R R28

Commission of Conservation
Canada

COMMITTEE ON MINERALS

Problems Relating to the Mineral Industry of Canada

BY

W. J. DICK
Mining Engineer, Commission of Conservation

Reprinted from the Eighth Annual Report of the Commission of Conservation

OTTAWA—1917

Problems Relating to the Mineral Industry of Canada

BY

W. J. Dick

Mining Engineer, Commission of Conservation

THE war has focussed world-wide attention on the manifold implications of the German system of economic penetration and of commercial and financial control of vitally important industries. The surprising fact is, not so much that Germany has controlled aniline dye, potash salt and other chemical industries, but that her industrial organization and development has enabled her, without imports or exports, to produce all those materials essential for the successful conduct of war. Just as truly, as the war has demonstrated the skill, foresight and preparedness of the Germans in regard to war, shall we be at great disadvantage with respect to German competition in trade unless we learn our lesson from the war.

That the Allies are cognizant of the situation is evident from the economic discussions of the Paris conference, at which Canada was represented by Sir Geo. E. Foster, Minister of Trade and Commerce, who has already done much toward organizing our industries. The conference suggested the following means of encouraging trade:

(a) Abolition of "favoured nation" treatment of the enemy.

(b) Permanent measures of mutual assistance and collaboration among the Allies. It was suggested that, for such permanent measures, the allied nations have recourse to enterprises subsidised, directed or controlled by the governments themselves, to the granting of financial assistance for the encouragement of science and technical research and for the development of national industries and resources, also to customs duties or prohibitions of a temporary or permanent character, or to a combination of any or all of these different methods.

The war has clearly demonstrated that:

(1) Defense is not obtained to-day by fighting men alone but by fighting industries. Behind every man in the firing line in Europe from 3 to 5 persons are employed to supply him with food, ammunition and other needs. To-day from two-thirds to three-quarters of all the industries of the warring nations are engaged in meeting the tremendous requirements of the battle-line.

(2) If a country is industrially unprepared, there is great danger and loss due to unavoidable delay in providing necessities. The necessary steps for industrial preparedness are a cheap form of insurance against such danger, particularly as industrial preparedness is, *per se*, a decided economic gain.

(3) A country must not only have the necessary resources within its borders but must have already established the industries necessary to the manufacture of munitions of war and should, if possible, be independent of essentials from other countries.

(4) The resistance of the enemy has been made possible by the remarkable economic and military organization effected by German engineers and technical men. The lack of such co-ordination on the part of the Allies demonstrates that, in times of peace, engineers must realize their responsibilities and must play an important part in affairs of modern government and of progress.

Having in view the lessons taught by the war and the suggestions outlined above, let us see what can be done in Canada, more especially with reference to the mineral industry.

Technical and Industrial Education

The opinion prevails in Germany that the nation possessing the best educational system is the best prepared to promote industrial progress and national welfare. Neither money nor personal effort appears to be lacking for the establishment and maintenance of institutions, schools, classes and other means which will accomplish these ends. The development of continuation and technical schools, if not the cause of the industrial and economic growth, has accompanied the progress of science and the practical applications of it. In 1910, the Dominion Government appointed a Royal Commission to study the needs and present equipment of the Dominion respecting industrial training and technical education, and the systems and methods of technical instruction obtaining in other countries. The report of the Commission was published in 1913 and is an invaluable examination of Canada's requirements and of the best practical achievements elsewhere.

A proper system of industrial training and technical education aims to promote not only the efficiency of industry but the general welfare of those engaged in it. Under such a system workmen become better educated and more contented. One result of particular importance to the mining industry is that the risk of accident is considerably lessened among trained workers.

The death rate among miners in Canada is greater than in any other civilized country. This is largely due, not to reckless disregard for human life but to the hazardous nature of the work and to the class of labour available for employment. The fatality rate in coal mines in Belgium is the lowest in the world, slightly exceeding one per thousand employed. In 1850, the fatality rate in Belgium was as high as it is in Canada to-day. The decrease is the result of the combined efforts of the mine owners, the workmen, and the administration of mines; it is due, in great measure, to diffusion of technical and professional education. This phase of mining education is of great importance and deserves more attention from our governments, especially as the safety of coal mines depends upon the individual intelligence of every man employed in the mines. The opening of a safety lamp in the mine, the carrying of matches, pipes or tobacco underground is forbidden. It is impossible, however, to keep constantly in touch with every man, and one act of carelessness, negligence or ignorance may blow up the whole mine. Attention should be directed to the education of the workman, that he may not endanger himself and others, and that he may become a more efficient workman and intelligent citizen. The law requires that coal mine officials have a certain standard of competency, yet nothing is done to enable the ordinary miner to qualify for this work.

