

CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN MCLEISH, DIRECTOR

**INVESTIGATIONS OF
MINERAL RESOURCES AND THE MINING
INDUSTRY, 1930**

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No. 723

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

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Annual reports on Mines Branch investigations are now issued in four parts, as follows:—

Investigations of Mineral Resources and the Mining Industry.

Investigations in Ore Dressing and Metallurgy (Testing and Research Laboratories).

Investigations of Fuels and Fuel Testing (Testing and Research Laboratories).

Investigations in Ceramics and Road Materials (Testing and Research Laboratories).

Other reports on Special Investigations are issued as completed.

MINES BRANCH INVESTIGATIONS OF
MINERAL RESOURCES AND THE MINING INDUSTRY, 1930

I

BITUMINOUS SANDS OF NORTHERN ALBERTA—OPERATIONS
DURING 1930

S. C. ELLS

Field work during 1930, included:

- (a) Design and construction of a heated mixing plant.
- (b) Quarrying operations at McMurray.

DESIGN AND CONSTRUCTION OF HEATED MIXING PLANT

At intervals during the past 15 years, the writer has given some attention to the design, construction, and operation of mixing equipment adapted to the heating and mixing of bituminous sand. In 1915,¹ a small portable plant was assembled at Edmonton, Alberta, and successfully used in connexion with the surfacing of certain areas on Kinnaird street. In 1926, a somewhat larger semi-portable plant,² having a charged capacity of upwards of 3 tons, was designed, constructed and placed in operation at Jasper, Alberta. As a result of the above work, the construction of a still larger plant appeared desirable. Designs were therefore prepared by the writer and construction commenced in January, 1930. Owing to various unavoidable delays, trial runs were not undertaken until the latter part of June.

The plant is installed on a standard steel frame railway car secured from the Canadian National Railways. Mixing-drums and the somewhat cumbersome power transmission were purchased second hand. For reasons of economy the method of power transmission was retained, although motor drive with speed reducer would have had obvious advantages.

Plants operated by the writer in 1915 and 1926 were designed primarily for the heating and mixing of natural bituminous sand. More recently, however, it has appeared that production of separated bitumen from the McMurray sands may be anticipated in the not distant future.¹ Consequently the plant constructed in 1930 was designed for the manipulation of (a) natural bituminous sand, and (b) synthetic mixtures, comprising separated bitumen and clean aggregate. The general arrangement of the plant as completed is illustrated in Figure 1, and Plates I and II.

Natural Bituminous Sand Mixtures

In operation, bituminous sand is loaded into two-way side-dumping cars (1) having a capacity of approximately 1,200 pounds each. These are pushed onto track-scale (2) and discharged through chute (3) into boot (4) of elevator (5). The elevator discharges into hopper of crushing rolls (6) where the bituminous sand is broken down to lumps having a maximum face of about 5 inches. Crushed material falls to chute (7),

¹ Mines Branch, Dept. of Mines, Canada, Summary Report 1915.

² Mines Branch, Dept. of Mines, Canada, Reports Nos. 684 and 694.

is elevated by elevator (8), fed alternately by chutes (9) and (10) to hoppers (11) and (12), and thence passes direct into heated mixing-drums (13) and (14). When mixed and heated, the road mixture is discharged by movable chute (15) and fixed chute (16) to street trucks.

Separated Bitumen Combined with Clean Aggregate

Clean aggregate is fed into mixing-drums as in the case of natural bituminous sand mixtures. When the moisture has been driven off, and the temperature of the aggregate sufficiently raised, bitumen is pumped from agitated heating kettle (17) to measuring boxes (18) and (19), and discharged direct to drums (13) and (14). Should the possible use of natural bituminous sand be disregarded, and the preparation of paving mixtures confined to the use of separated bitumen, one of the two elevators as well as the crushing rolls could be eliminated. Such modification, together with the more compactly arranged power transmission, would reduce the area now occupied by the mixing plant from approximately 420 square feet, to approximately 350 square feet.

Certain features connected with the operation of the above plant may be briefly referred to as follows:

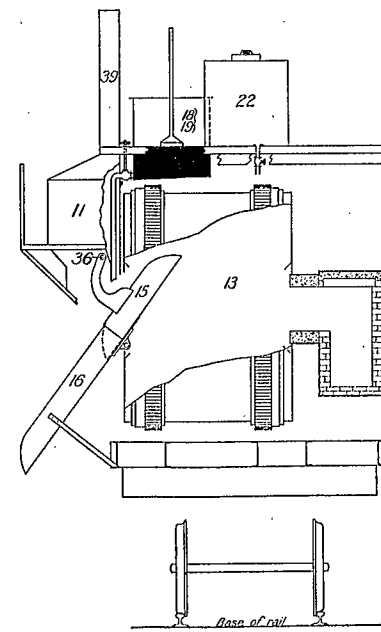
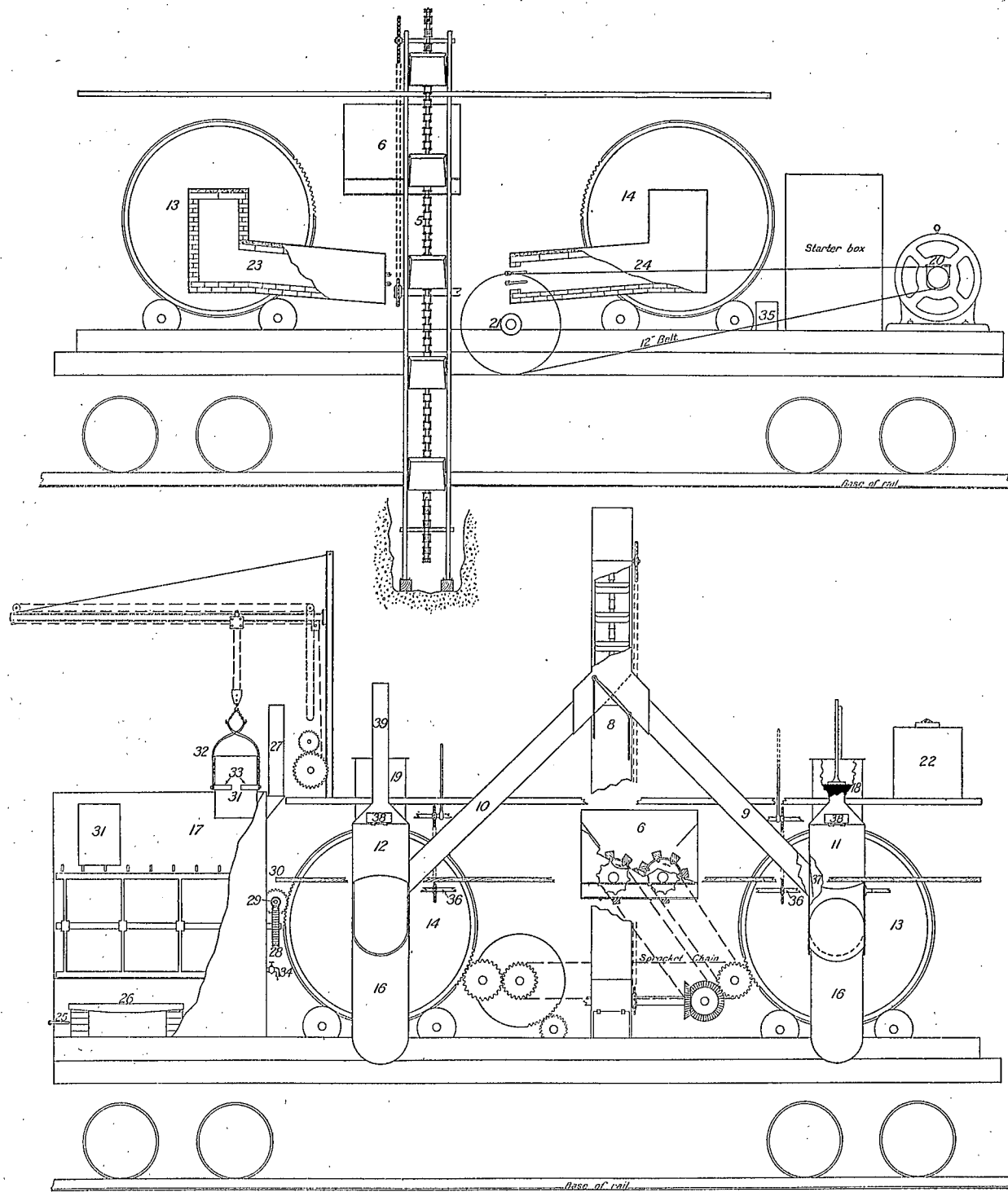
Power. Power is furnished by a 75 h.p. motor (20), 3-phase, 60-cycle, 110 volts, belted to a 52-inch line shaft pulley (21).

Crusher. This consists of two cast steel rolls, each 24 inches in length, 19 inches in diameter and 1 inch in thickness, fitted with heavy, specially designed, intermeshing teeth. In operation this type of crusher proved satisfactory, and apparently has a capacity of approximately 60 tons of bituminous sand per hour.

Heating. Heat for drums and bitumen kettle is supplied by Gem type oil burners, fuel oil of 27 degrees Bé. being fed by gravity from storage tank (22). Heating of mixing-drums is effected by combustion chambers (23) and (24), each chamber being equipped with two burners. As a temporary measure, fuel oil was atomized by steam from a 25 h.p. vertical boiler at 40 to 50 pounds pressure. For purposes of convenience it is hoped to replace steam by the use of compressed air. During the period in which moisture is being driven from clean aggregate, both burners are used in each combustion chamber and the flame may be allowed to enter the mixing-drums. Before natural bituminous sand or separated bitumen is introduced into the drums, one burner is shut off and the flame so regulated that it does not enter the drum.

Heating of bitumen kettle (17) is effected by a single burner (25) inserted into combustion chamber (26), combustion gases passing out through flue (27).

Bitumen Kettle. Separated bitumen is heated in a kettle (17). This consists essentially of a $\frac{1}{4}$ -inch sheet-iron tank having a semi-circular bottom and closed at the top by sheet-iron lids. The capacity is approximately 5 tons of bitumen. A series of bars, $\frac{1}{2}$ inch by 3 inches, forms a grid on which barrels of bitumen are placed. The kettle is enclosed in a light (16 gauge) metal housing which provides for heating space along both sides and one end. The bottom of the kettle is protected from direct flame



- 1 Dump car
- 2 Track scale
- 3 Chute
- 4 Elevator boat
- 5 Ground elevator
- 6 Crushing rolls
- 7 Chute
- 8 Elevator
- 9 Chutes to drums

- 11 Hoppers
- 12 Drums
- 13 Discharge chutes
- 14 Bitumen kettle
- 15 Measuring boxes
- 16 75 H.P. Motor
- 17 Main pulley
- 18 Fuel oil tank
- 19 Combustion chambers

- 25 Oil burner
- 26 Combustion chamber
- 27 Flue
- 28 Worm and worm gear
- 29 Gear
- 30 Bitumen containers
- 31 Hoisting grip
- 32 Asphalt pump

Scale
5 0 5 10 Feet

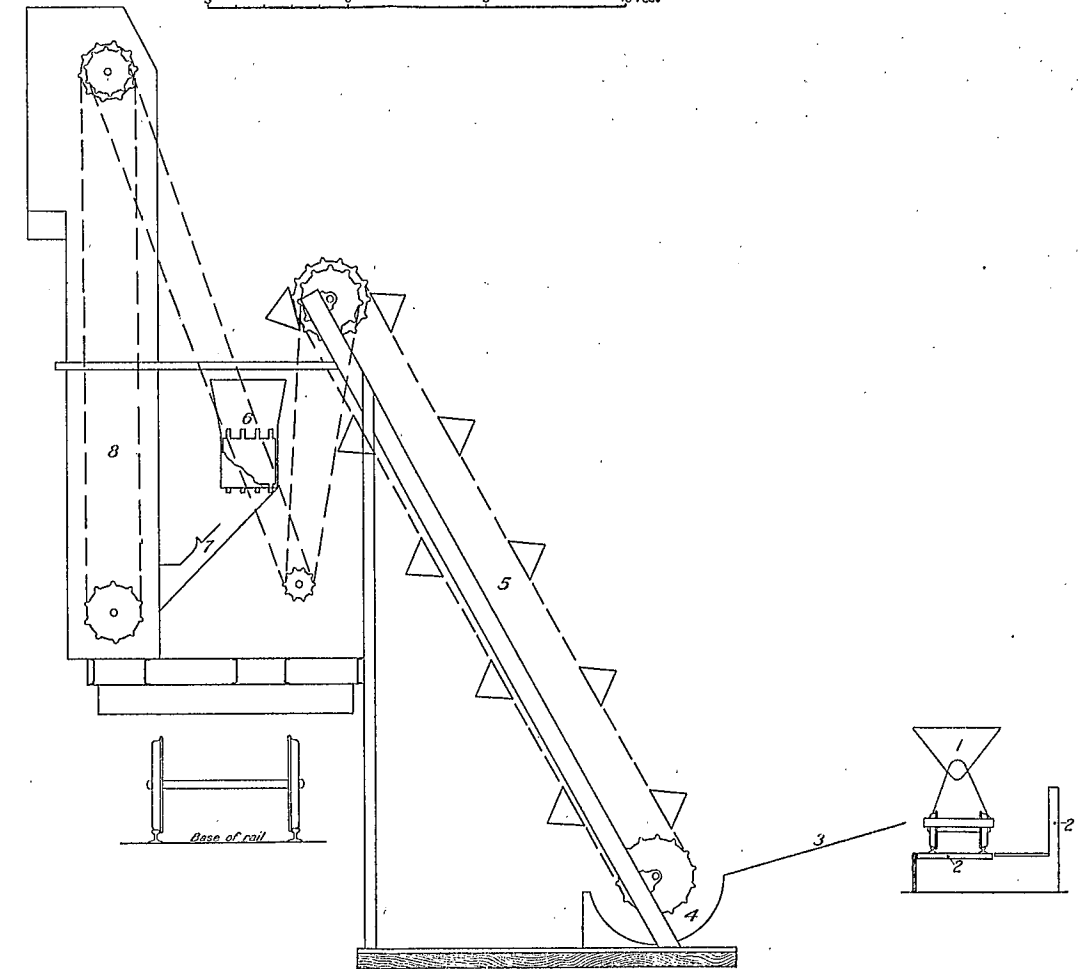


Figure 1. Diagrammatic sketch of portable, internally heated, drum type mixing plant.

by a series of fire grate bars resting on firebrick supports. A heavy blade agitator is driven by worm gear (28), worm (29), and gear (30), the latter meshing with one of the main gear bands on the outer face of the adjacent mixing-drum. Agitator blades not only ensure uniform heating throughout the mass of bitumen, but also prevent formation of coke on the inner surface of the kettle.

It may be noted that, pending production which will warrant the use of tank cars, separated bitumen is shipped from McMurray in light metal containers (31) having a capacity of approximately 47 gallons each. These containers are hoisted by grip (32), fitted with pivoted semi-circular bands (33), inverted at any desired point above the kettle, and lowered onto the grid. Here the containers are quickly drained.

Transfer of Bitumen to Mixing-Drums. Heated bitumen leaves kettle (17) at point (34) through a 2-inch pipe, passes by gravity to gear pump (35), and is elevated to metal measuring boxes (18) and (19). When not being discharged into measuring boxes, bitumen is circulated back to the heating kettle by a 3-way valve. Necessary valves and drains are provided throughout the system. For the most part, piping is protected by 3-inch steam jackets, but valves and pump tend to "freeze" up. This can be remedied by further jacketing.

Measuring Boxes. These are constructed of 16 gauge sheet-iron and are provided with hinged lids. Bottoms have a slight pitch toward the discharge openings. A light metal float operating an indicator arrow moving up or down a graduated board, shows the quantity of bitumen fed into or withdrawn from the measuring box.

Discharge Chutes. Each drum is equipped with two chutes, one fixed and one movable. The fixed section is 2 feet 3 inches wide at the top and 10½ inches deep. The movable section, which is 2 feet 11 inches wide at the top and 11½ inches deep, is controlled by a pair of curved arms keyed to shafting (38). A lateral extension of this shafting is fitted with a sprocket (16 inches in diameter) connected by chain with a second sprocket (10 inches in diameter) keyed to a countershaft immediately below the upper deck of the plant. This countershaft is moved by a hand-lever, 4½ feet in length, the operation being assisted by the introduction of a 100-pound counterweight. When drums are being charged and while heating and mixing are in progress, the movable chutes form a continuation of the bottoms of loading hoppers.

Ground Elevator. In order to receive somewhat large lumps of bituminous sand, buckets have a capacity of approximately 2·3 cubic feet. Side channels of elevator are 2 inches by 8 inches, vertical channel supports are 2 inches by 5 inches, and horizontal ground channels are 2 inches by 5 inches. This frame is bolted together and can be readily dismantled. In order to provide the necessary difference in elevation between track scale and elevator boot, it was necessary to excavate to a depth of approximately 4 feet below base of the mixing plant track.

Bitumen content of natural bituminous sand passed through the plant averaged 13·9 per cent. One batch consisting of 3,600 pounds of bituminous sand and 2,800 pounds of clean aggregate was elevated, crushed, heated to 325° F., and discharged in approximately 29 minutes. Of this

period 17 minutes was required for 3 men to load, tram, weigh, and empty the side-dump cars into the boot of the ground elevator. More men and better loading facilities, such as a storage pocket, would materially increase speed of operation. Time of discharge of drums when chutes were clean, was approximately $1\frac{1}{2}$ minutes, and no difficulty was experienced in checking the discharge by reversing the position of the movable chute. Design and arrangement of mixing flights in the drums themselves, proved efficient.

Loss of fine material in the form of dust was serious. During the period in which clean aggregate was being dried, much dust escaped at hinged doors (38), at end of chutes (9) and (10), at hinged doors (39) in the top of feed hoppers, up the stacks (40), and at discharge openings of drums. It is thought that this leakage can be largely prevented by minor modifications and that the use of a simple type of fan and dust collector would eliminate it altogether.

Operation of bitumen kettle (17) is satisfactory and bitumen can be raised to 300°F. within 3 hours. 'Freezing' up of pump and valves has caused considerable difficulty. Jacketing should overcome this.

During the early part of July, approximately 40 tons of bituminous sand—together with necessary percentages of added clean aggregate—were passed through the mixing-drums. The bituminous sand consisted of hard, weathered material which had been mined in August, 1927, but crushing and subsequent heating were effected without difficulty. The intermittent nature of trial runs, due to the necessity of effecting minor adjustments and alterations, and the variable percentage of moisture in the clean aggregate, precluded definite determinations of rate of heating and mixing. Moreover, the maximum charge per drum did not exceed $3\frac{1}{2}$ tons, whereas individual drum capacity is at least 4 tons. Efficiency was, however, at least equal to that attained at Jasper in 1926 and 1927.¹

On July 20, the first shipment of separated bitumen² was received from McMurray, and on August 1 and subsequent dates approximately 50 tons of bitumen plus clean aggregate was passed through the heating drums. This material was utilized in laying small areas of wearing surface for the Standard Iron Works (Plate IIIA), the W. H. Cushing Lumber Company, and Dr. R. F. Nicholls. On August 18 the mixing plant was closed down for the season.

QUARRYING OPERATIONS AT McMURRAY

Operations at McMurray consisted chiefly in excavating at the Mines Branch quarry, approximately 1,100 tons of bituminous sand. This material was delivered to the adjacent experimental separation plant operated by Dr. K. A. Clark of the Scientific and Industrial Research Council of the Province of Alberta. Paul Schmidt was in immediate charge of mining and transportation work, and certain observations embodied in his report may be briefly summarized.

As noted in previous reports,³ bituminous sand immediately adjacent to weathered outcrops differs in marked degree from unaltered material.

¹ Mines Branch, Dept. of Mines, Canada, Reports 684, 694.

² Shipped by Dr. K. A. Clark, Scientific and Industrial Research Council of Alberta.

³ Mines Branch, Dept. of Mines, Canada, Reports 632, 694, 710-1, 719.

Crushing facilities available at the separation plant were not adequate for the disintegration of the harder weathered sand. Moreover, separation methods in use proved inefficient in treating this class of material. Consequently it was necessary to restrict mining operations to the somewhat soft, unaltered bituminous sand. But even rich and unaltered bituminous sands from different parts of the quarry did not respond uniformly to separation treatment. This was apparently due to the presence of various deposited mineral salts which neutralized the action of the sodium silicate solution used in the separation tanks.

Efficiency of explosives when used in the upper portion of the bituminous sand strata, was low owing to the presence of numerous cracks and fissures. In passing downward the sand became 'tighter', two or three shots accomplishing results previously obtained by from ten to fifteen. As a rule, the bituminous sand could be readily spaded after blasting, and there was little difficulty in keeping digging tools clean.

Bituminous sand excavated showed considerable variation as regards grading of sand aggregate. Percentage of associated bitumen also varied, a condition due in part to the leaching action of numerous water seeps. Minor clay lenses, clay partings, individual particles of clay, fragments of fossil wood, and ferrous concretions were not uncommon. In places the upper portion of the bed exhibited marked evidence of cross-bedding. With the exception of the concretions, which were a source of danger to mechanical equipment, none of the above impurities seriously affected efficiency of separation.

The presence of fossil wood in the bituminous sands has long been recognized by the Mines Branch.¹ In 1914, such occurrences were first noted by the writer on Ells river, at the base of the bituminous sand and immediately above soft, grey, plastic clay. Subsequently, in 1924, during shaft sinking operations on Clearwater river near McMurray, additional discoveries of large and small fragments of wood were made, and the following reference thereto appeared in a report dealing with field operations of that year.²

Certain of these wood fragments (which apparently were originally accumulated as drift wood) have been partly or wholly carbonized, whereas others, that have been completely insulated by rich bituminous sand, are well preserved and appear to have undergone but little alteration.³ Possibly such preservation may be considered as an indication that impregnation of the sands by bitumen followed very shortly after, or even during, deposition.

