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NEW PYROMETALLURGICAL LABORATORY FOR TEST AND RESEARCH ON IRON AND STEEL

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In view of the growing importance of the iron and steel industry in Canada, the Department of Mines is providing laboratory facilities for test and research thereby extending to that industry the same degree of co-operation that has proved so advantageous to the non-ferrous mining industry. The Department has erected in Ottawa as an addition to its present Ore Testing Laboratories, a new pyrometallurgical laboratory, which is being equipped with laboratory scale and semi-commercial roasting, calcining, sintering, metallizing, melting, heat-treating, and standard laboratory testing and metallographic equipment for conducting extensive test and research on ferrous and non-ferrous ores, metals and their alloys, especially iron and steel.

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At the time the Mines Branch was organized into its various Divisions in 1907, the most pressing problem confronting the Division of Ore Dressing and Metallurgy was the beneficiation of Canadian iron ores and consequently the first laboratory to be built was equipped for beneficiation tests. Twenty-one ores from Nova Scotia, New Brunswick, Quebec, Ontario, and British Columbia were tested, the results showing that in many cases marketable products could be obtained, suitable for use in the iron blast furnaces. However, the work was not productive of establishing an iron ore industry as primary ores of foreign origin could be bought and laid down at Canadian furnaces cheaper than Canadian beneficiated ores.

During the war and post-war years, very little investigative work was done by the Mines Branch on iron ores or on any phase of ferrous metallurgy. This lack of attention may be attributed to two reasons: First there appeared to be no hope for the immediate utilization of Canadian iron ores due to the ready availability of cheap foreign ores; and second, to the demands for ore treatment test and research by the rapidly growing non-ferrous industry, stimulated by the urgency for the production of war metals. The investigative work of the Division of Ore Dressing and Metallurgy was therefore directed to the treatment of non-ferrous ores. Nevertheless the laboratory equipment for the beneficiation of iron ores has been kept up-to-date by the purchase from time to time of new equipment as progress has been made in other countries. Developments have been closely watched for their application to Canadian ores.

No large deposits of primary iron ores available for use in blast furnaces are known in Canada, hence, she has to rely on foreign ores to supply her requirements. The two chief sources are the United States for Ontario, and Newfoundland for Nova Scotia furnaces. However, located within reasonable distances of her furnaces are large deposits of the following types, all of which require beneficiation or some special method of treatment for their utilization:-

1. Siderites or iron carbonates
2. Low-grade, low-sulphur magnetites
3. High-sulphur magnetites
4. Magnetite-hematite mixtures
5. Titaniferous magnetites

It is felt that the time is approaching when it will be economically possible to utilize Canadian ores to supply Canadian furnace requirements and the iron and steel industry with products of Canadian origin. The annually increasing percentage of ores being beneficiated in other countries together with the developments in the technique of beneficiation processes and the vast amount of experimental work being done on direct reduction processes in the past few years have brought closer the time when Canadian ores can be utilized. It is believed that mixtures of Canadian beneficiated ores in the proper proportions will give grades of pig iron more adaptable to the production of diversified iron and steel products. It is therefore the purpose of the Division of Ore Dressing and Metallurgy to investigate the beneficiation of Canadian ores of the foregoing types and also their adaptability to direct reduction or sponge iron processes.

Direct reduction processes are under investigation in Norway, Sweden, Germany, Japan, and the United States and large sums of money are being spent to put them on a commercial basis. In the European countries, where high-grade scrap is scarce, processes have been developed on a presumably economic basis and production plants have been erected. It is claimed that sponge iron is a superior product for the manufacture of high grade irons and steels. The metallurgists of the Mines Branch have been and are watching closely the developments of these processes, in view of their application to Canadian ores and conditions. The plan of investigation as outlined is to determine, first the quality of the irons and steels produced from sponge iron made from Canadian ores in comparison with accepted grades made by present day methods and second, if superior products are obtained, which of the sponge iron processes would be more adaptable to Canadian ores and conditions. Direct reduction processes may provide a more suitable base for the manufacture of high grade irons and steels and, while there is no immediate likelihood of such processes encroaching to any appreciable extent upon present blast furnace operations, it is possible that in time steel-making practice may be modified to permit of at least a partial substitution of sponge iron for pig iron in the manufacture of the more common grades of steel.