Application of Science to Industry—Scientific Research

Modern industry, to be successful, must be based on scientific research. In Canada insufficient attention has been paid to the advantages of scientific research, and many business men fail to appreciate the economic importance of science. Since the outbreak of war, some of the largest corporations in Canada have taken up this work in their own interests but, naturally, some will not be willing to disclose the results of their investigations. To achieve the greatest success, such as Germany obtained before the war, requires complete co-operation between manufacturers and the Government to eliminate overlapping of effort and to promote the national welfare.

British Advisory Council

In 1915, Great Britain appointed an Advisory Council, for the threefold purpose of instituting scientific researches, establishing or developing institutions for the scientific study of industrial problems, and for the institution of research studentships and fellowships. It is intended that this Council shall form a permanent organization to promote industrial and scientific research throughout the kingdom and to organize the weapons of industry as the Government has already organized the weapons of warfare. The Council will undertake a campaign of education to point out to manufacturers the benefits from scientific research. To obtain the closer co-operation of manufacturers, the Council will first attack purely industrial problems, the practical bearing of which can be appreciated by all.

U. S. National Research Council

To encourage national efficiency in the United States, the National Academy of Science formulated plans for a National Research Council, whose purpose shall be to bring into co-operation existing governmental, educational, industrial and other research organizations, with the object of encouraging the investigation of natural phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defence, and such other applications of science as will promote the national security and welfare. Especially significant is the proposal to include in the membership of this council "leading American investigators and engineers, representing the army, navy, Smithsonian Institution, and various scientific bureaus of the government, educational institutions and research endowments, and the research divisions of industrial and manufacturing estaiblishments." The members are to be chosen in consultation wth the presidents of the leading national scientific, academic and technical societies, while the cabinet officers are to be asked to name representatives of the Government scientific bureaus under their supervision.

In the United States, industrial research is being carried on to a considerable extent in the different Government bureaus and in the universities. The Bureau of Standards was established by the United States Federal Government, primarily for the standardization of weights and measures and the quality of all supplies purchased by the Government. The annual grant was $100,000. Its research work is of enormous value not only to the Government but to the manufacturer and to the country at large. Although the work done by the Bureau is mainly for the Government, its testing facilities are also employed, to an extent which has reached important proportions of late, for investigations which cannot well be performed in commercial research laboratories. No private enterprise could attempt to maintain a laboratory as well equipped as that of the Bureau of Standards. Since the outbreak of war, the Bureau has assisted manufacturers to produce at home and out of American materials products for which, heretofore, they had been dependent upon foreign supplies.

Canada Appoints an Advisory Council

In June, 1916, the Canadian Government appointed, by Order in Council, a Committee of Council, consisting of the Ministers of Trade and Commerce, Interior, Mines, Inland Revenue, Labour and Agriculture. This Committee is charged with, and responsible for, the expenditure of any moneys provided by Parliament for scientific and industrial research. The order also appointed an Honorary Advisory Committee, responsible to the Committee of Council, to be composed of nine members, representative of the scientific and industrial interests of Canada, charged with the following duties:—

(a) To consult with all responsible bodies and persons carrying on scientific and industrial research work in Canada, with a view to bringing about united effort and mutual co-operation in solving the various problems of scientific and industrial research which, from time to time, present themselves;

(b) To co-ordinate, as far as possible, the work so carried on as to avoid overlapping of effort, and to direct the various problems requiring solution into the hands of those whose equipment and ability are best adapted thereto;

(c) To select the most practical and pressing problems indicated by industrial necessities and present them, when approved by the Committee, to the research bodies for earliest possible solution.

(d) To report from time to time the progress and results of their work to the Minister of Trade and Commerce, as chairman of the Committee of Council.

In addition to the necessity for scientific research in connection with the mining industry there is need for the testing and standardization of special mining equipment and chemical and mineral products. For example:—

(a) Standardizing of oxygen and caustic soda or caustic potash for use in mine rescue apparatus.

(b) The testing of miners' safety lamps and lamp parts.

(c) The testing and standardization of explosives for use in different mining operations.

(d) The standardization of chemical fertilizers and other chemical products.

Many imported products are now used in Canada which may, or may not, have been tested or standardized in Germany, United States and elsewhere. If we intend to manufacture these products in Canada it will be necessary to provide some means for guaranteeing their standard or purity.

Owing to the importance of this subject and to the increasing purchases made by the different departments of the government, it appears advisable that a National Bureau of Standards, similar to that in United States, be established in Canada.