In the fall of 1924, specimens of the wood referred to were forwarded to Ottawa and submitted to specialists for examination. Again in 1925, many small fragments of fossil wood were collected by the writer and A. W. G. Wilson along the gorge of Hangingstone river, approximately 3 miles from its mouth. Between the years 1926 and 1930, while excavating shipments of bituminous sand from Mines Branch quarries on Clearwater river, additional specimens in the form of branches and tree trunks were encountered in the bituminous sand at various elevations. Much of this material was, of necessity, badly broken up by the explosives used, but during 1929⁴ and 1930 a number of representative specimens were secured

¹ Mines Branch, Dept. of Mines, Canada, Reports 336, 632, 604, 710-1, 719.

² Mines Branch, Dept. of Mines, Canada, Report 632, p. 55 (1925).

³ Merriam, John C.: Bulletins issued by Univ. of Calif. on investigations at Rancho La Brea, Cal.

⁴ Mines Branch, Dept. of Mines, Canada, Report 719, 1930.

and forwarded to Professor I. W. Bailey, Bussey Institution for Research in Applied Biology, Harvard University. Much of the material excavated in 1930 was from an area approximately 1,200 square feet in extent and at depths varying up to 17 feet.

From a provisional statement¹ prepared by Professor Bailey it appears that one of the trees is a Gymnosperm entirely unlike any genus growing in North America at the present time, and that it most closely resembles *Sciadopitys* which grows in Japan. Another specimen belongs to the genus *Keteleeria* which is found at present in China and Formosa. Still another fragment of the "seam" wood belongs to Gothan's extinct genus *Xenoxylon*. *Xenoxylon* is known from the Jurassic with one doubtful find in the Trias, and is a rather common and typically Jurassic genus. Woods resembling *Sciadopitys* and *Keteleeria* have been described from Spitzbergen, King Charles Land, England, and other regions of northern Europe under the names, *Phyllocladoxylon* and *Protopiceoxylon*. The association of *Xenoxylon* with the bituminous sands is therefore significant.

During the accumulation of the great body of siliceous material which constitutes the basis of the bituminous sand deposit, logs were undoubtedly transported by water, even as they are to-day by the present streams. These apparently lodged in eddies and on bars, and subsequently became buried under the accumulating sand deposit. At a still later date, possibly after the deposit had drained and dried to some extent, a great inflow of asphaltic base petroleum, estimated at not less than 100 billions of barrels, saturated the sands and protected the embedded wood from the effects of disintegrating agencies.

In addition to smaller pieces of wood, at least seven logs were uncovered at the Mines Branch quarry on Clearwater river during July and August, 1930. Most of these were in a good state of preservation, and some could be traced continuously for distances up to 40 feet. The logs lie roughly parallel with the present river valley and vary in diameter from 8 to 14 inches. One substantial fragment, some 4 feet in length, was found in a vertical position, but all other logs lay horizontally. Owing to pressure, most of the smaller pieces have been pressed quite flat. When freshly cut, the colour of the wood varies from brown to reddish brown, and in most instances the structure is clearly seen.

Mr. Paul Schmidt, who was in immediate charge of quarrying operations, states that:

. . . . transverse jointing of the trees is common. At times this is not evident until the wood has been partially dried; at other times joint planes are clearly indicated as a result of infiltration of bitumen or even of bituminous sand.

In certain instances the wood has completely disappeared, being replaced by clay, iron carbonates, and various concretions, which preserve the shape of the original log.

For the most part logs are embedded in bituminous sand of variable richness. In some instances, however, water seeps have apparently followed along the logs, leaching out the bitumen from adjacent bituminous sand. Consequently wood may be either relatively dry or thoroughly wet.

As previously noted, joint or fracture planes of the larger logs contain appreciable amounts of bitumen. Moreover, even when no cracks are visible at the surface, bituminous material is at times found within the wood,—possibly a distillation product of the wood itself.

¹ March 15, 1930.

Slip planes in the bituminous sand have, in places, become distorted immediately adjacent to logs.

Specimens of fossil wood referred to above have been found at points upwards of 40 miles apart, but in what is virtually one continuous deposit of bituminous sand. The area within which other occurrences may be discovered in the future is thus very large.

Prior to 1914, the bituminous sand had been regarded as of early Cretaceous age, and referred to the Dakota. In 1914 two undescribed shells—a *Campeloma* and a *Melanoid* belonging to the genus *Pachymelania*—were found by the writer on Hangingstone river.¹ The earliest record of *Campeloma* in America is in the Bear River formation of Wyoming which lies at the base of the Cretaceous. Subsequently Dr. F. H. McLearn of the Geological Survey suggested that the bituminous sands were earlier than the Dakota and provisionally assigned them to the "McMurray formation". A study of the specimens of wood already found, as well as others which undoubtedly will be found, should make it possible to determine more definitely the geological age of the bitumen-bearing strata. The discovery of Jurassic flora in the lower beds suggests a Jurassic age for that portion of the deposit. Meanwhile it is evident that the material uncovered during the course of excavation work by the Mines Branch represents an interesting and valuable scientific discovery, the importance of which warrants further careful and systematic investigation. Such an investigation will probably be undertaken shortly by the Federal Department of Mines in co-operation with commercial organizations which are planning extensive development of the bituminous sands.

As yet no remains of prehistoric animals, such as dinosaurs, have been found in the bituminous sands, and the possibility of such discoveries is, of course, at present entirely a matter of surmise. On the other hand, dinosaurs lived in Triassic times and did not finally disappear until the close of the Cretaceous period. Consequently, while preserved bodies will not be found in the bituminous sand, it is quite possible that skeletons may be discovered. Similarly, while well preserved mammoths will not be found in northern Alberta, bones of these animals may be recovered from glacial deposits. As yet the only evidence of such remains is based on an unconfirmed report of the discovery about 1904 of a large bone—apparently a mammoth tusk—at McMurray Settlement.

OPERATIONS BY PRIVATELY CONTROLLED COMPANIES IN THE McMURRAY AREA

International Bitumen Company, Ltd., R. C. Fitzsimmons, Field Manager.

During a considerable part of each year since 1925 (incl.), R. C. Fitzsimmons has been conducting exploratory operations in sec. 36, tp. 96, R. 11 and in secs. 28, 31, and 32, tp. 96, R. 11. In 1931, however, exploratory work was discontinued and preliminary steps taken to develop a separation process for the recovery of bitumen from bituminous sand.

Seepages of bitumen along the east shore of Athabaska river in sec. 36, tp. 96, R. 11 and in secs. 1 and 12, tp. 97, R. 11, appeared to indicate the presence of workable beds of bituminous sand. A small pit was therefore

¹ Mines Branch, Dept. of Mines, Canada, Report 632, p. 44, 1925.

opened up in L.S. 2, sec. 1, tp. 97, R. 11, at a point some 75 feet from the shore. The floor of the pit is approximately 40 feet above water level, and the exposed face of bituminous sand about 25 feet in thickness. Drilling at this point had previously indicated the presence of not less than 80 feet of bituminous sand, and it is stated that results of drilling immediately adjacent to the eastward indicate a considerably greater total thickness. A sample of the bituminous sand taken by the writer from the working face of the pit was reported on as follows by the Fuel Testing Laboratories of the Mines Branch.¹

Bituminous Sand:

Moisture content	1.4 per cent
Dry bitumen content.....	14.5 " "

Bitumen:

Specific gravity at 60° F.....	1.005
--------------------------------	-------

Viscosity:

Saybolt Furoil at 210° F.....	2 mins. 6 secs.
(Equivalent to Saybolt Universal at 210° F., 20 mins. 30 secs. approximately.)	

Distillation Range: (by Engler method)

5 c.c.	496° F.
10	542
15	584
20	616
25	638
30	652
35	661
40	664
45	670
50	692
55	706
60	712
65	720
70	720
75	720 (cracking started)
79	720 -

<i>Specific Gravity of Distillate at 60° F.....</i>	0.922
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Products as Per Cent Weight of Bitumen:

Distillate up to 720° F.....	72.5
Heavy oil and pitch	22.5
Gas and loss.....	5.0

During the period May to August, 1930, a simple type of separation plant was installed by Mr. Fitzsimmons immediately adjacent to the exposure noted above. The primary object of the installation was to demonstrate the ease with which separation may be effected, and little attempt was made to introduce mechanically operated labour-saving equipment. Lumber required was sawed at the plant site, and most of the kettles, fittings, etc., were already available from previous operations. Consequently, apart from labour charges, the cost of the plant did not exceed \$25.

¹ Reported by A. A. Swinnerton.

In operation, bituminous sand from the quarry is shovelled directly into an open, semi-circular iron tank, 5 feet in length and 2 feet in diameter. This tank contains river water—without reagents—and is heated by direct fire from below. Partly purified bitumen is skimmed by hand from the surface of the water and sand tailings shovelled out between batches. The tailings are not completely free of bitumen, but for the present it is not considered economical nor essential to recover the total bitumen associated with the sand. The product from this tank is transferred to a circular settling-box, 5 feet in height and 4 feet in diameter, fitted with steam coils. Here a part of the water and sand settles out, while the bitumen flows to a wooden trough, 6 feet in length, 20 inches wide, and 21 inches deep, containing cold water. This trough is equipped with a stirring arm, and resembles a dough mixer. Here more water is kneaded out of the bitumen, while a jet of cold water assists in the removal of mineral matter. Surplus water is decanted by merely raising one end of the trough.

The product is then transferred by hand to two wooden boxes, one of which is $8\frac{1}{2}$ feet long, 3 feet wide, and $2\frac{1}{2}$ feet deep, and the other $4\frac{1}{2}$ feet long, 2 feet wide, and 2 feet deep. These boxes are heated by steam coils, and in them dehydration and final settling is effected. Frothing is prevented by manual stirring with wooden poles. The refined product is tapped into barrels.

During the period June 12 to August 25 some 300 barrels of bitumen—equivalent to 8,400 gallons—was produced. With the present primitive equipment labour costs are very high, 7 men being required to produce 5 barrels of bitumen in 10 hours. It is proposed to install a mechanically operated plant in the near future.

It may be noted that separated bitumen furnished the writer by Mr. Fitzsimmons, and said to represent the average product of the above plant, contained 0.2 per cent moisture and 3.9 per cent mineral matter.

In 1927¹ in connexion with paving operations at Jasper, Alberta, trial runs were undertaken on a commercial scale in order to determine (a) heating losses during various periods of time and (b) penetration of residual bitumen associated with the bituminous sand so heated. As a result however of recent progress in separation practice, it is now felt that bitumen recovered from bituminous sand rather than the natural bituminous sand itself will be used in the treatment of road surfaces.

Bituminous binders now in use are marked by a wide range in penetration. Consequently tests of separated bitumen have been conducted to determine (a) distillation loss and (b) penetration of residual bitumen following heating for various periods and at various temperatures. Results of these tests are stated in the following report by A. A. Swinnerton.

¹ Mines Branch, Dept. of Mines, Canada, Report 694, pp. 29-30.

The bitumen used in these experiments, namely, a sample of the 1930 production from the Clearwater separation plant, was heated without access of air in a glass distilling flask to remove varying proportions of distillate, after which the penetration of the remaining pitch was determined. The following results were obtained:

Distillate recovered (per cent by weight)	Specific gravity of distillate at 60° F.	Penetration at 77° F. 100 grms. at 5 secs. of pitch residue
11.3	0.903	222
18.3	0.904	231
24.4	0.906	263
34.6	0.908	184
39.1	0.908	111
		67

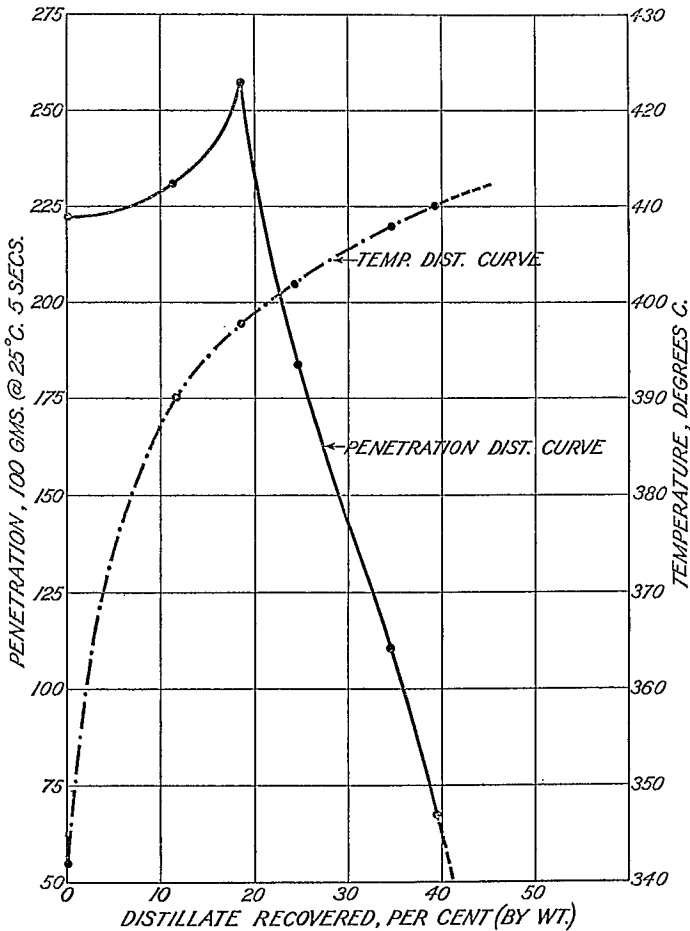
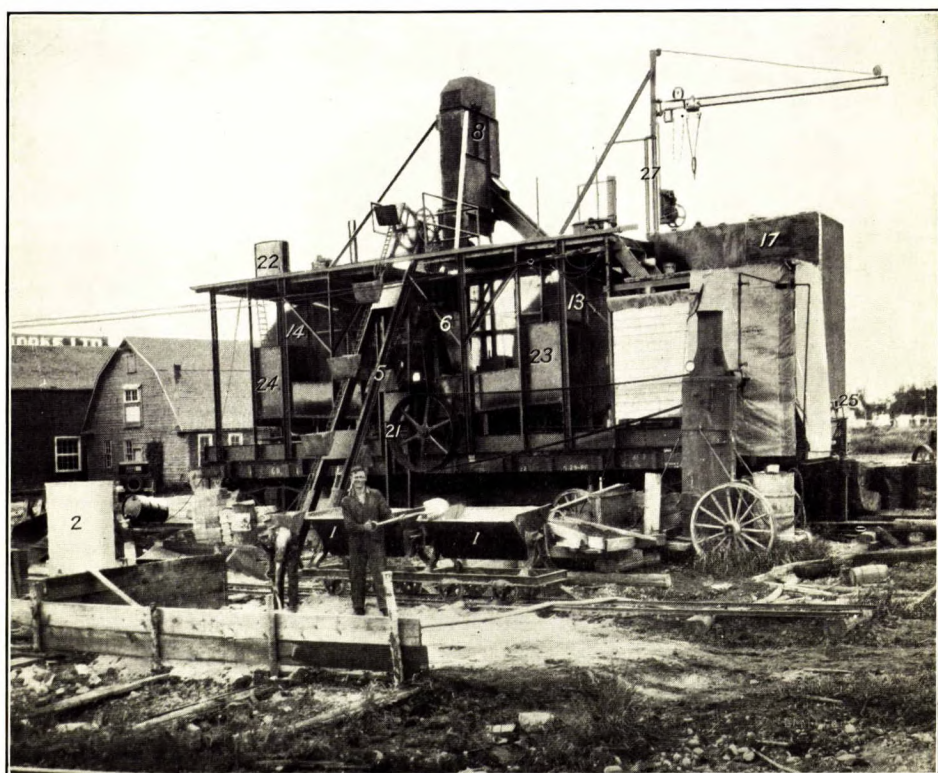
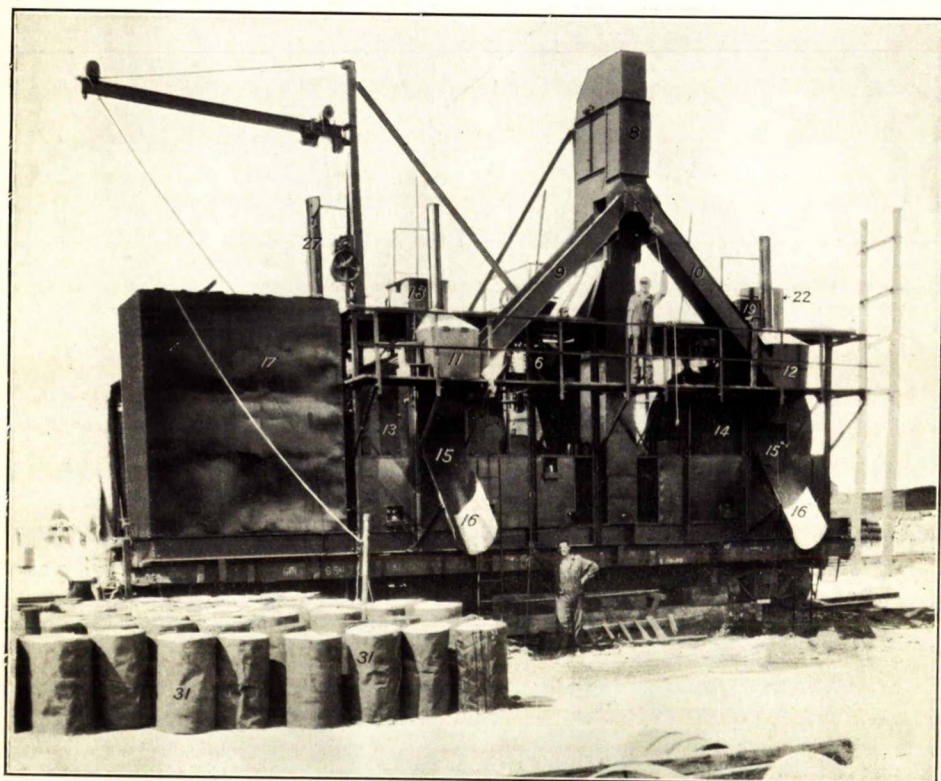


Figure 2. Distillation curve of bitumen sample.



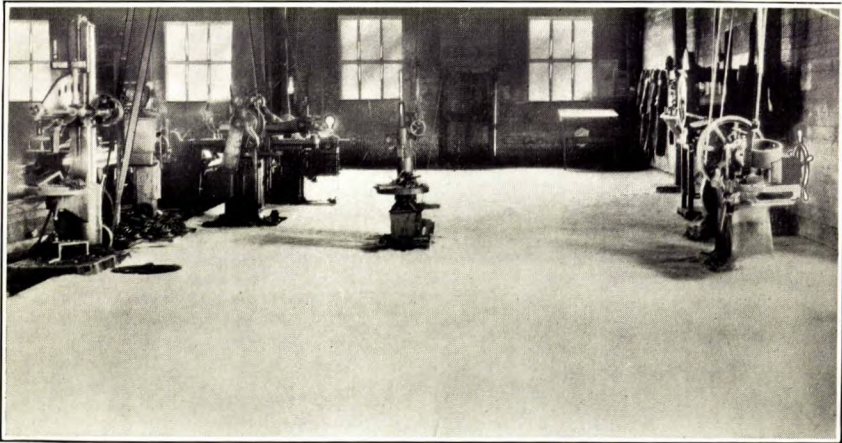
Rear view of portable, internally heated, drum-type mixing plant, showing combustion chambers and ground elevator. Built by Mines Branch at Edmonton, Alberta, 1930.



Front view of portable, internally heated, drum-type mixing plant, showing loading and discharge chutes. Built by Mines Branch at Edmonton, Alberta, 1930.



A. Corner of Mines Branch quarry, Clearwater river, Alberta, showing 17-foot face of bituminous sand. Fossil wood was encountered at elevations marked (X).



B. Shop floor of Standard Iron Works, Edmonton, covering 290 square yards. Right half surfaced with natural bituminous sand plus clean aggregate. Left half surfaced with separated bitumen plus clean aggregate.

From the graph (Figure 2) obtained by plotting the above figures, the following relation between penetration of pitch residue and amount of distillate recoverable is evident:

Penetration of 55 obtained after 42 per cent (by weight) distillate recovered.

Penetration of 100 obtained after 35 per cent (by weight) distillate recovered.

Penetration of 125 obtained after 31 per cent (by weight) distillate recovered.

Remarks. It is to be noted that the bitumen was treated without access of air and the results obtained would not apply directly where an oxidizing atmosphere is used during the removal of the distillate.

II

POSSIBLE INDUSTRIAL APPLICATIONS FOR BENTONITE

Hugh S. Spence and Margaret Light

INTRODUCTORY

In 1924, the Mines Branch published a report (No. 626¹) dealing with the character, occurrence, properties, and possible uses of bentonite. The report contained practically all the information available at that time on a little-known material, which, it appeared, might serve a wide variety of useful purposes in industry.

That bentonite has attracted considerable attention in recent years among research workers and others interested in its possible commercial applications is evidenced by the large number of patents that have been taken out since publication of the above report (many of them covering uses suggested in it), and by the literature dealing with the material that has since appeared. This interest, however, seems to have been confined principally to the United States, where the most important known deposits of bentonite are situated; and the greater number of the patents taken out, as well as most of the published literature, are American.

Investigation has shown that bentonite is of fairly widespread occurrence in western Canada; and while little in the way of systematic prospecting of likely areas, or exploration of known deposits, has as yet taken place, there is every reason to believe that beds of commercial extent and grade, favourably situated for development, exist in the Prairie Provinces and British Columbia, and that these deposits only await the creation of a market to become an important mineral resource.

Markets, of course, are the all-deciding factor governing enterprise aimed at exploitation of any natural product, and it must be admitted that, to date, efforts to create a market for Canadian bentonite have not met with conspicuous success. The Mines Branch has endeavoured to help towards this end, and was instrumental some years ago in having a quantity of Alberta bentonite shipped to Great Britain for experimental purposes. The results, however, were not such as to indicate that British industry was as yet ready to seriously consider bentonite as a raw material with important possibilities, a serious deterrent factor doubtless being the high laid-down cost due to rail and ocean freight charges.