Canadian titaniferous magnetites are a source of iron, upon which little investigative work has been done. These ores contain small amounts of vanadium, used extensively in the manufacture of alloy steels. The possibility of recovering the vanadium content lends interest to the problem of their commercial utilization, and will be investigated.

The making of alloy steels in Canada is in its infancy but in other countries this branch of the steel industry has had a remarkable expansion in the last ten years. Each year sees the field for alloy steel widen and statistics show that progress in the alloy steel industry has been eighteen times as rapid as in the general steel industry during the past fifteen years. The development of compositions of alloy steels and the proper treatment of such steels to meet special requirements are constantly recurring problems. In these developments Canada cannot afford to lag behind, particularly in view of the fact that the alloy steel industry provides the most important market for our nickel and may provide important outlets for our copper, molybdenum and other non-ferrous metals. We should be as well-informed as are the producers in other countries in the technique of making and treating alloy steels.

The electric melting furnace is particularly well adapted to the making of alloy steels but since cheap electric power is not generally available, the bulk of the production has been made by the open hearth process. In spite of the lack of cheap power, the electric furnace has made and is making rapid strides, and certain grades of alloy steel are being produced in large electric melting furnaces at a cost that enables them to compete successfully with open hearth steels on a price basis. It seems clear that with our cheap hydro electric power we have one advantage that should offset to a considerable extent that of mass production held by the producers in other countries and it would appear logical that our development in the field of special steels should be with the electric furnace. With the facilities available on completion of the new laboratories, the Mines Branch can be of considerable service to the steel industry, in the working out of electric steel making technique, in the development of new useful compositions, in the working out of methods of heat treatment and in co-operating with steel producers in overcoming difficulties encountered in practical operations.

It is anticipated that the investigative work will follow three distinct but closely related lines:-

1. Broad problems connected with the beneficiation and utilization of Canadian iron ores, and the investigation of both new and established processes of iron and steel production and their applicability to Canadian ores and conditions.
2. The development of new steels and other alloys and the working out of the proper methods of melting, working, and treating such alloys for specific uses.

3. Co-operation with producers and consumers of iron and steel products in solving specific problems.

The new pyrometallurgical laboratory which has been erected is 105 feet long by 56 feet wide and will house the following furnace equipment:

<u>Melting Equipment</u>

1. An Ajax-Northrup high frequency induction melting unit, consisting of the following main items:-

    (a) Motor-generator set, induction type motor rated at 260 h.p., 3 phase, 60 cycle, 550 volt, 1800 r.p.m. Generator rated at 150 kilowatts, output at 0.9 power factor; 900 volt, 960 cycle, single phase. Complete with switchboard, condensers, etc.

    (b) A 500-pound melting furnace, (nose-tilt) complete with hoist for tilting.

    (c) A 50-pound melting furnace, arranged to operate from the 150 kilowatt motor-generator set but not simultaneously with the 500-pound furnace.

2. A one-ton Heroult type arc melting furnace complete with transformers and electrical equipment. Transformer equipment will consist of three single phase 250 K.V.A. units with special provisions to permit a selection of voltages over a wide range. This is to provide for the use of these transformers for additional electric furnaces.

3. A gas-fired crucible brass melting furnace.

4. A small cupola furnace for cast iron.

The melting equipment will be served by a 3-ton overhead crane. Facilities for the pouring of ingots and for other purposes will be provided.