Correlating of Departmental Information

In this connection it is advisable to emphasize the following recommendation made by a special committee of the Canadian Mining Institute to the Minister of Trade and Commerce:—

Valuable Information Available

"There is at present available in several departments of the Government valuable information relating to resources, industry and trade. This information, however, is not correlated, nor is it in sufficient detail to be utilized effectively. To provide for the proper correlation of this information year by year, it is desirable that a commission be appointed without delay to organize the Departments of the public service to this end. It may here be remarked that similar action has already been taken in the United States. In that country the Bureau of Mines, Geological Survey, Bureau of Animal Industry, Bureau of Plant Industry, Forest Service, Bureau of Chemistry, Bureau of Soils, Bureau of Census, and the Bureau of Foreign and Domestic Commerce co-operate for the correlation of information. The Bureau of Standards has, for its main purpose, the standardization of the mechanical accessories, the processes and the products of these industries; the Bureau of Foreign and Domestic Commerce brings the producer of raw materials into touch with the manufacturer, and the latter into relation with the consumer, through its studies of markets and trade opportunities at home and abroad; and the Bureau of Census is the national bookkeeper of the industries."

Co-operation of Producer and User of Mineral Products

In the past much of Canada's ores and unrefined mineral products have been exported for treatment, refining and manufacture. Industries have been established in Canada which require these products but, in many cases, the manufacturer does not know whether the products he requires can be, or are, manufactured in Canada. Moreover, if asked to state what he uses and how much is imported, he hesitates to give the desired information to the producer of mineral products for fear of losing the foreign contracts upon which his business is based.

The mineral industry may be assisted by having mining trade experts attached to the Department of Trade and Commerce who could act in co-operation with the Manufacturers' Association, with the Departments of Mines, Provincial and Federal Governments and with British trade and consular officers abroad. The correlated statistics could then be sent to producers and users in the form of weekly or monthly mining trade bulletins, thereby encouraging trade in mineral products both at home and abroad.

Encouragement of Basic Industries

On account of the small population and domestic markets of Canada, speaking generally, it is unwise to encourage the establishment of highly specialized industries, unless such can compete in outside markets with similar goods manufactured elsewhere. As our home consumption is small in proportion to our resources and to our capacity to produce raw materials, it is desirable that basic industries be established first. Following the growth of home market requirements it will be possible to develop special industries to utilize the basic products. In this connection, national safety as well as economic advantage must be considered, and problems will arise involving not only the establishment but also the location of basic industries. So far as the mineral industry is concerned, the following basic industries are of paramount importance:

(1) Chemical industries.
(2) Iron and steel industry.
(3) Smelting and refining works.
(4) Coal trade.

A brief discussion of these industries follows:—

Chemical Industries

Chemical products form the basis of many important industries. The following discussion has reference especially to electro-chemical development.

The efficiency and adaptability of electric energy for the refining of metals and the manufacture of chemical products have long been recognized, but it was not until recent years that the industrial world awakened to the importance of the new field. Electric refining, at first applied to copper only, is now being extended to all the metals, and the electric current is also employed in their extraction from the ores. The manufacture of ferro-alloys of chromium, vanadium, molybdenum, tungsten, titanium, silicon, etc., required for special steels, has assumed rapidly increasing importance. The production of aluminum, of calcium carbide, of the abrasives, of new refractory materials, of graphite, etc., has already created large industries. Sodium compounds and other well-known chemicals have long been manufactured by electrolysis. The fixation of nitrogen, with its many subsidiary industries, such as the manufacture of nitric acid, ammonium nitrate, explosives, etc., the reduction of magnesium and the production of innumerable chemical compounds known at present only to the special trades requiring them, is now under commercial development.

On account of the low efficiency of electro-chemical work and the large amount of power used in the process, one of the controlling factors in the establishment of these industries is cheap electric power. The water-power resources of Canada are not only great, but include many large water-powers situated near tide-water which could be developed and operated at low cost. In addition, their situation and proximity to markets either on the Atlantic or the Pacific offer unrivalled opportunities for the expansion of present and the establishment of new chemical industries. Owing to these advantages, and to the fact that electric current in the eastern United States will become more valuable for power and lighting purposes, Canada is favourably situated to secure the principal electro-chemical and electro-metallurgical industries of eastern North America.

Norway has long foreseen the importance of developing her water-powers and, to-day, her electro-chemical products form the basis of many of the chemical industries in Europe.

The principal electro-chemical industries already established in Canada are: Manufactures of aluminum, acetone, calcium carbide, metallic magnesium, calcium cyanimide, phosphorus, ferro-silicon, and the refining of copper, zinc and cobalt. The first five industries enumerated produce considerable quantities, not only for home consumption but also for export.