The Branch has also sent out numerous samples of Alberta and British Columbia bentonite, in response to requests for the material. Interest in bentonite within Canada has not been conspicuous, and what little has been shown has mostly been evidenced in the West, high rail freight possibly helping to discourage consideration of using the material in the East. Consequently, the production of bentonite in Canada to date

¹ Copies of this report may be secured by application to the Director, Mines Branch, Ottawa.

has been practically negligible, although in the United States, output has shown a consistent increase. The estimated United States sales, according to official figures, amounted to 70,000 tons in 1929.

It has been thought that a list of the various patents covering the use of bentonite (including colloidal clays of similar character), as well as a bibliography of the more recent literature dealing with bentonite, might serve a useful purpose, as showing the great diversity in the field of useful applications for the material, and thereby perhaps resulting in a wider interest being aroused in its commercial possibilities. Accordingly, such a list and bibliography have been compiled and are presented, together with brief notes on the present status of the bentonite industry, in this report.

The authors wish to record their appreciation of the kind assistance given by Mr. Paul Bechtner, American Colloid Company, Chicago, in the securing of certain data used, and particularly of details relating to bentonite patents.

NATURE OF BENTONITE

Bentonite is a clay material having a somewhat greasy or waxy feel when dry and becoming exceedingly sticky when wetted. It is composed of exceedingly fine particles, of colloidal or near-colloidal dimensions, which, when dispersed in water, form suspensions that settle extremely slowly. The dry clay may absorb nearly five times its own weight of water, swelling enormously in the process, the increase in volume at full saturation ranging up to thirteen times the dry bulk.

Bentonite, itself, is not a definite mineral, but is a clay which, depending on its natural state of purity, contains varying amounts of the mineral that imparts to it its peculiar characteristics. These latter are so marked that a bentonite containing only a comparatively small amount of such mineral may be difficult to distinguish in the field from much purer material. Laboratory tests are necessary to determine the purity of crude bentonite.

The component minerals of bentonite have only recently been determined. It has been found that the clay is usually composed essentially of the mineral montmorillonite, a hydrous silicate of alumina, lime, and magnesia. This mineral is characterized by crystallization in minute flakes of micaceous form and with a high degree of cleavage. It is to these characteristics that bentonite owes its peculiar properties. To quote Ross and Shannon:¹

The peculiar micaceous habit and the easy cleavage, which is only potential in the original bentonite, but which may become actual in a slurry, result in a material that has tremendous surface area ready to exert adsorptive powers, and gives the greatest possible ratio between area and mass. The open, felted texture allows water to quickly penetrate throughout the mass so that the entire surface area of the micaceous plates is quickly covered by a film of water. This happy combination of large surface area and permeable texture gives bentonite the greatest efficiency for adsorption that nature ever seems to have devised.

Bentonite is believed to have resulted from the devitrification, usually in place, of the glassy particles of volcanic ash beds, which probably were

¹ Journ. Amer. Ceram. Soc., vol. 9, 1926, p. 86.

deposited in water. The beds, of which there may be a succession, separated by layers of sand, shale, clay, etc., often extend over large areas and sometimes attain a thickness of ten or more feet.

The name bentonite was given over thirty years ago to the clay from the type locality at Rock Creek, Wyoming. This clay was originally termed taylorite, and it is important to note that, more recently, a great variety of trade names has been used to designate the bentonitic clays of different districts. Many of these are place names, as, for example, shoshonite, amargosite, otaylite, ardmorite, elconite, etc., and, as such, logically relate only to the clay of particular districts, whereas the term bentonite is used in a wider sense to cover clays of bentonitic type generally. Other trade names, such as wilkinit, volclay, aquagel, etc., are used for the products of individual firms in the United States engaged in the production of powdered bentonite.

PRESENT INDUSTRIAL USES OF BENTONITE

As already noted, bentonite production in recent years in the United States has shown a consistent increase, the estimated sales in 1929 totalling 70,000 tons.

Owing to the considerable secrecy maintained in the trade, it is almost impossible to secure any reliable figures relating to the consumption of bentonite by industries, and it is possible that bentonite is finding useful application in a variety of directions, but about which little information is available. As far as it has been possible to ascertain, the two most important uses for bentonite at the present time are for oil refining and foundry work.

Oil Refining. For this purpose bentonites of the mountain type, (sometimes termed "sub-bentonites" or "meta-bentonites", and similar to the British Columbia clay) mined principally in California, are used almost exclusively. Clay treated before use with sulphuric acid gives the best results and is superior to fuller's earth, but untreated clay is also used. More bentonite is probably used for oil refining than for any other single use.

Foundry Work. Bentonite has found increasing application in the foundry industry, and most of the production of the prairie type of bentonite, obtained chiefly from Wyoming, is believed to be utilized in foundry work. (This type is similar to the bentonite of Alberta and Saskatchewan.) Its principal function is as a bonding ingredient to increase the strength of moulding and core sands, and it is also used as a suspending agent in core and mould washes.

Other Uses. Considerable investigation of the application of bentonite in cement, mortar, and concrete has taken place, and it is claimed that very encouraging results have been obtained by its use in improving the workability and flow of concrete, in preventing segregation before the set and in making the finished product waterproof. After oil refining and foundry work, cement and concrete probably rank as the next most important use for bentonite.

De-inking of newsprint, which some years ago showed promise of becoming an industry, and in which bentonite has been shown to have useful application, does not appear to have developed on the expected scale.

Minor uses, for which it is unofficially claimed that bentonite is now being employed, include:

As an improving bonding medium in firebrick and other refractories, asbestos cements, and insulating and acoustical plasters.

As a thickening and suspending agent in the heavy-mud system of rotary, oil-well drilling.

In the compounding of aqueous emulsions and dispersions of oils, bitumens, asphalts, resins, stearates, rubber latex, and gum chicle.

In soaps, detergents, and cleaning and polishing compounds.

As a suspending and adhesive agent in horticultural sprays, insecticides, and animal dips.

In asphaltic road, roofing and flooring materials, particularly of the cold-laying type.

For clarifying dry-cleaners' fluids.

In cosmetics, beauty-clays, antiphlogistic compounds, hoof-packing, etc.

As a thickening and suspending agent in polishes, dyes, and pastes.

In adhesives and sizes, in combination with casein, rubber latex, silicate of soda, etc.

As a suspending agent in ceramic glazes.

As an absorbent in various processes.

According to a recent article,¹ bentonite is effective in removing colloidal impurities from honey, and it is suggested that it may serve a useful purpose in the decolorizing and clarifying of low-grade honeys, as well as also improving the clarity and general appearance of the better grades of table honeys.

For most industrial uses, bentonite is required to be furnished in powdered form, and this entails provision of a grinding plant by the producer. Preliminary drying of the crude clay is required, and careful control of dryer temperatures is essential in order not to destroy the valuable properties of the material.

The principal bentonite producers in the United States are the following:

California

Commercial Minerals Company, 310 Irwin St., San Francisco.

Muroc Clay Co., 5525 Randolph St., Maywood.

Filtrol Co., 650 Spring St., Los Angeles.

General Petroleum Corporation, 1003 Higgins Bldg., Los Angeles.

Standard Oil Company of California, Standard Oil Bldg., San Francisco.

¹Lothrop, R. E., and Paine, H. S.: "Some Properties of Honey Colloids and the Removal of Colloids from Honey with Bentonite"; *Ind. Eng. Chem.*, vol. 23, No. 3, pp. 323-32 (March, 1931).

Wyoming

American Colloid Company, 608 South Dearborn St., Chicago, Ill.
(Deposits and plant at Colloid, near Upton, Wyo.)

Owyhee Chemical Products Company, Cheyenne, Wyo.
(Deposits and plant at Medicine Bow, Wyo.)

Federal Foundry Supply Company, 4600 East 71st St., Cleveland, O.
(Deposits and plant at Jerome, near Upton, Wyo.)

Silica Products Company, 700 Baltimore Ave., Kansas City, Mo.
(Deposits and plant at Osage, Wyo.)

Official figures of bentonite production in the United States, 1927-29, as given in Bureau of Mines reports, show:

	tons
1927..	34,089
1928..	66,577
1929..	69,085

Current quotations for prepared bentonite, powdered to pass 200 mesh, are about \$20 to \$25 per ton, in bags, f.o.b. Chicago.

BENTONITE IN CANADA*Occurrence*

The principal recorded occurrences of bentonite in Canada are found in Alberta, southern Saskatchewan, and British Columbia, and are noted and described in the Mines Branch report referred to on page 1. Briefly, the deposits occur as beds of Upper Cretaceous age in a belt extending southward from the Edmonton district, down the Red Deer valley, toward the southeast corner of Alberta, and thence into the Cypress hills of southwest Saskatchewan. All these occurrences carry bentonite of the more highly colloidal (prairie) type. In British Columbia, bentonite occurs in beds of Tertiary age near Princeton and Nicola, the material being of the less highly-colloidal (mountain) type. Most of the recorded occurrences are exposed naturally as surface outcrops, or in the eroded sides of river channels. A few have been uncovered in railroad cuts.

Production

Early records show that bentonite outcrops attracted attention many years ago, and that use was made of the material at Hudson Bay Company posts for washing blankets and woollens. More recently (about 1920), a bed of bentonite lying between two coal seams in the mine of the Rosedale Coal Company, at Rosedale, Alberta, aroused interest, as it was thought the clay might possibly be saved as a by-product. A few tons of this bentonite was shipped for experimental purposes to the Mines Branch, at Ottawa, and to the Imperial Mineral Resources Bureau, in London. However, it has not been found practicable to recover the material, which becomes broken up and contaminated in the mining of the coal.

Reports of the Dominion Bureau of Statistics show the only recorded production of bentonite in Canada as 30 tons in 1926 and 20 tons in 1928, this material having been mined from deposits at Princeton, B.C. It is unofficially reported that a further 132 tons was mined from these deposits during 1930. The material is understood to have been shipped to western oil refineries.

It is believed that shipments of Princeton bentonite can be furnished by the following:

B. C. Refractories, Ltd., 660 Taylor Street, Vancouver, B.C.
Francis Glover, 969 Jervis Street, Vancouver, B.C.

There is no official record of any commercial production of bentonite in Alberta or Saskatchewan. However, Claynett Distributors, Ltd., of Edmonton, Alberta (*see below*), has mined small amounts for its own use, and International Clay Products, Ltd., Estevan, Saskatchewan, has recently undertaken the exploitation of deposits in the Knollys-East End district, in southwestern Saskatchewan. The latter company reports having shipped a small tonnage in 1930 to its plant at Estevan, and that sales have been made to an oil refinery at Regina.

Consumption

Very little information is available regarding the present consumption of bentonite in Canada. Bentonite is not separately shown in the Customs records of imports, and any material brought in might enter under the general heading of clays or possibly under some trade name.

The only concern definitely known to be using bentonite is Claynett Distributors, Ltd., Jasper Avenue, Edmonton, Alberta. This firm manufactures cosmetic preparations, including tooth paste, face creams, beauty clay, paste and liquid shampoos, soaps, etc., in all of which bentonite is employed. The clay is obtained from a deposit owned by the company and located at Mile 6, on the Coalspur branch of the Canadian National Railways, just outside Jasper Park.

A detergent and scouring compound known as Mulloid, believed to contain bentonite, is put out by the Dye and Chemical Company, Ltd., of Kingston, Ont., but details of composition and manufacture of the product are withheld by the company.

Some years ago, small amounts of Alberta bentonite were used in the manufacture of stove polishing paste by a company producing graphite at Buckingham, Que., but this concern is no longer operating.

A small amount of bentonite is believed to be used by oil refineries on the Pacific coast.

It may be noted here that tests were recently conducted at the Central Experimental Farm, at Ottawa, on the efficacy of bentonite as a soil amendment (*see Canadian patents Nos. 244,187 and 259,583*). The results showed that the addition of 10 per cent of bentonite to a sand soil increased slightly the adsorptive power of the soil for ammonia and calcium. Tests to determine the moisture-conserving properties of bentonite in soils were not conclusive.

CLASSIFIED LIST OF BENTONITE PATENTS

The following is a list of patents covering the use of bentonite (and clays of similar character), as revealed by a search of the literature and of the available patent records. It is not claimed that the list is complete, the search being made difficult by the wide diversity in the possible uses, and consequently in the range of classes to be searched.

Matters are further complicated by the tendency of some patentees to avoid the use of the word "bentonite" for the material covered, employing instead such terms as "colloid clays", "hydrophilic colloids", "finely-divided siliceous earths", etc. Such a tendency is understandable, since thereby the contingent necessity of precisely defining the term bentonite is avoided, and the scope of the claims of the patent is at the same time enlarged. The wisdom of this precaution is made the more obvious when the large variety of trade names used for the bentonites of different districts, as pointed out above, is considered. A number of patents have, therefore, been included here which, while they do not relate specifically to bentonite, yet may be taken to cover clays of bentonite character. Patents in which the word bentonite is used are indicated by (B) at the end of the abstract.

Abrasives

Canadian Patents

No. 279,851, May 1, 1928, Arthur Biddle. Abrasive composition containing colloidal clay, rubber latex, and an abrasive substance.

No. 281,963, July 24, 1928, H. R. Power. Abrasive composition containing 8 parts of bentonite. (B)

United States Patents

No. 1,661,849, March 6, 1928, H. R. Power. Abrasive composition containing 8 parts of bentonite. (B)

Adhesives

Canadian Patents

No. 249,226, May 5, 1925, J. J. Harris. Adhesive material containing bentonite and water. (B)

United States Patents

No. 1,627,278, May 3, 1927, Bradley Dewey. Adhesive composition comprising colloidal clay in suspension, and rubber.

No. 1,631,265, June 7, 1927, J. J. Harris. An adhesive comprising a dispersion of bentonite, silicate of soda, water, and rubber. (B)

No. 1,498,269, June 17, 1924, J. J. Harris. An adhesive material comprising water, an adhesive base, and bentonite. (B)

No. 1,498,270, June 17, 1924, J. J. Harris. An adhesive material comprising amylaceous material, bentonite, and silicate of soda. (B)

Bonding Agents

United States Patents

- No. 1,487,057, March 18, 1924, E. Gossett.* Bonding material of bentonite, copper sulphate, and powdered iron rust; salt solution is added. (B)
- No. 1,657,573, Jan. 13, 1928, H. B. Hanley.* Moulding composition, including an unbonded sand, and bentonite. (B)
- Nos. 1,673,356 and 1,673,357, June 12, 1928, H. B. Hanley.* Core binder comprising dextrine, oil, and bentonite. (B)
- No. 1,711,136, April 30, 1929, F. G. Brotz.* Moulding composition consisting of sand, absorbent material, and a bonding agent such as bentonite. (B)

Cements, Mortars, and Plasters

Canadian Patents

- No. 187,259, Oct. 29, 1918, M. A. Popkess.* Surfacing and building compound containing finely divided earthy material having plastic and colloidal qualities.
- No. 249,251, May 5, 1925, C. E. Kraus.* Cement or mortar in which the plasticizing agent is bentonite. (B)
- No. 249,252, May 5, 1925, C. E. Kraus.* Method of imparting plasticity to cement or mortar by admixing bentonite therewith. (B)
- No. 278,510, March 13, 1928, G. M. Thomson.* Production of porous building material.

United States Patents

- No. 1,459,357, June 19, 1923, M. C. Booze.* Ceramic article formed by mixing crystalline alumina with clay, bentonite, and water. (B)
- No. 1,509,406, Sept. 23, 1924, C. E. Kraus.* Plastic composition containing bentonite. (B)
- No. 1,528,908, March 10, 1925, A. V. Bleininger.* Process of forming ceramic products from a fluid suspension containing colloidal clay.
- No. 1,554,184, Sept. 15, 1925, E. Holmes and G. J. Fink.* Production of quicksetting lime products by addition of zeolites.
- No. 1,601,295, Sept. 28, 1926, W. A. Collings.* Batch for concrete containing oiled bentonite. (B)
- No. 1,613,689, Jan. 11, 1927, C. W. Young.* Plaster-reviver consisting of bentonite calcined to destroy its colloidal properties. (B)
- No. 1,627,952, May 10, 1927, H. E. Brookby.* A plastic cementitious composition comprising hydraulic cement, finely divided clay, and lime.
- No. 1,629,714, May 24, 1927, C. E. Kraus.* Cement composition used to increase the plasticity of kaolin, clay, etc., by addition of bentonite or montmorillonite. (B)

- No. 1,666,936, April 24, 1928, Ludwig Kern.* Process of manufacturing ceramic products to which hydrated aluminium silicates and silicic acid are added.
- No. 1,670,425, May 22, 1928, E. O. Schnell.* Finishing lime formed by addition of bentonite to high calcium limestone. (B)
- No. 1,710,921, April 30, 1929, Roy Cross.* Light-weight concrete to prevent corrosion of metals in contact with walls, made by addition of bentonite. (B)
- No. 1,744,869, Jan. 28, 1930, Roy Cross.* Waterproof concrete comprising hydraulic cement, mineral aggregate, bentonite, and solid bitumen. (B)
- No. 1,747,551, Feb. 18, 1930, C. E. Kraus.* Building cement produced by roasting bentonite, treating it, and adding calcium oxide. (B)
- No. 1,755,502, April 22, 1930, W. A. Collings.* A hydraulic cement containing bentonite. (B)

Clay (Treatment of)

United States Patents

- Nos. 1,438,587 and 1,438,588, Dec. 12, 1922, W. Feldenheimer.* Treatment of clays by effecting deflocculation.
- No. 1,447,973, March 13, 1923, W. Feldenheimer and W. Plowman.* Treatment of clay by effecting deflocculation.
- No. 1,492,184, April 29, 1924, James Weir and J. C. Black.* Method of treating colloidal clay.
- No. 1,526,971, Feb. 17, 1925, W. Feldenheimer and W. Plowman.* Process for the purification of clay.
- No. 1,570,006, Jan. 19, 1926, Herman and Hugo Reinhold.* Process of treating alumina-silicate minerals of the bentonite variety. (B)
- No. 1,588,956, June 15, 1926, W. Feldenheimer.* Process of treating clays in aqueous suspension.

Detergents

British Patents

- No. 162,691, April 18, 1921, M. L. Williams and J. F. Moseley.* Improved soaps, polishes, and dressings, characterized by bentonite. (B)
- No. 197,012, May 3, 1923, C. J. Coleman.* A cleaning and polishing preparation containing bentonite. (B)

Canadian Patents

- No. 222,161, Aug. 15, 1921, W. Feldenheimer.* Manufacture of soap comprising mixing a prepared clay sol with a fluid soap.
- No. 234,937, Oct. 16, 1923, J. F. Moseley.* Detergent agent comprising oil, green acid soap, colloidal clay, and water.
- No. 253,764, Sept. 15, 1925, D. R. Kellogg.* Compound for protecting the skin, consisting of a mixture of bentonite, pure soap, and water. (B)

United States Patents

- No. 1,544,588, July 7, 1925, J. F. Moseley.* Deterative composition containing soap, a hydrogenated aromatic compound, and bentonite. (B)
- No. 1,574,733, Feb. 23, 1926, D. R. Kellogg.* Protective compound for hands, consisting of bentonite, soap, and water. (B)
- No. 1,608,418, Nov. 23, 1926, B. Payne.* Cleansing process which includes using bentonite solution. (B)
- No. 1,627,446, May 3, 1927, J. F. Moseley.* A deterative compound containing bentonite. (B)
- No. 1,709,294, April 16, 1929, J. M. Weiss and C. R. Downs.* Soap paste containing colloidal clay which has the property of swelling by absorption of water.
- No. 1,736,375, Nov. 19, 1929, S. T. Sherrick.* Cleaning composition comprising acid-treated bentonite, flour, and salt. (B)
- No. 1,738,967, Dec. 10, 1929, S. S. Sadtler.* A powdered detergent composed of bentonite, infusorial earth, and sulphonated oil. (B)
- No. 1,774,665, Sept. 2, 1930, G. O. Pierce.* Cleaning and polishing compound containing bentonite. (B)

Disinfectants

Canadian Patents

- No. 287,079, Feb. 5, 1929, W. Hiemenz.* Antiseptic and disinfectant composition of mercury, sodium carbonate, and bentonite. (B)
- No. 298,865, April 1, 1930, F. J. Funk.* Disinfectant containing bentonite. (B)

United States Patents

- No. 1,582,086, April 27, 1926, H. Schlossstein.* Antiseptic and disinfectant compound containing colloidal earth.

Dyes

Canadian Patents

- No. 238,611, March 11, 1924, W. Eberlein.* Process for dissolving basic dye-stuffs in water by means of natural or artificial aluminium silicates having base exchanging properties.

United States Patents

- No. 1,672,454, June 5, 1928, C. E. J. Goedecke.* Production of dyestuff emulsion and of colour lake therefrom by use of minerals in colloidal state, soap, glue, etc.
- No. 1,758,145, May 13, 1930, W. H. Clutterbuck.* Process for preventing the settling out of paste dyestuffs by use of bentonite. (B)

Emulsions

Canadian Patents

- No. 245,710, Dec. 30, 1924, *L. Kirschbraun*. Bituminous composition containing colloidal clay.
- No. 245,715, Dec. 30, 1924, *L. Kirschbraun*. Emulsion consisting of a suspension of water, bentonite, and bitumen. (B)
- No. 245,725, Dec. 30, 1924, *G. J. Manson*. Bituminous emulsion comprising asphalt, colloidal clay, and water.
- No. 247,469, March 10, 1925, *L. Kirschbraun*. Bituminous emulsion containing earthy colloidal material and sulphate liquor.
- No. 248,144, March 31, 1925, *L. Kirschbraun*. Road compositions containing asphalt, water, and colloidal clay.
- No. 248,852, April 21, 1925, *G. A. Henderson*. Bituminous mastic containing colloidal clay dust.
- No. 249,765, May 19, 1925, *L. Kirschbraun*. Emulsion comprising water, asphalt, and bentonite. (B)
- No. 249,766, May 19, 1925, *L. Kirschbraun*. Bituminous emulsion containing argilliferous emulsifying agents.
- No. 256,079, Dec. 8, 1925, *L. Kirschbraun*. Pavement comprising a concrete base, bitumen and colloidal clay emulsion, and coarse aggregate.
- No. 256,081, Dec. 8, 1925, *L. Kirschbraun*. Emulsion consisting of hard and soft bitumens, colloidal clay, and water.
- No. 264,216, Sept. 7, 1926, *G. W. Acheson*. Treatment of bitumen by acid and solid absorbent material such as clay.
- No. 273,833, Sept. 13, 1927, *A. Widdis*. Treatment of earth roadways, fields, etc., by spraying with water-diluted bentonite. (B)
- No. 276,936, Jan. 10, 1928, *L. Kirschbraun*. An infusible bituminous composition comprising bitumen and bentonite. (B)
- No. 279,241, April 10, 1928, *L. Kirschbraun*. Aqueous bituminous emulsion with bentonite as the dispersing agent. (B)
- No. 297,226, May 11, 1929, *J. A. Montgomerie*. Bituminous composition consisting of bitumen, water, colloidal clay, and magnesium oxide.

