glaude	1929-
H.P. Hudson	1929-
J.W. Custeau	1929-
R.J. Young	1929-
P.B. Seely	1929-
J.C. Hinton	1930-1957

* Deceased.