In 1913 the United Kingdom imported some $23,250,000 worth of chemical products, most of which could be manufactured as electro-chemicals. Of this amount over $2,750,000 worth were electro-chemicals, such as ferro-silicon, spiegeleisen, calcium carbide, and soda compounds. Of these imports of chemical products, Canada only supplied $200,000 worth and, of the electro-chemicals mentioned, did not export a dollar's worth to Great Britain. On account of the large water-powers situated near our shipping routes we have a splendid opportunity to secure a large share of this trade. Instead of developing our own electro-chemical industries we are developing our water-powers, transmitting the electricity across the line and building up electro-chemical industries there. As a result of this policy we are: First, developing some of our best water-powers and allowing industries to be created in the United States based upon this power, although experience has shown us that one of the great drawbacks to the economic manufacture of mineral products in Canada is the fact that we have to compete with well established plants to the south of the line. Secondly, if, owing to lack of demand for power in Canada, we allow it to be exported to United States, creating vested interests in that country, it may be difficult to prevent the export of this power when it is required in Canada.

The following extract from the *Seventh Annual Report of the Commission of Conservation** shows the importance of this subject:

"When development commenced at Niagara Falls, there was comparatively little market for electric power on the United States side of the river. Consequently, electro-chemical industries were induced to start, and large blocks of power were contracted for at a comparatively low figure. Considerable quantities of power were also exported from Canada to the United States, some of it being used in the newly started industries. The United States interests now fear that if they do not get the balance of the power that is already available, and can be made available under the existing treaty, at Niagara Falls, that the power will be used in Canada to build up Canadian industries. Before long, the electro-chemical industries, such as those manufacturing nitrogenous products, will be re-establishing themselves elsewhere. Under existing contracts they are getting at $10, $12, and $15 per horse-power power that has a market value in cities in New York state, ranging from $60 to $75 and upwards per horse-power. Now, if these industries in the United States can continue to increase their importation of electricity from Canada for a little while longer, and if the available surplus from Canada can once be transformed to the United States, then, according to the New York Public Service Commission, there need be no fear of its being withdrawn. This is a matter of great importance to Canada."

Nitric Acid and Fertilizer Industry

These industries are closely related. The element, nitrogen, which is the essential constituent of each, may be recovered electrically from the atmosphere. Nitric acid is the basis of many different chemical industries, including the manufacture of explosives and fertilizers. Commercial fertilizers are necessary for the maintenance of soil fertility. Their extensive use has been a primary cause of the relatively high crop yields in Germany, and an important factor in maintaining the food supply of that country during the war. The

*"Water and Water-power Problems," by A. V. White.

following table shows the comparative crop yields in certain countries, prior to the war:

Country and year	Bushels per acre				
	Wheat	Rye	Barley	Oats	Potatoes
Germany, 1913	35·0	30·4	40·9	61·0	235·4
Russia, 1912	10·1	14·3	16·1	23·6	121·3
Austria, 1912	22·3	23·2	29·7	36·1	148·7
Hungary, 1912	18·8	18·4	25·8	28·9	125·3
France, 1912	20·5	16·4	26·9	35·9	142·7
Canada, 1913	21·04	19·28	29·96	38·78	165·88
U. States, 1914	16·6	16·8	25·8	29·7	109·5
Argentine, 1912–13	13·8			39·2	

During the last thirty years, the crop yields per acre in Germany have nearly doubled. This excellent result is due partly to the development of the farmers' associations, to agricultural schools, and to the employment of modern methods, but chiefly to the ever-increasing use of fertilizers.

On account of Germany's dependence on Chile for her nitrogen supply, in the form of nitrate, the production of substitutes, in the form of ammonium sulphate and ammonia, in which the nitrogen is obtained from the air, has developed at a rapid rate. It is reported that the consumption in 1917 will amount to one and one-half times the consumption in 1913.

NOTES ON FERTILIZERS—Although some fifteen elements are required to sustain plant life, experiment has proven that three, and sometimes four, elements only need be furnished the plant artificially for its complete development. The other elements are present in sufficient quantities in the air and in the soil. Nitrogen, phosphorus and potassium are the elements usually exhausted most readily but, occasionally, calcium is also deficient.

An average soil contains enough plant food for about 100 crops but, unless fresh additions of plant food are made, the production will shrink in a very few years to one-third or one-fourth of the full crop. Once the yield has reached this lower level, it will remain for an indefinite period nearly stationary.