United States Patents

- No. 1,302,810, May 6, 1919, *L. Kirschbraun*. Bituminous composition containing a material having a substantial percentage of colloidal particles.
- No. 1,479,042, Jan. 1, 1924, *L. Kirschbraun*. Non-adhesive emulsion consisting of water, colloidal clay, and asphalt.
- No. 1,498,387, June 17, 1924, *L. Kirschbraun*. Emulsion made by mixing bentonite, water, and rubber (B)
- No. 1,517,075, Nov. 25, 1924, *L. Kirschbraun*. Process for making emulsified compositions containing colloidal particles and an emulsifying agent.

- No. 1,615,303, Jan. 25, 1927, *L. Kirschbraun*. Emulsion of fluid bitumen, clay, and water.
- Nos. 1,620,899 and 1,620,900, March 15, 1927, *L. Kirschbraun*. Bituminous composition containing bentonite. (B)
- No. 1,663,652, March 27, 1928, *H. R. Gundlach*. Manufacture of an emulsion by mixing bitumen with a colloidal suspension.
- No. 1,665,881, April 10, 1928, *E. Hutzenlaub*. Bituminous product containing an emulsifying agent.
- No. 1,679,475, Aug. 7, 1928, *L. Kirschbraun*. Process of making emulsion using bentonite. (B)
- No. 1,690,020, Oct. 30, 1928, *L. Kirschbraun*. Pavement with concrete foundation, overlain by mixture of bitumen and inert emulsifying agent.
- No. 1,725,198, Aug. 20, 1929, *L. Kirschbraun*. Fuel comprising comminuted coal, argilliferous emulsifying agent, and bitumen.
- No. 1,729,185, Sept. 24, 1929, *B. Redlich*. Preparation of emulsions by addition of a powdery substance of great absorptive power.
- No. 1,730,493, Oct. 29, 1929, *L. Kirschbraun*. Emulsion of bituminous particles, a pigment, and a colloidal clay.
- No. 1,733,494, Oct. 29, 1929, *L. Kirschbraun*. Bituminous emulsion containing a clay-like emulsifying agent.
- No. 1,738,906, Dec. 10, 1929, *L. Kirschbraun*. Bituminous composition containing bentonite as dispersive medium. (B)
- No. 1,788,706, Jan. 13, 1931, *Roy Cross*. Emulsion composition containing bentonite. (B)

Insecticides and Germicides

Canadian Patents

- No. 284,410, Oct. 30, 1928, *H. W. Banks*. Insecticide, having a bentonite base. (B)
- No. 284,411, Oct. 30, 1928, *H. W. Banks*. Colloidal fungicide containing sulphur and bentonite. (B)

United States Patents

- No. 1,550,650, Aug. 18, 1925, *H. W. Banks*. Colloidal fungicidal composition of bentonite and sulphur. (B)
- No. 1,646,149, Oct. 18, 1927, *P. R. Jones*. Insecticide emulsion of calcium caseinate, dextrine, bentonite, and black lignin liquor. (B)
- No. 1,742,472, Jan. 7, 1930, *E. C. Holton*. Parasitical compound containing pulverized bentonite. (B)

Insulating Materials

United States Patents

- No. 1,286,043, Nov. 26, 1918, *L. McCulloch*. Composite insulating material containing bentonite. (B)
- No. 1,365,331, Jan. 11, 1921, *L. McCulloch*. Electric resistance element having a coating containing boron oxide and bentonite. (B)
- No. 1,386,008, Aug. 2, 1921, *L. McCulloch*. Insulating material comprising boron, bentonite, and glycerin. (B)
- No. 1,434,133, Oct. 31, 1922, *T. G. McDougal*. Spark-plug insulator containing 3 per cent bentonite. (B)
- No. 1,741,574, Dec. 31, 1929, *C. E. Kraus*. Heat insulation material containing bentonite. (B)

Lubricants

United States Patents

- No. 1,517,577, Dec. 2, 1924, *Z. Olsson*. Lubricant composed of grease, water, and bentonite. (B)
- No. 1,739,631, Dec. 17, 1929, *Roy Cross*. Lubricating composition of petroleum oil, solid lubricant, and bentonite. (B)
- No. 1,758,265, May 13, 1930, *S. T. Sherrick*. Lubricant comprising acid-treated bentonite, water, and a lubricating oil. (B)
- No. 1,781,607, Nov. 11, 1930, *F. F. Stamberg*. Drawing lubricant comprising oil, green acid soap, colloidal clay, and water.

Paints

Canadian Patents

- No. 245,712, Dec. 30, 1924, *L. Kirschbraun*. Waterproof paint comprising a binder and aqueous suspension of colloidal clay.
- No. 292,427, Aug. 27, 1929, *A. P. Goodell and G. W. Tarr*. Water paint in which the suspension agent may be clay, asbestine, or other inert matter.

United States Patents

- No. 1,700,404, Jan. 29, 1929, *A. P. Goodell*. Water paint containing casein, lithopone, clay, and papermaker's wax.

Paper Making

Canadian Patents

- No. 222,060, Aug. 8, 1922, *H. R. Eyrich*. Bentonite used for de-inking printed paper. (B)
- No. 256,080, Dec. 8, 1925, *L. Kirschbraun*. Paper stock of an emulsion of water, colloidal clay, and a fusible waterproof base.

- No. 260,716, May 11, 1926, J. A. DeCew. Paper sizing composition containing glue, starch, or similar protective colloids.
- No. 276,092, Dec. 6, 1927, L. Kirschbraun. Use of adhesive waterproof materials containing colloidal clay for paper making.
- No. 299,971, May 6, 1930, F. W. Attack. Paper making process using an emulsion of grease solvent and bentonite to prevent deposits of pitch on machines. (B)

United States Patents

- No. 1,421,195, June 27, 1922, H. R. Eyrich. De-inking process using bentonite (B)
- No. 1,708,926, April 9, 1929, L. Kirschbraun. Treatment of fibrous stock containing bituminous base in an aqueous medium with colloidal clay.
- No. 1,746,888, Feb. 11, 1930, G. J. Esselen and R. P. Rose. Paper coated with a mixture of rubber latex, filling material, shellac, and a dispersing agent.

Petroleum Refining

Canadian Patents

- No. 89,006, Aug. 30, 1904, J. W. Warren. Method of clarifying hydrocarbon oil with Wyoming rock clay.
- No. 179,762, Oct. 16, 1917, J. Hansen. Distilling heavy oils with fuller's earth or similar material.
- No. 186,579, Sept. 17, 1918, W. A. Hall. Deodorizing and clarifying volatile organic liquids with fuller's earth or similar material.
- No. 243,297, Sept. 30, 1924, J. M. McClave. Separation of hydrocarbons from earthy matter by bentonite and sodium silicate. (B)
- No. 251,698, July 14, 1925, C. W. Stratford. Method of bleaching petroleum products with clay.
- No. 268,441, Feb. 15, 1927, A. J. Martinez. Use of untreated decolorizing clays for refining lubricating oils.
- No. 271,998, June 28, 1927, L. H. Clark. Purification of oil by an alkaline aqueous reagent, containing a colloidal substance in suspension.
- No. 271,999, June 28, 1927, H. V. Petzer. Improvement in cracking of hydrocarbons by use of fuller's earth or similar adsorbent material.
- No. 273,411, Aug. 30, 1927, T. T. Gray. Treatment of hydrocarbons with fuller's earth or other adsorbent earth.

United States Patents

- Nos. 1,408,655 and 1,408,656, March 7, 1922, C. W. Stratford. Recovery of spent clay by use of "Death Valley Clay".
- No. 1,435,972, Nov. 21, 1922, Z. Olsson. Refining element consisting of bauxite, starch, and bentonite. (B)
- No. 1,515,733, Nov. 8, 1924, Roy Cross. Refining material of highly adsorbent inorganic material combined with a metal salt.

- No. 1,544,210, June 30, 1925, *E. C. Bierce*. Process of treating colloidal clay to produce a filtering and decolorizing matter.
- No. 1,570,005, Jan. 19, 1926, *Herman and Hugo Reinbold*. Medium with a bentonite base for treating hydrocarbon compounds. (B)
- No. 1,575,945, March 9, 1926, *B. K. Stroud*. Application of mud-laden fluids to oil or gas wells.
- No. 1,587,491, June 1, 1926, *Roy Cross*. Vapours of hydrocarbon oil passed through mixture of bentonite and a metallic salt. (B)
- No. 1,591,744, July 6, 1926, *Roy Cross*. Dehydration of oils by mixing with bentonite. (B)
- No. 1,600,845, Sept. 21, 1926, *H. Reinbold*. Oil-treating composition of bentonite admixed with sodium hypochlorite. (B)
- No. 1,627,054, May 3, 1927, *J. C. Morrell and G. Egloff*. Resinous bodies and colouring material removed from oils with bentonite. (B)
- No. 1,633,871, June 28, 1927, *P. W. Prutzman*. Method of revivifying spent adsorbents for oil treatment.
- No. 1,634,514, July 5, 1927, *W. D. Rial and E. W. Gard*. Adsorbent for oils, of water-insoluble clay, sulphuric acid, and a petroleum distillate.
- No. 1,636,938, July 26, 1927, *H. L. Kauffman and I. A. Clark*. Bentonites and other altered volcanic ashes for decolorizing and clarifying petroleum oils. (B)
- Nos. 1,638,643 and 1,638,644, Aug. 9, 1927, *H. Schlosstein*. Bentonite base used in medium for treatment of oils. (B)
- No. 1,639,274, Aug. 16, 1927, *W. D. Rial and E. W. Gard*. Colloidal clay used in preparation of adsorbent for oils.
- No. 1,649,366, Nov. 15, 1927, *J. S. Potter*. Method of treating clays to adapt them for decolorizing and deodorizing oils.
- No. 1,667,984, May 1, 1928, *P. W. Prutzman*. Method of purifying and decolorizing oils with various types of clays.
- No. 1,682,369, Aug. 28, 1928, *J. M. Cory and F. H. Bunke*. Spent clay treated with colloidal clay, montmorillonite, etc.
- No. 1,684,035, Sept. 11, 1928, *H. L. Kauffman and I. A. Clark*. Bentonite and similar clays used to decolorize and deodorize petroleum oils. (B)
- No. 1,690,772, Nov. 6, 1928, *T. G. Delbridge*. Treatment of mineral oils with finely divided clay.
- No. 1,695,198, Dec. 11, 1928, *D. R. Merrill*. Fuller's earth and clay used for clarifying, decolorizing, and neutralizing oils.
- No. 1,696,338, Dec. 25, 1928, *H. E. Bierce*. Adsorbent earth used for decolorizing oils.
- No. 1,700,479, Jan. 29, 1929, *F. W. Hall*. Treatment of hydrocarbon oils with clays.
- Nos. 1,705,824 and 1,705,825, March 19, 1929, *H. Odeen*. Process of refining oils with clay of various grades.
- No. 1,706,614, March 26, 1929, *L. M. Johnson and J. L. Farrell*. Treatment of hydrocarbon oil with bentonite. (B)

- No. 1,709,203, April 16, 1929, J. C. Black, W. D. Rial, and R. T. Howes. Purification of petroleum oils with caustic soda, calcium hydroxide, and adsorbent clay.
- No. 1,716,828, June 11, 1929, J. C. Merrill and H. S. Montgomery. Preparation of clarifying agents, such as aluminium silicate clay.
- No. 1,744,843, Jan. 28, 1930, H. F. Taylor. Process of bleaching vegetable oils with clays and sulphuric acid.
- No. 1,749,976, March 11, 1930, R. B. Hill. Refining of edible oils with sulphuric acid and bentonite. (B)
- No. 1,760,585, May 27, 1930, Roy Cross. Treating hydrocarbons with bentonite. (B)
- No. 1,776,990, Sept. 30, 1930, W. S. Bayliss. Preparation of activated bentonite for oil purification. (B)
- No. 1,781,265, Nov. 11, 1930, W. S. Bayliss. Process for making a decolorizing clay from activatable colloidal clay.
- No. 1,788,653, Jan. 13, 1931, W. S. Bayliss. Process of treating crude oil having a tar and asphalt content, with bentonite. (B)

Refractories

United States Patents

- No. 1,442,413, Jan. 16, 1923, Z. Olsson. Refractory material comprising bauxite and bentonite. (B)
- No. 1,509,478, Sept. 23, 1924, C. E. Kraus. Refractory material containing bentonite. (B)
- No. 1,787,964, Jan. 6, 1931, B. F. Wallace. Foundry facing composition containing bentonite. (B)

Rubber

Canadian Patents

- No. 213,300, Sept. 13, 1921, P. Schidrowitz, W. Feldenheim, and W. W. Plowman. Preparation of clay for incorporation in rubber.
- No. 254,811, Oct. 20, 1925, E. Hopkinson and M. C. Teague. Process of treating rubber latex with colloidal clay, etc.
- No. 263,237, Aug. 3, 1926, W. B. Pratt. Colloidal clay dispersion agent for crude rubber in water.
- No. 264,862, Oct. 5, 1926, E. C. Crocker. Sealing composition of latex emulsion and bentonite. (B)

United States Patents

- No. 1,632,759, June 14, 1927, E. Hopkinson and W. A. Gibbons. Treatment of rubber latex with clays.
- No. 1,736,404, Nov. 19, 1929, E. Hopkinson and M. C. Teague. Treatment of rubber latex compositions with colloidal clay.
- No. 1,744,844, Jan. 28, 1930, H. L. Trumbull. Rubber isomer dispersed in aqueous medium of bentonite, glue, or the like. (B)
- No. 1,745,084, Jan. 28, 1930, B. Dewey and E. C. Crocker. Rubber latex cement containing bentonite. (B)

Soil Preparations

Canadian Patents

- No. 244,187, Nov. 4, 1924, A. Widdis. Bentonite mixed with soils. (B)
 No. 259,583, April 6, 1926, A. Widdis. Soil impregnated with bentonite emulsion. (B)

United States Patents

- No. 1,518,565, Dec. 9, 1924, A. H. Cowles. Fertilizer containing hydrated silica. See also patents Nos. 1,518,566-1,518,571 inclusive

Suspensions and Dispersions

British Patents

- No. 203,720, Sept. 10, 1923, J. F. Moseley. Colloidal dispersions containing bentonite. (B)

United States Patents

- Nos. 1,733,495; 1,733,496; 1,733,497; 1,733,498, Oct. 29, 1929, L. Kirschbraun. Aqueous dispersions containing bentonite. (B)
 No. 1,734,437, Nov. 5, 1929, L. Kirschbraun. Production of aqueous dispersions with bentonite as dispersive agent. (B)
 No. 1,737,006, Nov. 26, 1929, C. Ellis. Suspension composition containing metallic soap and bentonite. (B)
 No. 1,738,776, Dec. 10, 1929, L. Kirschbraun. Aqueous dispersions containing clay in "gelled" form.
 No. 1,759,913, May 27, 1930, F. R. Moser. Increasing the stability of aqueous dispersions.

Textile Manufacture

British Patents

- No. 226,850, Dec. 24, 1924, J. F. Moseley. Textile finishing solution containing bentonite. (B)

Canadian Patents

- Nos. 245,713 and 245,714, Dec. 30, 1924, L. Kirschbraun. Colloidal clay used in manufacture of felted fibrous composition.
 No. 263,333, Aug. 10, 1926, J. F. Moseley. Bentonite added to finishing bath for textile fabrics. (B)

United States Patents

- No. 1,554,919, Sept. 22, 1925, J. F. Moseley. Finishing composition for textiles containing bentonite. (B)
 No. 1,577,450, March 23, 1926, C. H. Crowell. Coating composition containing bentonite. (B)
 No. 1,671,856, May 29, 1928, H. V. Dunham. Coated book cloth of casein, borax, and bentonite. (B)
 No. 1,732,729, R. A. Phair and B. Bucaria. Improvement in laundering textile fabrics.

Waterproof Compositions

Canadian Patents

- No. 226,168, Nov. 21, 1922, *L. Kirschbraun*. Waterproof composition containing colloidal clay.
- Nos. 248,219 and 248,220, March 31, 1925, *L. Kirschbraun*. Waterproof composition containing colloidal clay.
- No. 260,604, May 11, 1926, *L. Kirschbraun*. Waterproof rubber sheets treated with paste of colloidal clay.
- No. 280,263, May 22, 1928, *W. A. Collings*. Waterproof plastic containing bentonite and Portland cement. (B)

United States Patents

- No. 1,479,043, Jan. 1, 1924, *L. Kirschbraun*. Waterproof sheet containing bentonite. (B)
- No. 1,489,254, April 8, 1924, *L. Kirschbraun*. Coated waterproof sheeting comprising a bituminous binder, fibre, and an emulsifying agent.
- No. 1,624,088, April 12, 1927, *A. Biddle*. Sealing composition or metal lacquer containing bentonite. (B).
- No. 1,650,864, re-issue No. 17,207, Feb. 5, 1929, *O. A. Collings*. Waterproof concrete made by admixing bentonite with other materials. (B)
- No. 1,670,844, May 22, 1928, *R. R. Cone*. Waterproofing composition containing colloidal clay.
- No. 1,708,927, April 9, 1929, *L. Kirschbraun*. Waterproof composition containing bitumen, protective coating material, and fibrous stock.
- No. 1,714,702, May 28, 1929, *W. B. Van Arsdell*. Waterproofing composition of matter containing 20 per cent of bentonite. (B)
- No. 1,738,509, Dec. 3, 1929, *L. Kirschbraun*. Waterproof sheet containing colloidal clay.

Water Softeners

Canadian Patents

- No. 174,312, Jan. 2, 1917, *G. H. Widner*. Water softener of hydrated silicate of aluminium.
- No. 177,857, June 26, 1917, *G. H. Widner*. Water-softening material from natural clay.
- No. 210,230, April 5, 1921, *R. Gans*. Zeolites or hydrated alumino silicates used for softening of water.
- No. 213,073, Aug. 23, 1921, *W. R. Snell*. Plastic clay having base exchange properties prepared for softening water.
- Nos. 254,220; 254,221; 254,222, Sept. 29, 1925, *C. H. Nordell*. Zeolites used for softening water.
- No. 258,561, March 2, 1926, *J. B. Wherry*. Preparation of natural clay for use as exchange silicates.

- No. 258,614, March 2, 1926, T. R. Duggan. Purification and softening of water by exchange silicates.
- No. 278,215, Feb. 29, 1928, O. W. Johnson. Water softener of zeolite material.
- Nos. 285,044; 285,045, Nov. 20, 1928, R. G. Tellier. Water-softening material prepared from natural clay.
- No. 289,228, April 30, 1929, J. B. Wherry. Water-softening material made from natural clay-like exchange silicate.

United States Patents

- No. 1,192,075, July 25, 1916, H. Kriegsheim. Purification of water by use of exchange silicates.
- No. 1,202,557, Oct. 24, 1916, C. Massaciu and A. Neuman. Amorphous material of igneous origin as water softener.
- No. 1,348,977, Aug. 10, 1920, G. L. Borrowman. Natural base exchange silicate prepared for water softener.
- No. 1,388,133, Aug. 16, 1921, J. B. Wherry. Manufacture of water-softening material from natural clay.
- No. 1,586,764, June 1, 1926, H. F. Wheaton. Double base exchange silicate and process of making it.
- No. 1,636,942, July 26, 1927, G. W. Prather. Preparation of water-softening material from hydrated silicate of aluminium.
- No. 1,642,880, Sept. 20, 1927, H. Kriegsheim. Manufacture of precipitated zeolites.
- No. 1,646,596, Oct. 25, 1927, H. Reinbold. Bentonite as a medium for treatment of water. (B)
- No. 1,659,023, Feb. 14, 1928, R. O. Friend and M. Kullander. Zeolitic water-softening mineral, and apparatus.
- No. 1,675,860, July 3, 1928, A. Neuman. Zeolite filter for softening water.
- No. 1,707,302, April 2, 1929, H. M. Godsey. Zeolitic material and process for use in softening water.

Miscellaneous

Canadian Patents

- No. 238,632, March 18, 1924, P. S. Brown. Medicinal and toilet paste containing bentonite. (B)
- No. 244,108, Nov. 4, 1924, A. de Waele. Stencil sheet comprising bentonite, an organic colloid, and oily substance. (B)
- No. 245,096, Dec. 9, 1924, G. J. Manson. Rosin size containing rosin, colloidal clay, and alkali.
- No. 278,247, March 6, 1928, G. F. Blombery. Seam sealing and lining composition for metal cans, containing colloidal clay.

United States Patents

- No. 1,479,044, Jan. 1, 1924, L. Kirschbraun. Composite board made from bitumen, water emulsion, fibre, and infusorial earth.
- No. 1,505,251, Aug. 19, 1924, A. F. French. Filler composition of graphite, fuller's earth, gum, and turpentine.