Roasting, Sintering and Metallizing Furnaces

1. A 36-inch inside diameter, 6-hearth, mechanically rabbled, Hereshoff roasting furnace, with top drying hearth. This furnace has been in use for some years on non-ferrous ores.
2. A Dwight-Lloyd sintering unit, consisting of two pans. This unit has been in use for some years for making sintering tests on iron ore concentrates, flue dust, and non-ferrous or concentrates.
3. A rotary kiln type, oil-fired, metallizing furnace, 22 feet long, large diameter 42 inches for 6 feet at the discharge end, tapered section 4 feet long, small diameter 21 inches for 12 feet at the feed end. This furnace has been in use for metallizing the iron content in ilmenite ores.
4. A 60-kilowatt rotating retort electric furnace, batch type, especially designed for making sponge iron by gaseous or solid fuel reduction of the ore. Capacity about 250 pounds of sponge iron.

Space is provided for supplementing the above equipment as required. Additional metallizing equipment will be installed to investigate the process or processes adaptable to Canadian iron ores and conditions.

Heat Treating Furnaces

A separate laboratory 54 feet long by 14 feet wide is provided for the heat treating furnaces. It is located on a mezzanine floor at one end of the building extending for its full width. The equipment will consist of:

A box-type electrically heated furnace, inside dimensions approximately 12 inches wide by 24 inches deep by 9 inches high.

A box-type electrically heated furnace, inside dimensions approximately 20 inches wide by 36 inches deep by 18 inches high.

A pot-type electric furnace, inside dimensions of pot 12 inches diameter by 18 inches deep.

An electrically heated tempering oven. Approximate dimensions 24 inches wide by 21 inches deep by 12 inches high.

An electrically heated oil tempering bath, approximate dimensions 30 inches long by 16 inches wide by 12 inches deep.

Quenching tanks and other miscellaneous equipment.

Additional furnaces and other equipment will be installed as required.

Pyrometer Equipment

A separate laboratory 21 feet long by 14 feet wide is provided for the pyrometer equipment. It is located above the room housing the motor generator set and other electrical equipment for the high frequency furnace, and is adjacent to the heat-treating laboratory. In addition to housing the temperature recording controller for the heat treating furnaces, it will also serve as a laboratory for the calibration and checking of pyrometer equipment. Each furnace is equipped with a Leeds and Northrup recording controller and there is provided for checking and calibrating purposes an electric furnace specially designed for checking thermocouples, a portable double-scale potentiometer indicator for rare and base metal thermocouples, and a triple range optical pyrometer.

Mechanical and Physical Testing Equipment

A laboratory 21½ feet long by 18½ feet wide is being provided for mechanical and physical testing equipment which will consist of the following:-

An Amsler tensile testing machine of 100 tons capacity, complete with arrangements for compression, transverse, and bending tests.

An Amsler single blow impact testing machine, capacity 240 ft-lbs. constructed for both Izod and Charpy tests.

An Olsen combination toughness and torsion testing machine

An Olsen bend testing machine.

An Alpha Brinell hardness testing machine.

A Rockwell hardness tester - Model 3H.

A Shore scleroscope - Model D.

A Vickers hardness testing machine.

Other testing machines will be added as the occasion demands.

Metallographic Equipment.

A laboratory 21½ feet long by 18½ feet wide is being provided for metallographic equipment which will consist of the following:-

A Zeiss 8-inch by 10-inch horizontal metallographic unit, complete with all necessary accessories.

A Bausch and Lomb binocular microscope

A camera for macrophotography.

A Leeds and Northrup transformation point appartus.

A Rockwell dilatometer, laboratory model.

Sample preparation machines, including cutting wheel, grinding wheels, and polishing machines, for which a separate laboratory is being provided.

A separate photographic dark room, completely equipped is also being provided adjacent to the metallographic laboratory.

Chemical Laboratories

The chemical laboratories of the Division are fully equipped and staffed for the conducting of analyses and special chemical investigations in connection with ores and metallurgical products.

Mechanical Shops

Complete facilities for the machining of test bars and other metallurgical samples are afforded by the Mechanical Division of the Mines Branch, which maintains machine shop, forging shop and other services necessary for maintenance and development of the mechanical side of the Branch's activities.