Because of the necessity for adding nitrogen, phosphoric acid and potassium for the growth of most crops, the name 'essential' is applied to these elements. Nitrogen and phosphoric acid are usually more liable to be deficient than potash, but no one of these essential elements can take the place of another, as each has its particular function to perform. The term fertilizers is applied to materials containing, in available form, any or all of these essential elements. Fertilizers may contain other elements, such as magnesia, sulphuric acid, etc., which, though needed by the crop, are unessential, as the soil contains a sufficient amount.

Nitrogen Fertilizers

Nitrogen is the most important element to consider in the study of fertilizers. It is the most expensive and most fugitive of the 'essential' elements. Nitrogen usually costs about three times as much as phosphoric acid or potash and, to be available as plant food, it must be in the form of nitrates, which are readily soluble in water. Nitrogen exists in different forms, which may, for present purposes, be classified as follows:—

1. Organic nitrogen, found in vegetable and animal substances, generally as protein.

2. Ammonia nitrogen, found in ammonium sulphate.

3. Nitrate nitrogen, found in nitrate of soda (Chile saltpetre) and in nitrate of potash.

4. Calcium nitrate, ammonium sulphate, ammonium nitrate and cyanamide, in which the nitrogen is extracted from the air by electrical means.

1. *Organic Nitrogen Fertilizers*—These fertilizers are manufactured from cotton-seed meal, linseed meal and from fish scrap, dried blood and packing-house waste. Natural guano, or bird excrement, is another important source of such fertilizers.

2. *Ammonium Sulphate* is unlike the organic compounds, as it is not a natural product but a manufacturing by-product, obtained in the coking or distillation of coal which usually contains about 1·8 per cent nitrogen. The ammonium sulphate recovered in plants established in Canada amounts to about 23 lbs. per ton of coal coked. It is guaranteed 24.5 to 25 per cent NH_3, or equal to about 20·75 per cent nitrogen. In normal years the Canadian production is exported to the United States and the West Indies. Ammonium sulphate is in a form very suitable for distribution in the soil and is readily converted into available plant food. It is more available than the organic forms, is a quick acting fertilizer and suitable, therefore, for quick return in crop production, an especial advantage

for truckers and market gardeners. It is often substituted for nitrate of soda.

3. *Nitrate of Soda*—The nitrogen in nitrate of soda can be used by plants without undergoing any change, and is the highest in point of availability of any of the nitrogenous fertilizers, excepting ammonium nitrate. It diffuses into the subsoil and induces roots to grow deeply. This is advantageous, as it enables plants to withstand dry spells and it increases the area of plant food supply. It is found in extensive deposits near the west coast of Chile and is often called Chile saltpetre. Reports have appeared concerning the rapid exhaustion of these fields but, according to the best authorities, such fears have little foundation. The annual exports are about 2,500,000 tons, while the reserves have been estimated at considerably over 250,000,000 tons. Until the outbreak of the war, the bulk of the Chile nitrate production went to Germany but, at the present time, the greater part of the production is shipped to the United States. In April, 1916, the price of the ordinary 95 per cent nitrate, free alongside vessel at Chile, was $1.80 per 101·4 lbs. Sodium nitrate contains from 15 to 16 per cent of nitrogen. Besides being a valuable fertilizer it is used to a considerable extent in the manufacture of explosives.

4. *Ammonium Nitrate and Calcium Cyanamide*—The utilization of nitrogen from the air, by artificially uniting and fixing it with other elements to form compounds that could compete with other nitrogenous fertilizer materials, has attracted the attention of chemists and investigators for many years.

In 1903, Berkeland and Eyde were able to prepare nitric acid from the air on a commercial scale, and, in 1907, erected a plant at Notodden, in Norway, utilizing a water-power of 40,000 h.p.; other works, using different kinds of furnaces, quickly followed. These furnaces vary considerably, but the common object is to bring the air into intimate contact with an electric arc. In the Berkeland and Eyde process the gases issuing from the furnace are cooled rapidly and passed into an oxidizing chamber where the nitric oxide is converted into nitrogen peroxide. The gases are then passed to a series of absorption towers, where they pass up through broken quartz and meet a descending shower of water and acid which converts the nitrogen peroxide into nitric acid. The weak acid is concentrated to 40 or 60 per cent strength and is used to decompose limestone, forming nitrate of lime, which, after evaporation, is ready for market. This process has a very low efficiency, namely, 5 per cent, consequently its commercial success depends entirely upon very cheap electric power. In the United States, the manufacture of nitrates has not been undertaken on account of the low efficiency of this process and because there are innumerable uses for electric power that will bring a greater return. In Canada conditions are not similar and the success of such an undertaking would depend upon tariff conditions and upon markets for the product.