- No. 1,659,401, Feb. 14, 1928, *L. Kirschbraun*. Recovery of waste fibrous materials by treatment of stock with bentonite. (B)
- No. 1,668,608, May 8, 1928, *E. O. Schnell*. Hair-treating composition, containing bentonite. (B)
- No. 1,675,977, July 3, 1928, *S. Imori and K. Suzuki*. Production of solvent oil by use of absorbents, such as acid earth, fuller's earth, etc.
- No. 1,681,921, Aug. 28, 1928, *J. Bjorkstedt*. Treatment of aluminium-containing minerals such as clay, green sand, bauxite, etc.
- No. 1,684,565, Sept. 18, 1928, *C. C. Waller*. Production of copper coatings on metallic plates by use of fibrous blank, copper sulphate, hydrous aluminium silicate, and gum arabic.
- No. 1,699,694, Jan. 22, 1929, *C. Ellis*. Sulphur composition containing bentonite. (B)
- No. 1,739,796, Dec. 17, 1929, *P. Mahler*. Process of bleaching beeswax with charcoal and a non-colloidal bentonite. (B)
- No. 1,748,787, Feb. 25, 1930, *H. S. Mork*. Method of identifying fuel and products thereof by means of clay (dye adsorption).
- No. 1,755,496, April 22, 1930, *A. S. Behrman*. Preparation of siliceous materials by means of silica gels.
- No. 1,765,134, June 17, 1930, *B. Dewey and G. C. Crocker*. Sealing composition containing bentonite. (B)

APPENDIX

The following twelve additional and unclassified United States Patents were traced after this report had gone into page proof.

United States Patents

- No. 1,766,211, June 24, 1930, *W. S. Bayliss*. Process of treating gasoline with a decolorizing clay and anhydrous sulphuric acid.
- No. 1,777,160, Sept. 30, 1930, *A. Biddle*. Albuminous adhesive composition containing colloidal clay.
- Nos. 1,777,161 and 1,777,162, Sept. 30, 1930, *A. Biddle*. Adhesive water-resisting composition containing bentonite. (B)
- No. 1,783,366, Dec. 2, 1930, *R. W. Lewis*. Method of dispersing bitumen with aluminium hydroxide paste, clay, and water.
- No. 1,787,425, Jan. 6, 1931, *A. B. Callaghan*. Coating composition including clay.
- No. 1,788,653, Jan. 13, 1931, *W. S. Bayliss*. Process for refining lubricating oil with adsorbent clay.
- No. 1,790,272, Jan. 27, 1931, *E. L. Leasman*. Colloid consisting of sodium phosphate and bentonite. (B)
- No. 1,792,625, Feb. 17, 1931, *W. S. Bayliss*. Decolorizing material consisting of clay and anhydrous sulphuric acid.
- No. 1,793,918, Feb. 24, 1931, *J. M. Fain*. Dispersion containing bentonite. (B)
- No. 1,793,957, Feb. 24, 1931, *R. K. Painter*. Method of emulsifying asphalt with colloidal clay.
- No. 1,795,011, March 3, 1931, *Roy Cross*. Moulding composition of bentonite and finely divided inert material. (B)

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 "Triassic Bentonite of the Painted Desert"; Am. Jour. Sci., 5th series, vol. 19, pp. 283-288 (April, 1930).
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- Fellows, R. O.: "Bentonite in South Dakota"; Eng. & Min. Jour.-Press, vol. 122, p. 182 (1926).
- Grim, R. E.: "Bentonite in Mississippi"; Mississippi Geol. Surv. Bull. 22, 14 pp. (1928).
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 "Beloit Formation and Bentonite"; Pan. Am. Geol., vol. 45, pp. 383-92 (1926).
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III

PETROLEUM AND NATURAL GAS IN EASTERN CANADA

E. H. Wait

Previous to the year 1924 the chief production of petroleum and natural gas in Canada came from Ontario and New Brunswick, but chiefly Ontario. However, with the bringing in of the Royalite No. 4 well in the Turner Valley in 1924 and the subsequent expansion of that field, as well as the Wainwright and the Red Coulee fields, Alberta has taken the lead in the production of both petroleum and natural gas. A glance at the figures of production of petroleum and natural gas, given below, for the year 1929 and the first six months of 1930, furnishes a comparison between the production of eastern Canada as represented by New Brunswick and Ontario, and western Canada as represented by Alberta:—

Petroleum			Natural Gas		
	1929	1930 (6 mos.)		1929	1930 (6 mos.)
	bbl.	bbl.		M cu. ft.	M cu. ft.
New Brunswick.....	7,499	3,696	New Brunswick.....	678,456	428,874
Ontario.....	121,194	55,041	Ontario.....	8,586,475	4,717,000
Alberta.....	988,675	581,147	Alberta.....	19,112,931	10,782,571
Total for Canada.....	1,117,368	639,884	Total for Canada....	28,377,862	15,928,445

The above figures show that in the first six months of 1930, Ontario and New Brunswick together contributed less than 10 per cent of the production of petroleum in Canada, and about $33\frac{1}{3}$ per cent of the natural gas production.

Since 1881 records have been kept of petroleum production by provinces in Canada. Up to 1910, Ontario was the only producer but in that year New Brunswick started the production. In 1914 the first oil production from Alberta was recorded, but it was not until in 1925 that Alberta took the lead from Ontario; a lead that has been kept ever since the wells in the Turner Valley started production.

Figures of natural gas production date from 1892, and Ontario was the only producer up to 1903. In 1903 Alberta's first production of natural gas is recorded. In 1912 New Brunswick started production from the Stony Creek field near Moncton and although the field has not been so large a producer as the Ontario fields where, in 1929, there was close to 2,400 producing gas wells, the production has been fairly steady.

PETROLEUM

In New Brunswick the production of petroleum has been confined to the Stony Creek field, about 9 miles southeast of Moncton. Both oil and natural gas are obtained from the Albert shale series at depths varying from 2,000 to 3,500 feet. The oil obtained is of a clear dark green colour, about 39° Baumé. The oil wells which number about 23, are pumped as the occasion demands and the oil stored in tanks until disposed of. The operating company, The New Brunswick Gas and Oilfields, Ltd., hope eventually to erect their own refinery at the property as the oil is a high-grade crude, and capable of yielding many valuable by-products for which there is a constant demand.

In the province of Quebec investigations have been carried on in various localities with the purpose of establishing a commercial supply of petroleum, but, up to date, no important discoveries have been made. Numerous wells have been sunk in the Gaspé peninsula and small showings of oil obtained; also several wells have been drilled north and south of the St. Lawrence river between Montreal and Quebec and in the vicinity of St. Hyacinthe. The Annual Report of the Quebec Bureau of Mines for the calendar year 1929, includes as Part B a "Report on the Oil and Gas Resources of the Province of Quebec"; this is a resumé and record of the work done in the early days in the province in the search for commercial supplies of oil and gas.

Ontario's production of petroleum dates back to 1861, when the Oil Springs field started production. The original discovery of oil in Canada was at the present village of Oil Springs, in Lambton county, where, as early as 1858, wells had been dug to shallow depths and a heavy oil recovered. The Oil Springs field, together with the adjoining Petrolia field, has been Ontario's chief source of production, and in 1929 both fields together produced 86,000 barrels. As stated previously Ontario held the supremacy in oil production in Canada up to the year 1924. Although the production of petroleum from these old fields in Ontario shows a gradual falling off each year, by careful attention to upkeep, the wells will continue to produce for many years. The Dominion Government passed an act in 1904, providing for the payment of a bounty of one and one-half cents per Imperial gallon on all crude petroleum produced from wells in Canada. This act was in effect until July 1925 and many of the smaller producers in Ontario found it an incentive to keep their wells on the pump during most of the year. Since the removal of the bounty, and also due probably to the low prices obtained for crude oil during the past few years, the production of crude oil in Ontario is gradually falling off each year. The peak of production was reached in the year 1907, when it amounted to 788,872 barrels, but twenty years later, in 1927, the production had fallen off to only 139,606 barrels. The average price received per barrel in 1929 was \$2.09.

Refineries

Although Canada was one of the world's earliest oil producing countries, it is to-day one of the largest oil importing countries, importing about 96 per cent of her oil requirements. Canada is also one of the world's largest users of automotive transport and the demand for gasoline is increasing annually. In 1929 Canada imported 175,151,570 Imperial gallons of gasoline and produced 436,620,614 gallons from refineries in Canada. There are seven refineries in eastern Canada distributed in the following localities: Halifax, Montreal, Toronto, Petrolia, and Sarnia. The bulk of the crude oil treated in the refineries is imported from foreign countries in the following proportions: United States—68 per cent, Colombia—19 per cent, Peru—9 per cent, and the balance from Venezuela, Mexico, Ecuador, etc.

The refinery at Sarnia is the largest in Canada and besides treating imported crudes, also handles the relatively small production from the Petrolia and Oil Springs fields.

NATURAL GAS

The New Brunswick production of natural gas comes from the wells in the Stony Creek field near Moncton. The city of Moncton and the town of Hillsboro have had their domestic and industrial requirements supplied from this source since 1912. These two localities are the only ones supplied and hence the production figure has remained fairly constant. New wells are drilled or old ones are deepened when the supply diminishes in the upper sands, and thus the figure of production has remained practically constant in recent years.

In the province of Quebec, during 1930, two companies were engaged in drilling for oil or gas, in the vicinity of Lanoraie, Joliette county. In this locality and in the adjacent county of Berthier, wells had been drilled in the early days by the farmers to supply gas for their own use. These wells were shallow and had only a short life. One company, between the years 1905 and 1907, put down several wells in the vicinity of Louiseville and were able to supply natural gas to several villages and also piped its product to Three Rivers. The supply of gas, however, was soon exhausted and the company ceased operations in 1908. The present drilling by interests at Lanoraie, is being done in the hope that a commercial supply of gas may be found at greater depths and one of the companies has drilled three wells in all of which a gas pressure was struck at around 200 feet. Two of the wells were capped and the third is being drilled to greater depths.

In Ontario, the chief producing gas fields are located in Kent, Essex, Welland, Haldimand, Norfolk, and Lambton counties. The peak production in Ontario was obtained in 1917, when over 19 million cubic feet was obtained. Since 1921, the production has been around 8 million cubic feet per year. This fairly constant production has been maintained, due to the systematic examination and repairing of the older wells by the large gas distributing companies. Good operating conditions have also been maintained by enlarging the pipe-lines and extending new lines to

provide for better and more flexible distribution. The objectionable sulphur content of the Tilbury gas has been eliminated since the scrubbing plants using the Koppers process were erected at Port Alma and Glenwood in 1925. New wells are being drilled each year in the various gas fields of the province to offset the falling off in production from the older wells. During 1930 considerable drilling of new wells took place in Tuscarora township, Brant county, and over thirty wells have been brought in at depths around 450 feet. These wells will be tied into the main supply line which supplies the city of Brantford, and the surrounding towns. The two largest distributors and producers of natural gas in the province, The Dominion Natural Gas Co., Ltd. and the Union Natural Gas Co. of Canada, Ltd., have both recently taken steps to acquire a supply of artificial (coal) gas for the purpose of mixing with the natural gas and so augment and extend the present supply of natural gas for many years. This supply of manufactured gas will be supplied by two companies in Hamilton, who have coke ovens in operation, and it will only be necessary to erect a mixing plant and lay short pipe-lines from the coke ovens and mixing plant to the present main natural gas lines. This move will result in not only conserving the natural gas supply in Ontario but will result in the greater use of coal at these coke ovens and the consequent enlargement of the ovens to meet the increased demand. At the present time, artificial gas is being imported into Ontario from the United States to augment the natural gas supply of the Ontario fields, however when the present plans of the two natural gas companies are put into effect, it will not be necessary for Ontario to import gas from across the border.

IV

DIATOMITE*

V. L. Eardley-Wilmot

Diatomite as prepared for the market is a fluffy, white powder, remarkably light in weight—it weighs only 10 to 15 pounds per cubic foot, or one-tenth as much as sand. Being extremely porous and inert, it is in large and increasing demand for insulation and filtration purposes, as a general filler, and for many other uses.

STRUCTURE

Structurally, diatomite is quite different from any other known commercial material. It is composed of myriads of microscopically small, siliceous shells of diatoms which belong to a group of flowerless aquatic plants called *algæ*. When these plants die, the siliceous remains sink to the bottom of the water and form beds of diatomite. Over 8,000 species of diatoms are known, named, and tabulated. The intricate scroll-work and patterns on many of these are one of the marvels of nature, and yet so small are they that from 40 to 70 million separate diatoms may be contained in one cubic inch of material. However, the size and shape of these diatoms, which vary greatly (*see* Plate IV), have an important bearing on the commercial use of the diatomite.

The diatoms in the majority of the known deposits are so typical of that deposit that, after a micro-examination, an expert can usually tell not only from what part of the world, but also from what particular deposit, the sample has come.

TYPES OF DIATOMITE

Diatomite may be of either marine or freshwater origin. Marine diatomite usually occurs as a dry, white material having the appearance of chalk, and in some places is present as beds many hundreds of feet in thickness. These beds may be comparatively hard and blocky or finely laminated and soft. There are two main classes of freshwater diatomite deposits. Those typical of the western American continent are of Tertiary age, are compact, and white to buff in colour, and, like the western marine deposits, they are remote from the waters of their original deposition. Recent deposits typical of the eastern part of the continent vary very considerably in appearance, owing mainly to the large amount of included plants, roots, peat, and other vegetable matter; they are found either under water or in swamps. In the majority of these freshwater occurrences, the diatomite occurs as a grey or brown peat; in some, as a dark brown to almost black mud; while in others, it is white or buff coloured. Consequently, it is sometimes difficult to identify the material as diatomaceous. However, after burning out the carbonaceous matter, a fluffy white (or, if iron is present, pink) powder, composed of diatoms, remains.

No marine diatomite deposits are known in Canada, and the dry compact freshwater Tertiary material appears to be confined to British Columbia.

*This article was presented at the annual meeting of the Canadian Institute of Mining and Metallurgy, March, 1931, in advance of publication.

COMPOSITION

Diatomite is a form of hydrous silica and when chemically pure contains 96 per cent silica and 4 per cent combined water, but material of this purity is not found in nature as it always contains varying proportions of iron, alumina, lime, magnesia, carbonaceous matter, and other impurities. The moisture content of even the driest compact material 'in place' is seldom less than 15 per cent, and is usually double this amount. The analyses of many impure diatomites show a high silica content due to admixed mineral silica (sand or silt, etc.), but it is of great importance commercially that the silica be in the form of diatom silica and not as sand. A few analyses of diatomite from various parts of the world are given in Table I.

COMMERCIAL DIATOMITES

The size and shape of the diatoms (which vary considerably), and to some extent their toughness, play a highly important part in the ultimate uses of diatomite in the industries. It so happens that the major production has come from deposits of marine origin, and research work also has been mainly confined to these. As a result, it appears to be generally concluded that such deposits are the most suitable commercially. Doubtless this opinion is largely a matter of prejudice and equally good and, for some uses, better results can be obtained with the freshwater types.

Attempts have been made to determine the standard requirements of good commercial diatomite, but as these vary according to the purposes for which the material is to be used, careful research in comparing different types of diatomite with one another must be done. As yet little, if any, work has been carried out along these lines; at least, no results appear to have been published. Moreover, the importance of structural and physical conditions of the diatomites have not been sufficiently stressed. Chemical analysis is a guide, but is not conclusive. Diatomite should, however, contain for most purposes at least 80 per cent diatom silica and be free from grit and non-diatom silica, low in iron, lime, and alumina, and contain a large proportion of clean, unbroken diatoms. The iron content can be approximately determined by calcination of the salt-free material, since, from about 0.3 per cent iron upwards, the colour ranges from pale pink to brick-red; below this it is white, unless manganese is present. The microscope is the first and most important means of determining the quality and most suitable uses for a diatomite, followed by calcination and substantiated by a chemical analysis. With practice, the proportion and coarseness of grit, if present, can be approximately determined by its feel between the teeth, or more accurately by examination under the microscope in polarized light.

USES

Although diatomite has many and varied uses, its three major ones, which in the United States account for over 75 per cent of the total consumption of diatomite, are: as a heat and sound insulator; as a filter medium; and as an admixture in concrete.

On account of its relatively low thermal conductivity and its great porosity, due to its myriads of enclosed air cells, diatomite is an effective insulator against the passage of heat and sound. It has few, if any, equals in this respect and has the advantage of being absolutely fireproof. It is efficient over a wide range of temperature, and particularly so at the higher temperatures at which other materials break down. The thermal efficiency of different diatomites, however, varies according to their density and diatom structure. The material is used as a loose powder; as pea-sized aggregates; in the form of natural or manufactured bricks and slabs; or mixed with a fibrous binder, such as asbestos. Its field of application ranges from household furnaces, water pipes, boilers, etc., up to furnaces used in the manufacture of steel and in the smelting industry; in fact, in any place where heat can be economically conserved. Recently, the largest diatomite producer in the world (the Celite Company, Los Angeles, Cal.) passed into the hands of the Johns-Manville Corporation, manufacturers of asbestos insulating materials. This circumstance is significant as indicating the trend towards the greater use of diatomite in high-temperature insulation.

In the filtering of certain solutions, diatomite is now recognized as one of the best media for accomplishing rapid and clear filtration. It is rarely used alone, but as a filter-aid in conjunction with ordinary filters or presses, the cloths or plates of which, after a short period of operation, act as a backing or retainer for the diatomite. The usual practice in large-scale operations for filtering many liquids is to 'pre-coat' the filter cloths with a layer of diatomite. During circulation of the liquids, the diatomite builds up on the cloth and thus forms a protecting coat of an open, sponge-like structure. There is greater variation in the effectiveness of different types of diatomite when employed as a filtering medium than in any other of its uses. The most efficient diatoms appear to be the round, or oval-shaped, types of varying sizes, with a predominance of long, thin needle-shaped or hair-like frustules. Those containing badly broken, or an excess of small equal-sized, diatoms do not filter efficiently. The material must also be light in weight, and as free as possible from sand, iron, alumina, colloidal matter, and other impurities. The filtering properties are improved by calcination with a small proportion of certain salts or alkalis.

TABLE I
Analyses of Diatomite

No.	Location	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	H ₂ O at 105°C.	CO ₂ + Organic	Total
1	Canada, B.C., Powell river.....	90.64	1.57	0.98	1.28	0.29	4.30	0.57	99.63
2	" B.C., Quesnel, Big Bend.....	86.60	3.76	1.74	0.30	1.05	3.42	1.93	98.80
3	" N.S., Rhude pond ¹	93.70	0.85	0.05	0.50	n.d.	4.80	.....	99.90
4	" N.S., Trout lake.....	80.00	6.43	0.47	0.39	0.44	n.d.	11.88*	99.61
5	" N.S., Digby Neck ¹	94.11	2.04	1.55	0.86	0.28	0.14	0.42	99.40
6	" N.B., Pollet lake.....	82.62	5.43	0.67	0.39	0.73	n.d.	10.58*	100.42
7	" Ont., Spence lake ¹	87.46	6.94	1.46	1.88	0.91	n.d.	1.60	100.25
8	U.S.A., Cal., Lompoc.....	86.24	3.05	1.02	0.18	0.63	5.62	1.20	97.96
9	" Ore., Terrebonne.....	86.74	4.64	1.46	0.85	0.37	5.80	0.40	100.28
10	" Wash., Kittitas.....	86.60	2.62	2.58	0.57	0.56	5.08	0.12	98.13
11	" Nev., Carlin.....	81.13	7.42	3.03	1.79	0.31	4.86	0.62	99.16
							K ₂ O Na ₂ O		
12	" Md., Popes Creek.....	81.53	3.43	3.34	2.61	.....	1.16 1.43	6.04	99.54
13	Prussia, Oberohe.....	87.86	0.13	0.73	0.42	.....	.....	10.71	99.85
14	Ireland, Antrim, River Bann.....	73.01	8.55	2.09	1.14	0.83	0.28	14.10	100.00
15	Australia, N.S.W., Bugaldi, Warrumbungle Ranges.....	82.22	2.43	1.27	0.28	0.53	0.46 0.38	11.70	99.27

¹Calcined. All remainder are crude material,

*Total loss on ignition and includes combined water.

The filtering of sugar solutions by means of diatomite has now become almost universal on the American continent. Diatomite is also used for the filtering of many other liquids, such as oils, varnish, cereal beverages, emulsions, soaps, wines, etc.

The use of diatomite as an admixture in concrete has, in the past few years, made proportionately greater strides than any of its other applications, and now constitutes about 25 per cent of the total United States consumption. Its advantages are still doubted by some contractors, but this doubt is being dispelled as large-scale utilization and practical tests by reliable authorities are continually proving the value of this addition agent. Several factors, however, must be considered, such as the richness or leanness of the mix, quality of the cement, and the types of diatomite added. Its main advantages are increased workability and decreased tendency of the concrete to segregate. Other minor advantages are increased strength, yield, and watertightness. The latter results are more marked with the leaner mixes and with the poorer qualities of cement. Laboratory experiments comparing different diatomites under similar conditions have shown variations, and determination of the ideal type is a subject of further research. The marine diatomite from Lompoc, Cal., upon which specifications are largely based, has the widest market. As a result of comparing several different types of diatomite, the writer found that the freshwater Tertiary material, consisting of the tough, dotted, cylindrical (*Melosira*) diatoms, gave excellent results.

Diatomite has also been successfully used as an addition agent to plasters made from gypsum, cement, or lime and sand, thereby increasing workability, spreading power, and surface hardness, as well as improving the insulation properties.

For the polishing of metals, diatomite is one of the best materials known, for the angular nature of the silica skeletons, especially when broken, gives it an efficient abrasive power and, moreover, because of the low compressive strength of the diatoms, there is no danger of scratching the surface of even the softest metal—provided, of course, that grit or mineral silica is entirely absent. The small-sized diatoms appear to give the best results. Diatomite is also used as the abrasive base in some automobile polishes, and nail and dental powders. It is largely used as a filler, particularly where light weight insert fillers are required. During 1930, considerable progress was made in its use as a filler for hard-rubber and battery boxes. It has been calculated that about 25,000 tons of diatomite were used in the manufacture of asphaltum battery boxes in the United States last year (1930). These boxes contain about 30 per cent diatomite, resulting in a much lighter weight and more efficient container than had been produced before. Unfortunately, only a few diatomites are suitable, since the great majority contain a little manganese, of which not a trace is permissible on account of its detrimental action in shortening the life of the battery and attacking the wood separators.

Other uses for diatomite are as a carrier for catalytic agents—a use which has recently increased in various fields; as an absorbent for many liquids and gases; as a substitute for other forms of silica in the manufacture of some compounds; as a carrier for corrosive liquids; for packing purposes; and for several other minor applications.