There is an indirect method of preparing nitric acid from atmospheric nitrogen which is more economical of power and has the additional advantage that the plant need not be situated near a huge water-power. This process depends upon the oxidization of ammonia. The ammonia may be prepared in several different ways, directly and indirectly, from atmospheric nitrogen. A simple process is that of passing super-heated steam over cyanamide. The cyanamide is made by passing nitrogen through heated calcium carbide.

The ammonia is mixed with air and passed rapidly over platinum, causing the ammonia and oxygen to unite to form nitric acid and water. The nitric acid is usually neutralized with ammonia, forming ammonium nitrate. Ammonium nitrate is a rich nitrogenous salt, containing 35 per cent nitrogen (over twice the nitrogen content of sodium nitrate). It is ordinarily too expensive to employ for fertilizing purposes but is used extensively in the manufacture of explosives.

Calcium Cyanamide

Calcium cyanamide contains about 20 per cent nitrogen and on most soils has about the same fertilizing value as ammonium sulphate. It is, therefore, highly available and its use is especially advantageous on acid soils. The first step in its manufacture consists in the production of calcium carbide by heating a mixture of coke and limestone in an electric furnace. The carbide is powdered and placed in airtight, coal-fired retorts. After the carbide has reached a white heat, pure nitrogen gas is passed over it and the carbide absorbs the nitrogen, forming calcium cyanamide. The nitrogen gas is obtained by passing air over red-hot copper or by the liquid-air process. The only plant in North America manufacturing fertilizers in which the nitrogen content is derived from the air is that of the American Cyanamid Co., situated at Niagara Falls, Ont. When established in 1909 this plant had a capacity of 12,000 tons per annum; this was later increased to 64,000 tons. The electric energy continuously used at the plant is approximately 30,000 h.p., the greater portion of which is used in the manufacture of calcium carbide. In the past practically the whole production of this plant has been exported to the United States and her insular possessions, where it was used in the manufacture of so-called complete fertilizers. The following are the shipments of cyanamide from Canada to United States, 1909-1913:

1909, 1,450 tons; 1910, 4,650 tons; 1911, 9,500 tons; 1912, 11,100; tons; 1913, 27,400 tons. The average value of Canadian cyanamide exported to the United States, during 1914, was $51.40 per ton.

Calcium cyanamide may be put to a great number of uses but, thus far, the fertilizer market has absorbed the entire output of the plant. Among the different products which may be manufactured from calcium cyanamide, the following may be noted: Liquid ammonia, ammonium sulphate, ammonium phosphate, ammonium nitrate, ammonium chloride, nitric acid, sodium cyanide and dicyandiamide. All of these products serve a great number of important uses.

Iron and Steel Industry

Although iron ores are widely distributed throughout Canada, the present extensive metallurgical industry in iron and steel has been developed chiefly on the basis of imported ores, notably the conveniently situated and comparatively cheaply mined ores of Bell island, Newfoundland, and ores from the iron ranges in the United States, south and west of lake Superior. Each of these sources contributes about one-half the present imports. There are, nevertheless, important iron ore deposits in Canada which have already contributed considerable outputs in the past, and numerous occurrences of low grade ores which may constitute valuable sources of future supply.

An estimate, covering iron ore deposits upon which more or less work has been done, shows total known available reserves in Canada of about 200,000,000 tons. The great bulk of these ores, however, consists of low grade magnetites and siderites requiring concentration, or desulphurization, before being marketable.

The actual ore production has averaged less than 400,000 tons per annum. Much of this has had to find a market in the United States, not being acceptable to Canadian furnacemen. The blast furnace capacity in Canada is about 1,500,000 tons per annum, whereas actual production has exceeded 1,000,000 tons in one year only. In 1913 Canada consumed over 3,000,000 tons of iron and steel goods of all kinds. Not only are we dependent on foreign imports for 75 per cent of the iron and steel goods consumed in Canada, but even the iron ore which is manufactured into steel in Canada comes from outside sources. To increase the smelting of Canadian ores, it is evident that steps should be taken to encourage domestic smelting.

Smelting and Reduction Works

Prior to the war, a considerable portion of the world's trade in metals was controlled in Germany. Refining plants were established in that country through government assistance; mine products were imported far in excess of domestic needs and the excess of refined or manufactured articles was exported. To quote one example: The assistance and encouragement given the smelting and refining industry, together with other contributing factors, enabled Germany to purchase the unrefined zinc ores of Australia at a price which not only returned a handsome profit but prevented the establishment of rival smelting plants in the British Empire. When war broke out, Australia had enormous stocks of zinc ores but no zinc smelter. Fortunately, this situation is now changed. The erection of smelting works in Australia has been made possible by the British Government guaranteeing the purchase of the refined product at a certain price for a number of years.