CANADIAN CONSUMPTION AND FUTURE REQUIREMENTS

Unfortunately, accurate statistics giving the imports of diatomite into Canada are not available. This is largely due to the fact that it enters the country under various trade names, as well as in the form of products and compounds, such as insulation bricks, slabs, tiles, pipe coverings, metal polishes, dental powders, fillers, etc. A personal survey by the writer 4 years ago showed about 2,700 tons consumed in 1926, but more recent investigations have indicated considerable increase in many lines, besides new applications of the material, in Canada. It is believed that the present annual consumption is about 7,000 tons, and is still increasing.

The largest individual application is as a filter-aid in the sugar-refining industry. With one exception, it is used by every Canadian refinery, the annual consumption ranging from 200 to 700 tons each. Any future increase in consumption will be coincident with an increase of the sugar output from the refineries. Diatomite is also employed as a filter-aid in refining various other liquids and juices such as starch, vinegar, wine, beer, flavouring extracts, etc. Up to the present, no Canadian diatomite of filter-aid quality has been marketed, but this grade has been produced experimentally from Nova Scotia material and it is hoped that within the year this will be used in the home refineries. It is also expected that a suitable grade will eventually be produced from the Muskoka district of Ontario.

Next to filtering, insulation products absorb the largest tonnage of diatomite in Canada. These are mainly in the form of bricks, which are used between the inner and outer walls of furnaces, ovens, boilers, etc. These bricks are marketed in various types and may be crude material cut direct from the beds of diatomite, or the same type of brick calcined, or else pulverized, puddled with sufficient clay to bind, and then pressed and burned. In other types of brick, the diatomite is previously mixed with cork or sawdust and burnt after being moulded. The burning out of the carbonaceous matter leaves voids which render the brick very porous and light in weight. Some of the standard bricks weigh only $1\frac{1}{2}$ pounds. For high-temperature insulation, the natural bricks are generally the most efficient, but they are the weakest structurally. All these diatomite products, including slabs, tiles, pipe coverings, etc., are at present imported, mainly from the United States, but there are also substantial imports of English and Danish diatomite bricks and tiles. Recently, at least two Canadian firms have started to manufacture these bricks, as well as insulation pads for electric stoves. One of these firms is using Muskoka diatomite, 10 tons of which was mined and utilized for this purpose in 1930. Two or three other Canadian firms are preparing to put these products on the market. The potential market for insulation products in Canada is very great, for it covers not only all types of heat installations, both domestic and industrial, but also refrigeration plants; in walls and roofs of houses (for which several car lots of British Columbia material were used in 1930); as a protection against cold; and in safes and filing cabinets, etc., as a protection against total loss of their contents by fire.

Diatomite was first used commercially in Canada as a concrete admixture 5 years ago, about 300 tons being consumed in 1927. This amount has now increased to well over 1,000 tons in 1930. At first, all the diatomite was imported, mainly from California, but during the past 3 years the output from British Columbia, which is now about 200 tons annually, has been mainly used for this purpose, the market being largely confined to the west.

Tests conducted with the co-operation of the writer four years ago showed that this British Columbia (Quesnel) material is equal or superior to any imported diatomite as a concrete admixture.¹ Some of the Nova Scotia diatomite is also being used for this purpose by eastern contractors.

Following the successful utilization by United States manufacturers of diatomite as one of the principal ingredients in asphaltum battery boxes, it is of interest to note that some Canadian containers are now being made with diatomite. At present all the diatomite is being imported. The writer is, however, making an investigation of samples from all known Canadian commercial deposits in order to ascertain which are free from manganese and other injurious impurities and so be capable of meeting the somewhat exacting requirements of battery-box manufacturers.

WORLD'S OCCURRENCES AND PRODUCTION OF DIATOMITE

Although diatomite occurs in nearly every country in the world, it has been produced by only 18 countries during the last ten years (see Table II), and in most countries the deposits are very small and impure, or are confined to lakes or swamps, as a result of which the material cannot be economically marketed. The United States is the largest producer and the deposits in California are the largest so far discovered anywhere. Large deposits, but of lesser extent, occur in Canada, Algeria, Germany, and Denmark.

All the large deposits of great thickness—some as much as 2,000 feet—occur as dry, compact beds which were formed in the Tertiary period and are often of considerable elevation above the present level of the water. Parts of these beds are in the form of hard diatomaceous shales and in places they are so chalcedonized as to be of little commercial value. Such deposits are usually of marine origin, though there are some exceptions, such as the extensive freshwater deposit along the Pitt river, north California, and those in the vicinity of Harper, in eastern Oregon.

The diatoms in all these Tertiary deposits appear to be the same types and species as are found living in the present day.

The world's annual consumption of diatomite has doubled during the last five years and must now be well over 200,000 tons. This increase is largely due to successful research work on the domestic and industrial uses of this unique material.

¹For full details, Mines Branch Report No. 691, pp. 134-140.

The following table shows the world output by countries over the last five-year period. Unfortunately, the United States production figures are not available for publication, since about 80 per cent of the output has been maintained by one concern from deposits at Lompoc, California. Private investigation, however, indicates that the present output, which is increasing, is well over 100,000 tons.

TABLE II
World Production of Diatomite
(Long Tons)

	1925	1926	1927	1928	1929
Algeria.....	8,209	9,842	7,874	9,000	15,000
Australia (N.S.W.).....	701	911	1,210	1,360	1,107
Barbados.....		10	10	10	10
Canada (g).....	Nil	60	237	329	383
Denmark (e).....	(a)	30,500	32,200	29,353	37,697
France.....	1,500	7,017	5,905	9,842	(d)
Germany (b).....	4,842	5,824	5,926	6,597	40,000(ec)
Hungary (b).....	762	1,462	1,769	3,491	(a)
Ireland.....	3,343	2,975	3,373	4,244	4,500(e)
Italy.....	413	1,180	700	241(e)	323(e)
Japan.....	4,651	(a)	(a)	(a)	5,000(e)
Java.....	(a)	350	380	360	420
Norway (b).....	47	57	79	83	Nil (c)
Portugal.....	50	59	246	30	(a)
Russia (d).....	2,307	7,952	5,105	(a)	(a)
Spain.....	854	791	352	246	(a)
Sweden.....	806	467	612	710	(a)
United States.....	65,205	77,791(e)	(f)	(f)	(f)

Statistics mainly from Imperial Institute, Min. Ind. of British Empire; also private information.

(a) Data not available.

(b) Exports.

(c) Production.

(d) Including Georgia; year ending September, 1930.

(e) Estimated.

(f) Not available for publication, but believed now to be about 100,000 tons.

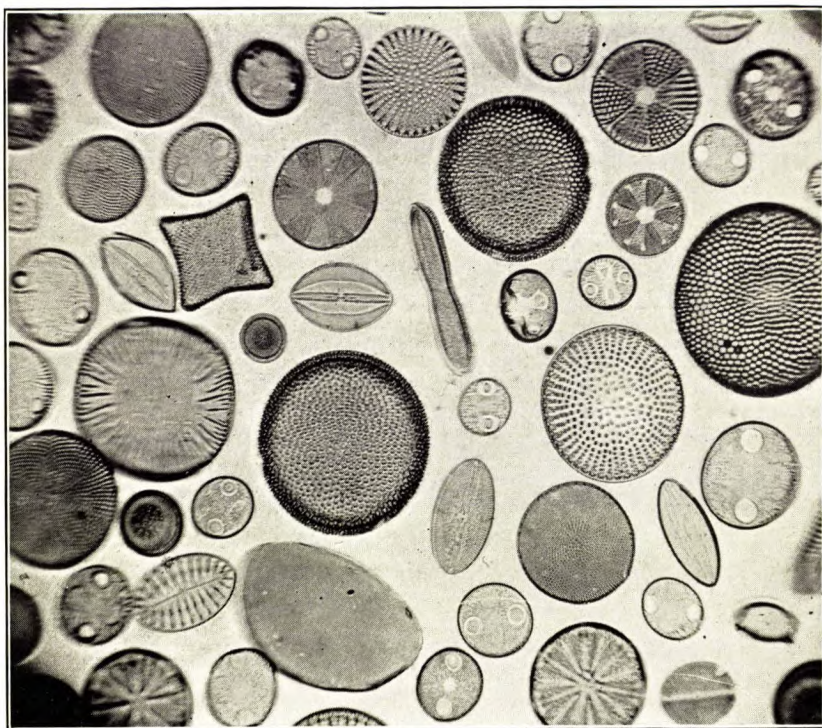
(g) Canadian production, 1930, 630 tons; shipments, 554 tons.

(h) Estimated production; exports, 8,564 tons.

WORLD DEPOSITS OF DIATOMITE

Canada

The occurrence of diatomite in Canada was first recorded in the early Geological Survey reports between 1870 and 1877, the first discoveries being along the Blackwater river in central British Columbia and at Pollet lake in Kings county, New Brunswick. A series of interesting experiments on the manufacture of insulating bricks and other products from the Pollet Lake material was conducted by Dr. Hoffmann of the Geological Survey in 1879. Canadian manufacturers were apparently slow in recognizing the benefits of diatomite insulation, for it was 50 years later (1930) before the first Canadian-made diatomite brick was put on the market. No records of production are available until 1895, when diatomite was mined from Silica lake, Colchester county, Nova Scotia.



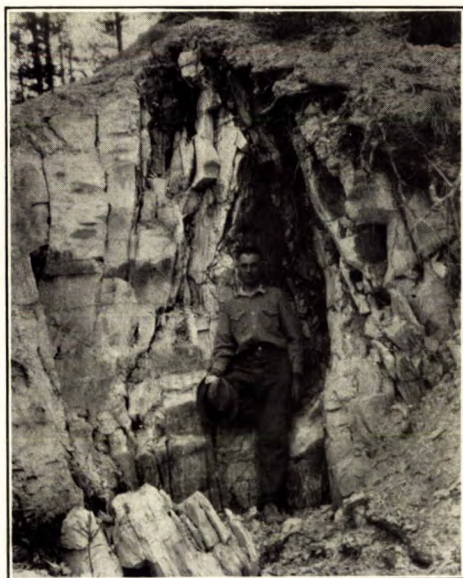
Typical marine diatoms.



A. General view of diatomite deposits at Digby Neck, N.S.



B. Plant of International Diatomite Industries, Ltd., Digby Neck, N.S., erected in 1930. A dragline scraper excavates the wet diatomite which is then conveyed to a rotary calciner.



C. Prospect quarry in the diatomite bluffs on the property of B. C. Refractories, Ltd., at the bend of the Fraser river, 9 miles north of Quesnel (July, 1930).

Production was comparatively heavy in the early years of the industry, but the output fell to nothing in 1925. Investigations were then started by the Mines Branch, Ottawa, which resulted in a general revival of interest and the starting of operations at Quesnel, B.C., at Digby Neck, N.S., and later in the Muskoka district of Ontario. The benefits to be derived by employing diatomite in various industries were drawn to the attention of numerous potential users throughout the Dominion, and consequently there has, in the past five years, been a steady increase in production as well as a large increase in imports.

Approximately 120 diatomite deposits in Canada have been examined and recorded by the writer. Most of them are in the Maritime Provinces, a few are in the Muskoka district of Ontario, and some are in British Columbia. All are of freshwater origin and, with the exception of the largest deposits in British Columbia, are of Recent or post-Tertiary age. Descriptions of all these deposits are included in the author's monograph published by the Mines Branch during the latter part of 1928. Unfortunately, the issue of 4,000 copies is exhausted, but a revised and up-to-date edition is now being compiled. For the purposes of this paper, details are confined to those localities in which operations are at present under way.

Nova Scotia: The Oxford Tripoli Company has been producing on a small scale for 25 years, first from Silica lake in Colchester county, and now from a series of ponds south of Tatamagouche in the same county. The material is calcined close to the deposit, and then shipped to a treatment plant at Haverstraw, N.Y. The product is white and fluffy, the diatoms being better preserved than in the average of the eastern deposits. The company has also acquired a number of other deposits, including those of Trout lake, also Pollet lake, in New Brunswick. During 1929 this company was reorganized under the name of the International Diatomite Industries, Ltd., of Montreal, and acquired the property of the Scotia Diatom Products Company at Little River, Digby Neck. This deposit is in the form of a chain of 5 or 6 closely connected swamps extending over an area of 4 miles long by about $\frac{1}{4}$ mile across. It is the largest known in the east, being in places 20 feet deep and estimated to be capable of producing approximately one million tons of finished diatomite.

The top few feet of the deposit is in the form of a brown peat which is self-calcining, leaving a pure white fluffy diatomite. (*See analysis No. 5.*) The next 5 to 8 feet is spongy and grey in colour, underlain by a dark brown diatomite mud. The diatoms in this calcined peat are well preserved and tests indicate a good filtration material.

During the past year the new concern completed and remodelled the treatment plant started by the Scotia Diatom Products Company, and produced several hundred tons of calcined material. This included shipments of "calcined aggregates" (the first of its kind from Canada) in the form of hard pea-sized lumps which were used by a concern near Montreal. When mixed with sufficient cement to act as a bond, it becomes an excellent insulation concrete for furnaces.

Ontario: The Diatomite Products Company of Toronto has erected a dredge in Slocombe lake (140 miles due north of Toronto), and has started to pipe the sludge one mile into a natural basin at Martin siding,

Muskoka, where an efficient and up-to-date treatment plant is almost completed. The material is high in carbonaceous matter and there is a considerable shrinkage when the wet product is dried; nevertheless, about a hundred thousand tons of the finished product can be obtained from the different lakes in the immediate vicinity. There are also other lakes and swamps of similar material within a radius of 20 miles. The calcined diatomite is light in weight and the diatoms, both large and small, are well preserved. In addition to other uses, it should make a good filter medium.

The Diatomite and Silica, Ltd., of Toronto, has acquired several ponds containing diatomite in Chaffey and Stisted townships, 4 and 5 miles north of Martin siding.

The Diatomite Syndicate of Huntsville has started to build a treatment plant on Austin pond, a 40-acre swamp six miles southwest of Scotia junction, on the northern boundary of the Muskoka district. The syndicate estimates over fifty thousand tons of diatomite in the Austin and two other swamps in the immediate vicinity.

British Columbia: There are no recorded diatomite occurrences between Muskoka, Ont., and central British Columbia, where, at Quesnel (the present terminus of the Pacific Great Eastern railway), the B.C. Refractories, Ltd., of Vancouver, is operating the largest known deposits in the Dominion. The beds, of comparatively dry and blocky, cream-coloured diatomite, are known to be in places at least 60 feet thick, and are situated about 800 feet above and along the west bank of the Fraser river. The diatoms were evidently laid down in a chain of shallow lakes during the Tertiary period before the present Fraser river was formed. Outcrops and borings have shown these diatomite beds to occur to the north and south of Quesnel over a distance of about 50 miles along the river. All samples taken have shown identical diatoms, so it is probable that the original deposits were continuous. A vast amount of displacement and denudation has taken place during the formation of the present river valleys and canyons, leaving remnants of these diatomite beds, some of which contain many hundred-thousand tons. Some of these outcrops are capped by basalt, which at one time must have flowed over the surface of the lakes, thereby changing the topography of the whole country. The contact shows evidence of chilling where the basalt flow encountered the wet diatomite, which splashed up into the pores of the lava and was converted into a hard meerschaum-like material. The most southerly known deposit of this series, 20 miles below Quesnel, which has not hitherto been recorded, was examined by the writer in July, 1930. The country here is flatter and more accessible than that above Quesnel and indications are that good quality material extends over at least 3 or 4 square miles, with comparatively little overburden.

The main exposures at the 'bend', 9 miles north of Quesnel, are owned by the B. C. Refractories, Ltd. No material, except samples, has been shipped from this area, but a road to the deposit is now being constructed. For the past three years this concern has been shipping diatomite from low ground near the river 2 miles north of the town. These latter deposits are not in place, but are huge masses, covering many acres, that have slid down from the higher elevations of their original place of deposition.

Owing to the small and comparatively regular size of the diatoms, and to the fact that they are almost entirely of one type (*Melosira granulata*—like dotted cylinders), the Quesnel material is not suitable for filtration purposes. It has been mainly marketed for use as a concrete admixture, but it is also a good insulator, and preparations are under way to manufacture bricks and wallboard. Clays suitable for these and other purposes underlie the diatomite beds.

About 40 miles northwest of Quesnel is the Blackwater diatomite occurrence, which was recorded almost 60 years ago. The diatoms are similar to those in the deposits further south, and it is reasonable to suppose that there are large, and at present unknown, areas covered by diatomite in this region of central British Columbia.

There are many more recent swamp deposits, particularly along the main coast and on Vancouver island. Although some of these have excellent diatom structure, nevertheless, none have yet been found that are large enough to be considered commercial.

FOREIGN DEPOSITS

The countries from which diatomite is obtained are given in the table of world production.

The United States is by far the world's largest producer. The main deposits, centred at Lompoc, California, cover an area of many square miles and are several hundred feet in thickness. The crude diatomite is now mined by underground stoping, employing the room-and-pillar method. The beds dip at about 30 degrees and the material is dragged by scrapers down the slope to chutes over the main adit tunnel, which is nearly 8,000 feet long and 12 feet square. The main storage bins are hollowed out in the deposit itself at the tunnel portal, where a 500-ton treatment plant is located. The natural bricks are sawn direct from the beds by means of special multiple-saw machines. The products of this mine are marketed all over the world. About 90 per cent of the diatomite imported into Canada comes from here.

There are now about 17 diatomite producers in the United States, the majority operating in the western states of California, Oregon, Washington, and Nevada. In the east, a small output is maintained from New York, Maryland, and Virginia.

The methods employed in the German kieselghur (diatomite) industry, and also statistics of the industry, are kept secret, but this country is the second largest world-producer, with an output estimated at about 40,000 tons annually. A tonnage almost as large as that from Germany, consisting of an impure diatomite-clay mixture known as '*Moler*', is obtained from some islands off Denmark. This material is used by an English concern which maintains a large output of bricks, tiles, and similar products from a plant at Hythe, on the east coast of England. During the past two years an appreciable quantity of these bricks has been imported into Canada.

Among the earliest recorded diatomite deposits are those of Tripoli, on the north African coast. The material was locally called '*tripoli*', but unfortunately this has since been adopted as a trade-name for another form of semi-amorphous silica of mineral origin which is mined in Missouri. This has led to confusion, but, in present-day usage, the name '*tripoli*' should *not* refer to diatomite, but to the Missouri or similar type of silica. A large output of the African material is maintained from deposits in the Department of Oran in Algeria. Two United States concerns are now operating these and an appreciable tonnage is exported to America.

The annual output from the remaining countries mentioned in the table ranges between 100 and 5,000 tons each. Russia (U.S.S.R.) is believed to be producing more than this, but reliable information is not at present available.

PREPARATION

The material from the marsh or under-water deposits, typical of the eastern section of the American continent, is either dug out from the drained area and sun-dried as much as possible, or else dredged out by suction and the sludge conveyed to trap launders that retain the grit and thence to settling and filter tanks. The crude material, high in carbonaceous matter, is then, after artificial drying, calcined at 800°C. in kilns or rotary calciners. The product from these, in the form of small lumps, is pulverized, care being taken to avoid breaking up the fragile diatoms. Better results and more thorough calcination may be obtained by pulverizing and roughly air-separating the dry material before burning. In this way, small lumps are avoided, the fine dust is calcined at a lower temperature, the operation is easily controlled, and a more consistent product is obtained. It is then either bagged for shipment, or further treated by passing through a system of screens and air separators—usually the cyclone type—to yield a number of different mesh products. Coarse grit, if present, is removed in the first air separator, but it is almost impossible to eliminate the very fine grit.

The compact material of the deposits of the western United States is cut out in blocks and air-dried and then passed through the usual crushing and grading system, but calcination is not always necessary on account of the low percentage of carbonaceous matter. The western material used for concrete admixture is usually not calcined; the uncalcined product, also, is often used for insulation-brick manufacture.

The efficient treatment of diatomite in order to convert it into the numerous products required by the market calls for considerable skill, experimental work, and thorough knowledge of exactly the type required for each use.

PRICES

The United States quotations are as follows: Per short ton f.o.b. producing plant: kiln-fired brick, \$65; kiln-fired aggregate, $\frac{1}{4}$ -in., \$45; insulating powder, \$25; natural aggregate, $\frac{1}{4}$ -in., \$18 to \$20; air-floated powder, \$45; 80-85 per cent silica, 98 per cent through 200 mesh, \$20 in car lots.

There was, however, during the past year, price cutting on the part of the smaller producers of the western United States, insulation and filtration powders being sold as low as \$18 to \$20 per ton.

The prices, delivered in eastern Canada, are about \$45 per ton for concrete and insulation powders; \$55 for filtration powders; and about \$136 per 1,000 for kiln-fired California bricks. Imported bricks from England (Danish origin) vary from \$110 to \$140 per 1,000, according to grade and density.

CONCLUSIONS

Quite apart from its commercial value, diatomite is a material of unusual scientific interest owing to its unique nature. The study of diatoms is, and always will be, the wonder and joy of every diatomist and microscopist.

The many benefits and advantages to be derived from the use of diatomite, both in the home and in industry, are becoming more generally known and understood, but the suitability of the several types of diatomite for its different applications should be carefully considered. Although much advance has been, and is being, made in research problems connected with this material, there is still a large field for future study.

Many and varied types of diatoms are to be found in Canada's numerous deposits which have as yet been barely touched. In spite of these resources, only a few hundred tons are as yet being mined annually, although about 90 per cent of the home requirements are being imported. This, however, has been largely due to lack of knowledge on the part of the potential producers as to the best and most suitable types of material required, and also to inadequate treatment plants, which latter, however, are now being improved.

There appears to be a great future for Canadian diatomite in her industrial plants, and doubtless the utility of this unique material will become more generally recognized, since only a small percentage of the amount that could advantageously be used, is now being used. There is a fertile field for Canadian-made diatomite products in the line of bricks, slabs, tile, wallboards, pipe coverings, etc., for fireproof insulation against heat, cold, and sound.

V

THE POSSIBILITIES AND PROSPECTS FOR THE UTILIZATION OF CANADIAN-PRODUCED COPPER IN HOME MANUFACTURING INDUSTRIES*

By A. H. A. Robinson and W. H. Losee†

INTRODUCTORY

Until quite recently—practically up to the present time—all but an insignificant amount of the copper produced in Canada was shipped abroad in the form of ore, matte, blister, etc., there to undergo the further treatment necessary to bring it to the refined state in which it is required by fabricators of copper. Consequently, Canadian manufacturers were forced to import nearly all the copper required in their business; and a considerable portion of the ultimate value to be derived from a Canadian raw material was lost to the country of its origin. In the early days of Canadian copper mining, when both the production and consumption of copper in Canada were much smaller than now, such a condition of affairs was perhaps economically unavoidable, and, in any case, was not a matter of sufficient importance to attract general attention. Later on, however, when there had been large and rapid increases both in the production and consumption of copper in Canada, it formed the basis of much adverse criticism, deserved or not, of producers of Canadian copper—criticism that became intensified during the war and subsequent years. Happily, the chief grounds of complaint have now been removed, and there are to-day copper refineries in Canada, either operating or under construction, that are capable, in the aggregate, of turning out amounts of refined copper greatly in excess of any indicated Canadian consumption. There are now also two plants in Canada—one in operation, and the other under construction—for the primary stages of the fabrication of copper. For the future, therefore, Canadian copper-using industries will have available to them as raw material, from purely domestic sources, an ample supply of refined copper in various forms.

MINES AND REFINERIES

At present, the several companies producing copper ores in Canada are disposing of their output as follows:

The Granby Consolidated Mining and Smelting Company, Ltd., concentrate and smelt the ores of their Hidden Creek and neighbouring mines at Anyox, B.C., the resulting blister copper being sent, in part, to the Ontario Refining Company, Ltd., at Coppercliff, Ontario, and in part to the United States, for treatment. The ores of the Copper Mountain mine in British Columbia, also owned by Granby Consolidated, are shipped to a concentrator at Allenby, the concentrates being sent to Tacoma,

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Washington, U.S.A., for smelting and refining. The Britannia Mining and Smelting Company, Ltd., Britannia Beach, B.C., also ship concentrates to the American Smelting and Refining Company at Tacoma. The copper-nickel matte output of the International Nickel Company at Coppercliff, Ontario, is shipped to Port Colborne, Ontario, to Clydach, Wales, and to Huntington, West Virginia. Converter copper made from this matte at Port Colborne is at present being returned to the Ontario Refining Company, Ltd., at Coppercliff, for refining. The Falconbridge Nickel Mines, Ltd., produce nickel-copper matte which is shipped to Norway for further treatment. Ores from the Noranda mine, from the Waite-Ackerman-Montgomery mine, and from the Amulet mine, all in Quebec, are smelted at the Noranda smelter. The resulting blister copper from Noranda is being at present exported but will soon be refined in Canada at Montreal East. Copper concentrate made at Bradley, Ontario, from lead-zinc-copper ores, is shipped to United States smelters. Concentrates from the Eustis mine in Quebec are also exported to the United States. For the sake of brevity, the potential copper output of mines not actually producing at the time this paper was written, such as the Flin Flon and Sherritt-Gordon mines in Manitoba, is being left out of consideration for the present.

The Consolidated Mining and Smelting Company was the first concern to undertake the refining of copper in Canada, when, in the early war-years and largely as a war measure, it built at Trail a plant capable of producing about 15,000 tons of refined copper a year, and in 1916 made the first refined copper produced in the Dominion. It has been found impossible, however, to keep this plant in continuous operation and its output has been small. It is, we believe, at present idle. A copper rod-mill that was built in connexion with it was never operated. The British America Nickel Corporation also produced a little refined copper at their nickel-copper refining plant at Deschenes, Quebec, between 1920 and 1924. The third, and most important, project of this kind yet undertaken, however, was the establishment of a refinery, with a capacity of 120,000 tons of refined copper annually, at Coppercliff, Ontario, by the Ontario Refining Company, Ltd., of Canada, a company jointly owned by the International Nickel Company of Canada, the American Metal Company, the Consolidated Mining and Smelting Company of Canada, and Ventures, Ltd. This plant, which went into operation in July of this year (1930), was built primarily to treat blister copper produced at the International Nickel Company's smelter, but it will also treat that produced at the Granby Consolidated Mining, Smelting, and Power Company's smelter at Anyox, B.C., and any other custom copper offering. The first contract for the sale of copper from this new refinery was made with the Eugene F. Phillips Electrical Works, Ltd., who operate a copper fabricating plant at Brockville, Ontario; the contract calling for the delivery of 5,000,000 pounds of electrolytic copper. Shipments of refined copper are now said to be being made regularly, and to be finding a ready market with fabricators of copper both in Canada and in the United States.

The fourth copper refinery to be built in Canada is now under construction on tidewater at Montreal East, Quebec, by Canadian Copper Refiners, Ltd., all the common stock of which is owned jointly by Noranda

Mines, Ltd., the British Metal Corporation, Ltd., and the Nichols Copper Company. Through the recent merger of the Nichols Copper Company with the Phelps Dodge Corporation, the latter also has become interested in this Canadian enterprise. The Canadian Copper Refiners' plant will have a rated capacity of 75,000 tons of refined copper a year, and it is expected it will be ready for operation in 1931. It is being constructed primarily to refine the copper produced by Noranda Mines smelter, but will operate also as a custom refinery. The Hudson Bay Mining and Smelting Company, Ltd., has already contracted for the refining at this plant, for a term of years, of the output of copper from its Flin Flon mine in Manitoba, which it is expected will be producing next year. Adjacent to this refinery, the Canada Wire and Cable Company, in which Noranda Mines has acquired a financial interest, is building a copper fabricating plant.

Within the next few months Canada will thus have facilities for the refining of some 210,000 tons of copper annually, as against a total production of copper in all forms, including blister, matte, and in ores exported, in 1929, of some 124,000 tons. The excess of refining capacity over mine production at present seems large, especially when it is remembered that the Allenby, Britannia, and Eustis mines export all their production to the United States in the form of concentrates and thus reduce the Canadian copper available to Canadian smelters by 34,778 tons; and that a considerable quantity of nickel-copper matte will necessarily continue to go abroad for treatment. But there is little doubt that the gap can quickly be filled by the mines, including the Flin Flon and the Sheritt-Gordon, already connected up in one way or another with Canadian refineries, once the condition of the world's metal markets warrants the necessary increase in mine output.

PRODUCTION AND BOUNTIES

How far the great variety of manufactured and semi-manufactured forms in which copper is consumed in Canadian industry can profitably be made in Canada from Canadian copper, can be answered best by Canadian manufacturers; the miner and the metallurgist have at least done their part in providing them with ample domestic supplies of pure metal to work on. In order to promote the manufacture of Canadian copper in Canada, the Federal Government, in 1923, brought in a *Copper Bounties Act*, whereby certain bounties were given on copper bars or rods manufactured in Canada; and since that time bounties to the amount of \$401,023.46 have been paid out. A copy of this Act, and a table of the bounties paid, follows:

THE COPPER BOUNTIES ACT

18-19 GEORGE V

CHAP. 40

An Act respecting the Payment of Bounties on Copper Bars or Rods

[Assented to 30th June, 1923]

HIS Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:

1. This Act may be cited as *The Copper Bounties Act, 1923*.

2. The Governor-in-Council may authorize the payment out of the Consolidated Revenue Fund of the following bounties on copper bars or rods manufactured in Canada and sold for consumption therein, from copper produced in Canada from ore mined in Canada, during the periods and at the rates following, that is to say:

From the twelfth day of May, 1923, to the thirtieth day of June, 1924, both inclusive	.....one and one-half cents per pound;
From the first day of July, 1924, to the thirtieth day of June, 1925, both inclusive	.....one and one-fourth cents per pound;
From the first day of July, 1925, to the thirtieth day of June, 1926, both inclusive	.....one cent per pound;
From the first day of July, 1926, to the thirtieth day of June, 1927, both inclusive	.....three-fourths of one cent per pound;
From the first day of July, 1927, to the thirtieth day of June, 1928, both inclusive	.....one-half of one cent per pound

3. The sum to be paid as such bounty shall not exceed two hundred thousand dollars in any one of the said periods.

4. The said bounty shall not be paid on copper bars or rods exported from Canada, nor on copper rods made from copper bars on which a bounty has already been paid.

5. The Governor-in-Council may make regulations to carry out the intention of this Act.

6. The Minister of Trade and Commerce shall be charged with the administration of the provisions of this Act.

18-19 GEORGE V

CHAP. 15

An Act to Amend the Copper Bounties Act, 1923

[Assented to 11th June, 1928]

HIS Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:

1. Section two of The Copper Bounties Act, 1923, being chapter forty of the statutes of 1923, is amended by adding thereto the following:

From the first day of July, 1928, to the thirtieth day of June, 1929, both inclusive	.....one-half of one cent per pound;
From the first day of July, 1929, to the thirtieth day of June, 1930, both inclusive	.....one-half of one cent per pound;
From the first day of July, 1930, to the thirtieth day of June, 1931, both inclusive	.....one-half of one cent per pound.

Copper Bounty Paid

July 1, 1923, to June 30, 1924.....	Nil		Nil
July 1, 1924, to June 30, 1925.....	1,164,140 lb. at 1½c.....	\$	14,551 75
July 1, 1925, to June 30, 1926.....	10,808,627 " 1 c.....		108,086 27
July 1, 1926, to June 30, 1927.....	16,387,302 " ¾c.....		122,904 39
July 1, 1927, to June 30, 1928.....	12,514,446 " ¾c.....		62,572 24
July 1, 1928, to June 30, 1929.....	6,837,124 " ¾c.....		34,185 63
July 1, 1929, to June 30, 1930.....	10,857,149 " ¾c.....		54,285 75
July 1, 1930, to Oct. 1, 1930.....	889,286 " ¾c.....		4,446 43
Total.....	59,458,074 lb.		\$ 401,032 46

Without attempting to arrive at any definite conclusion as to how much, and to what stage of fabrication, Canada's copper can be economically worked-up in the Dominion, either for domestic use or for export, some statistics having a bearing on these questions have been compiled for consideration.

Canada's copper production in 1929 consisted of:

	Pounds
Blister copper.....	160,190,580
Copper in matte exported.....	18,220,487
Copper in ores exported.....	69,555,365
Copper in copper sulphate made.....	154,357
Total.....	248,120,769

Of this total, British Columbia produced 103,903,738 pounds, or 42 per cent; Ontario, 88,879,853 pounds, or 36 per cent; and Quebec, 55,337,169 pounds, or 22 per cent.

Although refined copper has been produced in Canada since 1916, it has been found most convenient for general statistical purposes to compute it at the blister stage. This production of refined copper in Canada has been as follows:

Production of Refined Copper in Canada

	Tons
1916.....	483
1917.....	3,901
1918.....	3,809
1919.....	3,467
1920.....	2,590
1921.....	2,143
1922.....	365
1923.....	824
1924.....	1,768
1925.....	170
1926.....	10,581
1927.....	9,191
1928.....	8,806
1929.....	3,518
Total.....	51,616

All this refined copper, with the exception of a small amount produced by the late British America Nickel Corporation at their Deschenes refinery between 1920 and 1924, came from the Consolidated Mining and Smelting Company's plant at Trail.

IMPORTS AND CONSUMPTION

Of the total copper produced in the Dominion in 1929, sixty-five per cent, or 160,190,150 pounds, was brought to the blister stage in Canada, and therefore was in a condition to go direct to Canadian refineries. If it had all been refined in Canada, how much of it could have been absorbed by Canadian industries, *i.e.*, what is the potential domestic market for refined Canadian copper? As a preliminary to any attempt to answer this question, a review of Canada's present consumption of copper is essential. In 1928 and 1929, Canada's imports of copper were as follows:

Imports of Copper into Canada, 1928 and 1929
(In pounds)

	1928	1929
Copper in bars and rods.....	36,500,000	55,500,000
Copper in pig and block.....	7,800,000	12,000,000
Copper in strips, sheets and plates, etc.....	2,600,000	2,800,000
Copper tubing.....	2,500,000	2,600,000
Copper wire, plain, tinned or plated.....	800,000	1,000,000
Copper wire, covered (estimated).....	2,200,000	2,600,000
Copper scrap.....	5,600,000	5,000,000
Total.....	58,000,000	81,500,000

In addition to this imported copper, there was available to Canadian consumers, in 1929, 7,000,000 pounds of Canadian-refined copper, all of which may be assumed to have been used in Canada; and an estimated amount of about 4,000,000 pounds of domestic copper scrap was also used. Under these three headings alone, therefore, we arrive at a Canadian consumption of copper in 1929 of 92,500,000 pounds, which probably entered Canadian manufacturing plants as:

	Pounds
Ingot, bars, and rods for manufacture into wire, cable, sheets, etc....	73,500,000
Finished sheets (imported as such).....	2,800,000
Ingot and bars for manufacture into brass and bronze.....	1,000,000
Scrap (actual consumption).....	9,000,000
Tubing (imported as such).....	2,600,000
Wire, plain and covered (partly estimated).....	3,600,000
Total.....	92,500,000

and emerged therefrom as the following products ready for final consumption:

	Pounds
Wire and cable.....	66,100,000
Sheets and tubing.....	16,400,000
In brass and bronze made in Canada.....	10,000,000
Total.....	92,500,000

In addition to the above, a further Canadian consumption of copper is indicated by imports of copper in various manufactured forms, for which no weights are given in the Customs' returns, but which had a value of over \$1,300,000 in 1929; and copper sulphate (both dehydrated and blue vitriol), of which over 4,000,000 pounds were imported in the same year. There are also our imports of brass, which contains from 60 to 80 per cent copper, and which amounted to 10,300,000 pounds in 1928 and to 12,300,000 pounds in 1929, made up as shown in the accompanying table; as well as imports of various manufactures of brass for which no weights are available, but which had a value of about \$4,000,000 in 1929.

Imports of Brass into Canada, 1928 and 1929
(In pounds)

	1928	1929
Brass, blocks, pig.....	1,000,000	1,000,000
Brass, scrap.....	3,400,000	4,800,000
Brass in bars and rods.....	800,000	1,000,000
Brass in strips, sheets, or plates.....	1,400,000	1,000,000
Brass tubing.....	3,300,000	4,000,000
Brass wire, plain.....	400,000	500,000
Total.....	10,300,000	12,300,000

If, therefore, to the 92,500,000 pounds of copper already definitely indicated as having been consumed in Canada in 1929, we add a further estimated amount of 8,000,000 or 9,000,000 pounds—which appears to be well within the mark—to cover copper contained in imported manufactures for which no weights are available, in imported brass, and in chemical compounds of copper, we arrive at a total estimated Canadian consumption of copper at the present time of, say, 100,000,000 pounds, or 50,000 tons, to put it in round figures. It is not to be inferred, however, that, now we have ample refining facilities, all Canadian consumption can be filled economically from Canadian sources. We will no doubt continue, for various reasons, to import a certain amount of manufactured or semi-manufactured copper, and copper in chemical compounds; but the consumption figure given will serve to indicate approximately the limits of what we may call the theoretical domestic market. How far it can be made a commercial market will depend in some measure on the Canadian manufacturer, who might well investigate the commercial possibility of substituting for imported material the Canadian copper now available to him; and also the possibility of undertaking lines of copper fabrication not heretofore profitable in this country.

Even if Canada's whole present consumption of copper were to be supplied from Canadian sources, there would still remain a very large surplus of new copper for which an outlet must be found in foreign markets—and this at the present rate of production, to say nothing of prospective increased production in the immediate future. And here it may be remarked that, in addition to new copper, there is already available, but not utilized in Canada, a certain amount of secondary metal in the shape of copper and brass scrap. In 1928, for instance, Canada exported over 8,000,000 pounds of copper scrap, and in 1929 over 11,500,000 pounds; in each of the same years brass scrap to the amount of, roughly, 12,000,000 pounds was exported. The amount of brass scrap exported just about equals the amount of brass, in all forms, imported, however.

Though any discussion of where and in what form Canada's surplus copper can best be disposed of is beyond the scope of this paper, a series of tables have been appended that may be of service to anyone interested in this particular phase of the matter. These tables show the present imports into, and exports from, Canada, of copper and brass in their various forms, and the chief countries of origin or destination of these imports and exports. Further tables give the tariffs on, and the principal imports of, copper and its products entering a number of copper-importing countries whose markets might be available to Canadian producers.

TABLE I

Imports into Canada of Copper and its Products, 1928 and 1929

Commodity	1928			1929		
	Great Britain	United States	Total*	Great Britain	United States	Total*
Copper, in bars and rods when imported by manufacturers of trolley, telegraph, and telephone wires, electric wire, and electric cables, for use only in the manufacture of such articles in their own factories; also copper bars for use only in the manufacture of rods to be used exclusively in the manufacture of electrical conductors, and copper rods for such manufacture, the individual units of such electrical conductors not exceeding the area of No. 7-0 gauge conductor.....	lb. 200 \$ 43	35,923,200 5,515,225	36,063,400 5,537,148	..... .....	54,774,600 9,913,910	54,824,600 9,922,096
Copper in bars and rods, in lengths of not less than 6 feet, unmanufactured.....	lb. 5,000 \$ 879	534,300 101,861	539,300 102,740	13,500 3,025	704,700 161,150	719,200 164,642
Copper ore and concentrates.....	lb. \$	100 52	100 52	..........	..........	..........
Copper, precipitate of, crude.....	lb. \$	3,825 102	3,825 102	..........	..........	..........
Copper in blocks, pigs, or ingots.....	lb. \$	7,883,600 1,176,941	7,883,600 1,176,941	..... .....	12,084,000 2,246,600	12,084,000 2,246,600
Copper, scrap.....	lb. 46,400 \$ 6,582	5,540,500 776,787	5,606,900 785,141	36,800 4,856	4,808,000 809,332	4,958,300 827,832
Copper in strips, sheets, or plates, not polished, planished or coated.....	lb. 182,000 \$ 43,643	2,395,400 476,137	2,586,700 521,559	327,600 85,860	2,463,300 610,095	2,806,300 698,974
Copper tubing in lengths of not less than 6 feet, not polished, bent, or otherwise manufactured.....	lb. 256,257 \$ 58,429	2,281,681 541,671	2,549,901 602,730	391,989 108,460	2,247,761 607,640	2,662,706 721,869
Copper rollers for use in calico printing.....	\$ 19,764	1,239	21,003	28,650	9,014	37,664
Copper wire, single or several, covered with cotton, linen, silk, rubber, or other material, including cable so covered.....	\$ 58,093 40,202	615,133 783,450	677,923 827,059	162,583 172,816	640,902 764,875	809,729 937,858
Copper wire, plain, tinned, or plated.....	lb. 13,117 \$	203,732	217,735	44,251	223,110	267,464

TABLE I—Concluded
Imports into Canada of Copper and its Products, 1928 and 1929—Concluded

Commodity	1928			1929		
	Great Britain	United States	Total*	Great Britain	United States	Total*
Copper wire cloth or woven wire of copper.....	\$ 2,223	11,538	14,128	1,528	8,085	9,613
Copper, manufactures of, n.o.p.....	\$ 62,173	988,700	1,074,156	29,606	1,268,162	1,313,811
Anodes of nickel, zinc, copper, silver, or gold.....	\$ 102	15,751	15,853	.....	16,125	16,127
Copper, sub-acetate of, or verdigris, dry.....	lb.	410	410	.....	681	681
.....	\$ 94	94	94	.....	177	177
Copper, sulphate of, dehydrated for agricultural or spraying purposes.....	lb. 801,810	260,010	1,627,074	465,220	795,702	2,252,122
.....	\$ 41,207	13,383	84,130	25,819	45,929	122,056
Copper, sulphate of (blue vitriol).....	lb. 551,135	1,909,021	3,741,971	267,120	836,008	2,118,304
.....	\$ 26,681	100,671	190,515	15,365	46,721	114,637
Total.....	\$ 264,946	10,409,118	10,731,358*	468,819	16,498,000	17,019,794*

*This total includes a small value for imports from other countries.