Refining of Metals and Non-metallic Minerals in Canada.—The refining of our raw materials in Canada is a requisite to the manufacture of metallic or non-metallic products. Owing to our comparatively small population, large area, and capacity for production we will be able, for many years, to produce raw materials which, if manufactured, would be largely in excess of our own needs. In the past, we have been content to export most of our raw products for refining, but we have awakened to the necessity for altering that policy. Zinc and copper refineries have recently been established and nickel refineries are being constructed. This change has been brought about by the war. Previously, we refined more or less of our lead, gold, silver and cobalt production; in addition, nickel oxide and a small quantity of metallic nickel were refined. Admitting that Canada can produce and manufacture, or partly manufacture, more than she can consume, the question arises, how are we to dispose of this surplus? In so far as the precious metals and those mineral products of which we have a monopoly are concerned, there is little doubt that we could dispose of them profitably, either as the finished, or partially manufactured, product.

Coal Trade

The coal deposits of Canada compare favourably with those of the greatest coal mining countries of the world in respect of quality, quantity and accessibility for mining purposes, but, owing to their occurrence in the eastern and western portions of the Dominion, the large central market is supplied by imported coal.

United States bituminous coal is used in the area between a north-and-south line through Farnham, Que., and a line through Battleford to Moose Jaw and thence to Estevan, Sask. Although a considerable quantity of this coal is used in Manitoba and Saskatchewan, these provinces are also supplied by coal from the Crowsnest, Canmore, Edmonton, Lethbridge and Souris districts.

Eastern Canada possesses no deposits of anthracite coal. As this coal is admirably suited for domestic heating and cooking purposes, it is imported in considerable quantity from the United States and is sold over an area extending from Nova Scotia, in the east, to Battleford, Sask., in the west. The imports in 1913 amounted to over 4,640,000 tons, being more than double the imports of 1906. The demand for this class of coal is increasing, notwithstanding the rising prices.

The supply of anthracite coal in the United States is limited and there is no assurance that its export to Canada will be long continued. In 1913, it was estimated that there were 16,153,000,000 tons of anthracite coal in the United States. In 1913, 91,524,922 tons were mined and, as it has been estimated that for every ton of coal lost a ton and a half is sold or used,* the exhaustion is proceeding at the rate of over 152,000,000 tons per annum. If production continued at the same rate, it would exhaust the anthracite of the United States in little over 100 years. We must, therefore, expect that the price will gradually increase. Coincidently with the rising price, production will decrease, thus prolonging the life of the mines.

Of the total coal consumption in Canada during 1913, 42·6 per per cent was domestic coal and 57·4 per cent imported coal. In 1916 the production amounted to nearly 14,500,000 tons, while the imports for the same year exceeded 17,500,000 tons. In other words, we imported more coal than we produced. The importance of this fact may be more fully recognized when it is realized that, in 1916, the coal production amounted to over 22 per cent of our total mineral production, being valued at about $38,300,000. The situation then is this: Although Canada has over 17 per cent of the world's reserve of coal, our production is small and we import more than we produce.

It is desirable, both from the mining and national standpoint, that these conditions be changed. This question may be resolved into several special problems:—

(1) Domestic fuel problem in central Canada.

(2) Imported bituminous coal fuel on the railways of central Canada and of part of western Canada.

(3) Domestic fuel problem in Prairie Provinces.

(4) Cheap power problem in Prairie Provinces.

Mineral Resources of the United States—Part II, 1913, page 728.

It is the purpose of this paper merely to indicate how the foregoing problems may be solved:—

(1) The following solutions of the domestic fuel problem in central Canada are suggested: (a) The installation of by-product coke ovens at certain points on the St. Lawrence and Great Lakes system, the coke being used for domestic purposes in place of anthracite coal. (b) The development of a peat industry. (c) Eventually, no doubt, electric energy will, to a certain extent, replace coal for heating purposes in this area.

(2) In central Canada the electrification of some of our railways may, later, be found to be economically possible. The railway fuel problem in certain portions of Western Canada may be solved by the use of powdered coal (using western lignites or sub-bituminous coal); by the use of a suitable briquetted fuel made from lignites or bituminous coal, and by the further use of our own bituminous coal.

(3) and (4). Two questions of great importance in the Prairie Provinces to-day, the solution of which will become a matter of even greater moment in the future, are the problems of securing cheap power and an assured domestic fuel supply. In western Manitoba, in Saskatchewan, and in eastern Alberta water-power development costs are, in most instances, high. These districts are within reach of great deposits of lignite. It is, therefore, essential that something be done to utilize the low-grade fuels which underlie the greater portion of Alberta and part of Saskatchewan and Manitoba. To make the coal transportable and suitable for domestic and power purposes, it is necessary:

1. That it be of sufficient value to bear the cost of transportation.

2. That it withstand handling and a certain amount of weathering.

3. That it be a suitable fuel for domestic and power purposes.

The above conditions are fulfilled by coal briquettes and carbonized lignite briquettes. The Mines Branch and the Conservation Commission, in co-operation with the Advisory Council on Industrial and Scientific Research, are working on these problems and indications point toward an economic solution.

Industrial Alcohol

The imports of petroleum and petroleum products into Canada have been rapidly increasing, while the domestic production has been decreasing. The imports of petroleum, crude and refined, during the calendar year 1916 totalled over 292 million gallons, valued at over

$14,600,000. As our crude petroleum production in 1916 amounted to about 7½ million gallons, valued at about $392,300, it can be seen that Canada is dependent upon foreign sources for her supplies of petroleum and petroleum products. Ninety-nine per cent of the production of crude petroleum comes from Ontario, but the production is steadily declining in spite of efforts to enlarge the areas of producing fields, or to find new fields.

In considering the development of a substitute for petroleum for illumination, cooking, and for use in internal combustion engines, industrial alcohol, which is used to a considerable extent in Germany and Great Britain, has been suggested.

In 1916, Canadian imports of refined and illuminating oils amounted to over 8,080,107 gallons, valued at $543,000; during the same year 18,322,000 gallons of gasolene, valued at $3,625,000, were imported. If industrial alcohol could be produced economically in Canada so as to replace these products there would be a reduction of over $4,000,000 worth of imports. It has been reported that, on account of the rising price of gasolene, many tractors have been rendered idle in the Prairie Provinces, thus reducing the acreage to be sown. The Director of the United States Bureau of Mines declares that the high prices may not only continue for some time but will undoubtedly reach higher levels before there is any permanent relief. He states that the United States Government will, during the next fiscal year, pay 31½ cents for its gasolene. He, therefore, concludes that if the United States, using such vast quantities, is compelled to pay this high price, the private consumer will have to pay much more. Furthermore, at the present rate of production, the known supply of crude oil in the United States, from which we obtain our present supply of gasolene, will be exhausted in 27 years.

Possibility of Establishing Alcohol Industry

In considering the establishment of an alcohol industry in Canada it is necessary to distinguish war conditions from those obtaining in normal times. As alcohol is essential in the manufacture of smokeless powder, present prices are abnormally high. Normally, there is no great demand for alcohol for this special purpose and it would then have to compete with kerosene and similar products.

The raw materials used elsewhere than in Canada for the manufacture of industrial alcohol are potatoes, sugar beets, molasses and sawdust.

The present price and yield of potatoes in Canada are not such as would warrant the founding of a potato alcohol industry in Canada. W. T. Macoun, Dominion Horticulturist, states that, if best methods are followed, 300 bushels of potatoes per acre can be produced. He estimates the cost of production and marketing such a crop at 20½ cents per bushel, but says that this will be reduced on large areas where the most modern machinery is used. *The Census and Statistics Monthly* states that the profit per acre, in 1913, for spring wheat grown in Manitoba, Saskatchewan and Alberta was $2.65, $1.72 and $2.09 respectively, so that it is evident that if potatoes were sold at 21½ cents per bushel there would be a greater profit to the farmer than growing wheat in these provinces. Potatoes used in the manufacture of alcohol need not be sacked and may be shipped frozen with but a trifling loss. The establishment of an alcohol industry on a suitable scale would promote profitable agriculture in areas otherwise unsuited to crop growing; the feeding of the spent mash to cattle would encourage live stock growing and the alcohol could be utilized by the farmers as illuminant, for cooking and heating purposes, and as a source of motor fuel.

Another promising field for the development of an alcohol industry in Canada seems to be in the utilization of sawdust and wood waste from our saw-mills. The large mills make practically no use of this material and burners are kept going night and day to destroy the wood waste. The E. J. Du Pont de Nemours Powder Co., the largest powder and explosives manufacturers in the United States, use enormous quantities of spirit in their numerous factories. Their factory at Georgetown, South Carolina, produces nearly 750 gallons of spirit per day from sawdust and wood waste. As the plant is situated near three large saw mills and was established *before* the war, their costs for sawdust alcohol must have been less than for alcohol produced from molasses or any other local product.