TABLE II

Exports from Canada of Copper and its Products, 1928 and 1929

Country	Copper, fine, contained in ore, matte, regulus, etc. (This item shows weight and value of copper and not the gross weight of ore, etc.)	Copper, blister	Copper, pig	Copper, old and scrap	Copper in bars, rods, strips, sheets, plates, and tubing	Copper wire and cable, insulated	Copper, manufac- tures of, n.o.p.	Total
1928								
United Kingdom..... lb.	18,521,600			166,600	13,700			18,701,900
\$	1,384,993			17,778	4,510	467	210	1,407,958
Newfoundland..... lb.								
\$						30,653		30,653
New Zealand..... lb.					117,900			117,900
\$					30,701	15,845		46,546
United States..... lb.	57,906,300	94,796,200		7,151,100	3,200			160,036,800
\$	5,638,891	13,761,824		757,956	812	413	6,620	20,166,516
Germany..... lb.		9,788,500		335,100				10,123,600
\$		1,613,520		42,334				1,655,854
Japan..... lb.				245,800				245,800
\$				31,623				31,623
Brazil..... lb.								
\$						105,975		105,975
Cuba..... lb.								
\$						84,397		84,397
Mexico..... lb.								
\$						10,695		10,695
Other countries..... lb.				163,100	23,400			186,500
\$				20,148	4,965	10,985	19,100	55,198
Total..... lb.	76,427,900	104,764,700		8,051,700	153,200			189,412,500
\$	7,023,884	15,375,344		869,839	40,933	259,430	25,930	23,595,415

TABLE II—Concluded

Exports from Canada of Copper and its Products, 1928 and 1929—Concluded

Country	Copper, fine, contained in ore, matte, regulus, etc. (This item shows weight and value of copper and not the gross weight of ore, etc.)	Copper, blister	Copper, pig	Copper, old and scrap	Copper in bars, rods, strips, sheets, plates, and tubing	Copper wire and cable, insulated	Copper, manufac- tures of, n.o.p.	Total
1929								
United Kingdom..... lb.	11,544,000			13,700	6,700			11,564,400
..... \$	908,965			2,385	2,687	150	132	914,319
Newfoundland..... lb.								
..... \$						53,732		53,732
New Zealand..... lb.					97,800			97,800
..... \$					26,329	15,066		41,395
United States..... lb.	75,455,100	131,689,000		11,196,700				218,340,800
..... \$	8,036,000	23,413,527		1,520,524		1,573	2,879	32,974,503
Germany..... lb.		16,589,500		113,700				16,703,200
..... \$		3,298,340		17,876				3,316,216
Japan..... lb.				173,900				173,900
..... \$				24,527				24,527
Brazil..... lb.								
..... \$						26,460		26,460
Cuba..... lb.								
..... \$								
Mexico..... lb.								
..... \$						1,864		1,864
Other countries..... lb.				61,600	27,600			89,200
..... \$				9,400	6,884	20,185	10,511	46,980
Total..... lb.	86,999,100	148,278,500		11,559,600	132,100			246,969,300
..... \$	8,944,965	26,711,867		1,574,712	35,900	119,030	13,522	37,399,996

TABLE III

Imports into Canada of Brass and its Products, 1928 and 1929

Commodity	United Kingdom	United States	France	Germany	Other countries	Total
1928						
Brass in blocks, ingots, or pigs..... lb.	57,600	1,117,600				1,175,200
Brass, scrap..... lb.	11,049	142,439				153,488
Brass caps, adapted for use in the manufacture of electric batteries	\$ 71,100	3,101,800			222,800	3,395,700
Brass cups, being rough blanks, for the manufacture of paper shells or cartridges when imported by manufacturers of brass and paper shells and cartridges for use exclusively in the manufacture of such articles in their own factories..... \$	9,658	327,391			18,951	356,000
Brass in bars and rods, in coils or otherwise, not less than 6 ft. in length..... lb.		11,710				11,710
Brass in strips, sheets, or plates not polished, planished, or coated.. lb.	47,313	109,961				157,274
Brass tubing, not polished, bent, or otherwise manufactured, in lengths not less than 6 feet..... lb.	318,300	454,900				773,200
Carburettors, of brass..... \$	48,318	93,832				142,150
Pumps, hand, brass, n.o.p..... \$	101,800	1,314,700				1,416,500
Valves, brass..... \$	20,230	244,321				264,551
Water meters, n.o.p..... No.	611,531	2,676,690			33,989	3,322,210
Wire, plain, brass..... lb.	\$ 130,078	611,003			7,788	748,869
Wire cloth, or woven wire, of brass, n.o.p..... \$	56	34,740			219	35,015
Manufactures of brass, n.o.p..... \$	947	27,385			179	28,511
Total..... \$	2,938	396,754			2,132	401,824
	1,373	734				2,107
	16,301	11,688				27,989
	43,552	349,652				393,204
	13,165	85,493				98,658
	24,548	23,079		3,074	2,762	53,463
	317,037	2,965,038	95,564	115,498	168,343	3,661,480
Total..... \$	641,638	5,084,834	95,564	118,572	200,374	6,140,982

TABLE III—Concluded

Imports into Canada of Brass and its Products, 1928 and 1929—Concluded

Commodity	United Kingdom	United States	France	Germany	Other countries	Total
1929						
Brass in blocks, ingots, or pigs..... lb.	55,800	952,700				1,008,500
\$	10,079	155,365				165,444
Brass, scrap..... lb.	9,800	4,639,600			130,700	4,780,200
\$	494	608,541			8,457	617,492
Brass caps, adapted for use in the manufacture of electric batteries.		11,137				11,137
Brass caps, being rough blanks, for the manufacture of paper shells or cartridges when imported by manufacturers of brass and paper shells and cartridges for use exclusively in the manufacture of such articles in their own factories..... \$	22,383	151,226				173,609
Brass in bars and rods, in coils or otherwise, not less than 6 ft. in length..... lb.	412,700	609,000				1,021,700
\$	72,290	130,620				202,910
Brass in strips, sheets, or plates, not polished, planished, or coated. lb.	184,400	920,900				1,105,300
\$	41,761	224,164				265,925
Brass tubing, not polished, bent, or otherwise manufactured, in lengths of not less than 6 feet..... lb.	862,100	3,181,711			30,858	4,074,669
\$	212,907	801,707			6,317	1,020,931
Carburettors, of brass..... \$	101	42,985			704	43,790
Pumps, hand, brass, n.o.p..... \$	397	30,171			719	31,287
Valves, brass..... \$	7,628	554,674			9,249	571,551
Water meters, n.o.p..... No.	1,068	966				2,034
\$	28,185	17,339				45,524
Wire, plain, brass..... lb.	39,722	431,509			566	471,797
\$	12,268	125,516			216	138,000
Wire cloth, or woven wire, of brass, n.o.p..... \$	38,859	19,894		3,268	2,374	63,895
Manufactures of brass, n.o.p..... \$	314,136	3,301,174	111,414	119,171	158,690	4,004,585
Total..... \$	760,988	6,174,513	111,414	122,439	186,726	7,356,080

TABLE IV

Exports from Canada of Brass and its Products, 1928 and 1929

Country		Brass, old and scrap	Brass in bars, rods, strips, sheets, plates, and tubing	Brass valves	Brass manu- factures, n.o.p.	Total
1928						
United Kingdom.....	lb.	444,100	8,900			
	\$	46,345	865	159,826	499,729	706,765
British South Africa.....	lb.					
	\$			8,523		8,523
Australia.....	\$			14,902		14,902
Newfoundland.....	\$				18,342	18,342
United States.....	lb.	9,806,500	4,500			
	\$	823,877	797	4,834	41,978	871,486
Germany.....	lb.	1,231,800				
	\$	108,590				108,590
Denmark.....	\$			13,201		13,201
Netherlands.....	\$			14,390		14,390
Other countries.....	lb.	65,800	36,200			
	\$	5,259	7,723	45,743	34,110	92,835
Total.....	\$	984,071	9,385	261,419	594,159	1,849,034
1929						
United Kingdom.....	lb.	228,000				
	\$	24,064		174,047	815,507	1,013,618
British South Africa.....	lb.					
	\$			13,203		13,203
Australia.....	\$			19,076		19,076
Newfoundland.....	\$				11,595	11,595
United States.....	lb.	11,539,400				
	\$	1,170,104		1,750	43,943	1,215,857
Germany.....	lb.	101,100				
	\$	12,282				12,282
Denmark.....	\$			12,261		12,261
Netherlands.....	\$			15,036		15,036
Other countries.....	lb.		66,900			
	\$		15,910	46,456	21,805	84,171
Total.....	\$	1,206,510	15,910	282,429	892,850	2,397,699

TABLE V

Rates of Duties on Brass and Copper and Their Products Entering Canada

No.	Article	Rate of duty			Tariff Item
		Preferential	Intermediate	General	
	<i>Brass and its products—</i>				
6011	Brass in blocks, ingots, or pigs.....cwt.	5 p.c.	10 p.c.	10 p.c.	348c
6012	Brass, scrap.....cwt.	Free	Free	Free	348b
6013	Brass caps adapted for use in the manufacture of electric batteries..... \$	Free	Free	Free	485
6014	Brass cups, being rough blanks, for the manufacture of paper shells or cartridges, when imported by manufacturers of brass and paper shells and cartridges, for use exclusively in the manufacture of such articles in their own factories..... \$	Free	Free	Free	484
6015	Brass in bars and rods, in coils or otherwise, not less than 6 feet in length...cwt.	5 p.c.	7½ p.c.	10 p.c.	349
6016	Brass in strips, sheets or plates, not polished, planished, or coated.....cwt.	5 p.c.	7½ p.c.	10 p.c.	349
6017	Brass tubing not polished, bent, or otherwise manufactured, in lengths not less than 6 feet..... lb.	5 p.c.	10 p.c.	10 p.c.	348c
6018	Carburettors of brass..... \$	20 p.c.	27½ p.c.	30 p.c.	352
6019	Pumps, hand, brass, n.o.p..... \$	20 p.c.	27½ p.c.	30 p.c.	352
6020	Valves, brass..... \$	20 p.c.	27½ p.c.	30 p.c.	352
6021	Water meters, n.o.p..... No.	20 p.c.	27½ p.c.	30 p.c.	352
6022	Wire, plain, brass..... lb.	15 p.c.	17½ p.c.	20 p.c.	406
6023	Wire cloth, or woven wire of brass, n.o.p..... \$	17½ p.c.	22½ p.c.	25 p.c.	418
6024	Brass, manufactures of, n.o.p..... \$	20 p.c.	27½ p.c.	30 p.c.	352
	<i>Copper and its products—</i>				
6031	Copper ore and concentrates.....cwt.	Free	Free	Free	329
6032	Copper, precipitate of, crude..... lb.	Free	Free	Free	208
6033	Copper in blocks, pigs or ingots.....cwt.	1c. p. lb.	1½c. p. lb.	1½c. p. lb.	343
6034	Copper, scrap.....cwt.	Free	Free	Free	348b
6035	Copper in bars or rods, when imported by manufacturers of trolley, telegraph, and telephone wires, electric wires and electric cables, for use only in the manufacture of such articles in their own factories; also copper bars for use only in the manufacture of rods to be used exclusively in the manufacture of electrical conductors and copper rods for such manufacture, the individual units of such electrical conductors not to exceed the area of No. 7-0 gauge conductor..cwt.	Free	Free	Free	348d 778; 779
6036	Copper, in bars and rods, in lengths of not less than 6 feet, unmanufactured cwt.	5 p.c.	10 p.c.	10 p.c.	348c
6037	Copper, in strips, sheets, or plates; not polished, planished, or coated..cwt.	5 p.c.	10 p.c.	10 p.c.	348c
6038	Copper tubing in lengths of not less than 6 feet, and not polished, bent, or otherwise manufactured..... lb.	5 p.c.	10 p.c.	10 p.c.	348c
6039	Copper rollers adapted for use in calico printing..... \$	Free	Free	Free	370

TABLE V—Concluded

Rates of Duties on Brass and Copper and Their Products Entering Canada—
Concluded

No.	Article	Rate of duty			Tariff Item
		Prefer- ential	Inter- mediate	General	
6040	Copper wire, single or several, covered with cotton, linen, silk, rubber, or other material, including cable so covered..... \$	20 p.c.	27½ p.c.	30 p.c.	407
6041	Copper wire, plain, tinned, or plated.. lb.	15 p.c.	17½ p.c.	20 p.c.	406
6042	Copper wire cloth, or woven wire or copper..... \$	17½ p.c.	22½ p.c.	25 p.c.	418
6043	Copper, manufactures of, n.o.p..... \$	20 p.c.	27½ p.c.	30 p.c.	352

TARIFFS ON COPPER AND IMPORTS OF COPPER FOR
COUNTRIES OTHER THAN CANADA*United Kingdom (Great Britain and Northern Ireland)*

There is no Customs' duty on copper, copper wire, sheets, and similar states of manufacture entering the United Kingdom (Great Britain and Northern Ireland) from any country, except in the case of insulated wire in which the insulation includes silk. In this case, the silk component is dutiable.

Imports of Copper, etc., into the United Kingdom, 1927 and 1928*

(Long tons)

	1927	1928
Ore, matte, etc.....	39,832	45,809
Bars, ingots, etc.: Electrolytic.....	90,952	104,796
Other.....	39,280	39,208
Plates, sheets, etc.....	1,677	1,993
Rods.....	11,642	14,683
Tubes.....	1,881	2,074
Wire.....	4,736	4,312
Sulphate.....	302	429

*Imperial Institute publications.

Irish Free State

There is no Customs' duty on copper of the stated descriptions entering the Irish Free State; nor are there any silk duties.

Imports of Copper, etc., into the Irish Free State, 1927 and 1928*

(Long tons)

	1927	1928
Sheets, wire, tubes, etc.....	1,735	1,413
Sulphate.....	3,483	3,810

*Imperial Institute publications.

United States

Imports of Copper into the United States, 1927 and 1928*

(Long tons)

Copper content of	1927	1928
Ore.....	44,343	47,407
Concentrates.....	30,443	17,622
Matte.....	622	1,179
Unrefined.....	195,801	242,507
Refined.....	46,107	37,826
Scrap.....	3,565	4,735

*Imperial Institute publications.

Article	Rate of duty
Copper ore; regulus of, and black or coarse copper, and cement copper; old copper, fit only for remanufacture, copper scale, clippings from new copper, and copper in plates, bars, ingots, or pigs, not manufactured or specially provided for.....	Free
Manganese copper..... <i>ad val.</i>	25 per cent
Copper in rolls, rods, or sheets..... per lb.	2½ cents
Copper engravers' plates, not ground, and seamless copper tubes and tubing..... per lb.	7 cents
Copper engravers' plates, ground, and brazed copper tubes..... per lb.	11 cents
Phosphor-copper or phosphorus-copper..... per lb.	3 cents
All wire, composed of iron, steel or other metal, not specifically provided for (except gold, silver, platinum, tungsten, molybdenum)..... <i>ad val.</i>	25 per cent
All flat wires and all steel in strips not thicker than one-quarter of one inch and not exceeding sixteen inches in width, whether long or short lengths, in coils or otherwise, and whether rolled or drawn, through dies or rolls, or otherwise produced..... <i>ad. val</i>	25 per cent
Provided that all wire of iron, steel, or other metal, coated by dipping, galvanizing, sherardizing, electrolytic, or any other process with zinc, tin, or other metal, shall be subject to a duty of two-tenths of 1 cent per pound in addition to the rate imposed on the wire of which it is made.	

Argentina

Items are quoted from a consolidation of the Argentina tariff issued in January, 1927. It has not been found that any changes have been made in these rates since then.

Costs of a relatively minor nature connected with the entry of goods through the Argentina Customs comprise statistical fees, charges for warehousing, slingage, uses of crane, and stamps on documents. These charges are in addition to the duties shown in this statement.

Argentina has a common tariff for the world and duties apply equally, as far as is known, to imports from all countries.

The gold peso equals 96½ cents Canadian; one kilogram equals 2.2 pounds.

Article	Official valuation, gold pesos per kg.	Rate of duty levied on official valuation, per cent	Approximate Canadian equivalent of duty, cents per lb.
Copper wire, tinned.....	0.72	32	10.10
Copper scrap.....	0.24	32	3.37
Uncovered wire of copper of all kinds.....	0.72	32	10.10
Uncovered wire of copper of all kinds, up to 5 mm. (0.197 inch) in diameter.....	0.72	5	1.58
Copper bars, pipes, sheets, ingots, plates, and soldering irons.....	0.64	32	8.97
Copper solder.....	0.56	57	14.00
Wire or cables of copper, up to 5 mm. in diameter, covered with cotton, gutta-percha, or other materials, excluding those covered with lead or silk and flexible cords of all kinds.....	1.12	32	15.72
The same, more than 5 mm. in diameter.....	0.96	5	2.10
Wire or cables of copper, up to 5 mm. in diameter, covered with lead.....	0.80	32	11.23
The same, more than 5 mm. in diameter.....	0.80	5	1.75
Wire or cables of copper, any diameter, covered with silk.....	4.00	32	—
Wire or cables, strengthened underground, with interior envelope of lead and iron or steel armour.....	0.24	32	3.37
Flexible cords, with two or more conductors, of copper, twisted, in any diameter, covered with cotton, mohair, wool, or other materials, except silk.....	2.40	32	33.69
The same, covered with silk.....	4.00	32	—
Copper, pure metallic, in shavings, grains, filings, etc.....	1.60	32	22.46

Imports of Copper, etc., into Argentina, 1927 and 1928*

(Long tons)

	1927	1928
Ingots, sheets, and bronze.....	2,005	1,730
Sulphate.....	2,439	3,325

*Imperial Institute publications.

Brazil

Items are quoted below from a consolidation of the Brazilian tariff issued in 1927. It has not been found that any change has been made in these rates since it was published.

Brazilian duties are payable 60 per cent in gold and 40 per cent in paper. That is, 60 per cent of the rate shown in the tariff is considered as gold milreis (1,000 reis), equal to 54.6 cents Canadian, and 40 per cent as the paper milreis, equal to nearly 12 cents. In the case of goods dutiable on an *ad valorem* basis, the duty is calculated on the value of the goods in paper milreis and the amount thus arrived at is paid 60 per cent in gold and 40 per cent in paper. This results in a considerable increase in the actual *ad valorem* rate over the nominal rate as shown in the tariff.

In addition to the duty, there is at most Brazilian ports a port tax of 2 per cent *ad valorem* levied on an official value indicated by the tariff, and payable entirely in gold. This surtax has been included below in the conversion to Canadian equivalent. There are also some other surtaxes, but they are relatively of a minor nature.

The rates quoted on the next page would apply equally, as far as is known, to imports from any country.

Imports of Copper, etc., into Brazil, 1927 and 1928*

(Long tons)

	1927	1928
Ingots, plates, and bars.....	1,456	Not available
Blocks and scrap.....	3,585	6,604
Wire.....	914	269
Sulphate.....	718	1,639

*Imperial Institute publications.

Article	Rate of duty, payable 60% gold, 40% paper, per kg.	Approximate Canadian equivalent, including gold port-tax; per pound
<i>Copper and its Alloys, Raw or Wrought—</i>		
Copper, smelted, cast, in filings, blooms, bars, ingots, rods, etc., rolled in plates or sheets, with or without alloys..	200 reis	4 cents
Rods of copper, of a diameter not less than 14 mm. (0.55 in.) and not more than 15 mm. (0.59) in coils of 50 to 100 kg., rough brass or copper bars, 2 by 3 by 24 inches, scrap, filings, pieces, and waste of copper, brass, and bronze, also scrap wire of such metals, rough brass in bars, 2 by 3 by 24 inches; all these articles when imported by industrialists or manufacturers as raw materials for their industry.....	20 reis	0.4 cents
<i>Manufactures of Copper and its Alloys—</i>		
Plates, smooth, for engravers.....	1,000 reis	18 cents
Plates, engraved with the burin, with inscriptions for bills of exchange or other commercial papers or documents and the like.....	32,000 reis	\$5.77
Plates, engraved with the burin, for printing tissues and the like.....	8,000 reis	\$1.73
Plates, fixed upon lead or other metals and on wood.....	2,000 reis	36 cents
Wire, plain, in cords, strings, cables, cordage, and other wares—		
Uncovered or plain, of white, red, or yellow metal.....	400 reis	7.5 cents
Covered with paper, cotton, rubber, or any other composition, for whatever use.....	900 reis	16.75 cents
Gilt or silvered, or covered with silk, pure or mixed with cotton, wool, or linen, for whatever use.....	2,400 reis	45 cents
Covered with cotton and rubber with an envelope of lead or iron, for submarine or underground cables, telegraphs, telephones, the transmission of motive power, and all other electric installations.....	20% <i>ad. val.</i>	71% <i>ad. val.</i>
Wire gauze, in the piece.....	2,400 reis	43.25 cents
Wire gauze, in endless pieces for paper-making machines	1,210 reis	21.5 cents
Wire gauze, in articles of all kinds.....	4,000 reis	72 cents
Leaves for gilding and silvering.....	12,000 reis	\$2.16
Tubing of all kinds.....	500 reis	9 cents

Mexico

The following items are quoted from the Mexican tariff of January 1st, 1930, as amended by a decree of June 18th, 1930.

In addition to the duties quoted below, there is in Mexico a surtax of 2 per cent of the duties.

The rates would apply equally, as far as is known, to imports from all countries.

The peso equals almost 50 cents Canadian; one kilogram equals 2·2 pounds.

Article	Rates of duty, per kg. gross	Approximate Canadian equivalent, per lb.
Copper in ingots pieces, waste, shavings or filings.....	0·09 peso	2·45 cents
Wire, uncovered, of copper and its alloys, up to 2 mm. (0·079 inch) in diameter.....	0·30 peso	6·82 cents
The same, from 2 to 12 mm. (0·47 inch) in diameter.....	0·20 peso	4·54 cents
Wire, uncovered, of copper with core of iron.....	0·15 peso	3·41 cents
Cable, uncovered, of copper or its alloys.....	0·25 peso	5·68 cents
Cable, uncovered, of copper with core of iron.....	0·20 peso	4·54 cents
Bars of copper or its alloys, not specified in the complete tariff..	0·25 peso	5·68 cents
Sheets of copper, not specified in the complete tariff.....	0·25 peso	5·68 cents
Pipes of copper.....	0·05 peso	1·18 cents
Gauze of copper wire or its alloys, not specified in the complete tariff.....	0·85 peso	19·32 cents
Gauze of copper wire, of circular cut, containing more than five threads in one square centimetre.....	0·10 peso	2·27 cents

Imports of Copper, etc., into Mexico, 1927 and 1928*

(Long tons)

	1927	1928
Ingots.....	614	Not available
Bars, sheets, alloys, etc.....	144	Not available
Sulphate.....	936	Not available

*Imperial Institute publications.

Belgium

The rates of duty quoted apply to imports from all countries.

The Belgian franc equals 2·78 cents Canadian; 100 kilograms equal 220·4 pounds; one millimetre equals 0·0393 inch.

Article	Francs per 100 kg.	Approximate Canadian equivalent cents per lb.
Rough cast copper, in ingots, lumps, cakes, rosettes, blocks, sheets, anodes, filings, scrap, and waste of old wares.....	Free	—
Sheets, leaves, and plates, hammered or rolled, of copper and copper alloys:		
(a) Ordinary, simply hammered or rolled, even if corrugated.....	gross wt. 65	0·82
(b) The same, cut up otherwise than at right angles.....	net wt. 78	0·98
(c) Polished, tinned, lacquered, varnished or perforated (except plates polished for engraving and photo-engraving).....	net wt. 140	1·76
Plates polished for engraving and photo-engraving.....	net wt. 60	0·76
Thin leaves (less than 0·25 mm. in thickness) of copper, brass, tombac, and similar alloys.....	net wt. 275	3·46
Bars and wire of copper and copper alloys, simply rolled or drawn, of a thickness of more than 10 mm. (1):		
Cold drawn.....	gross wt. 65	0·82
Other.....	gross wt. 50	0·63
Bars and wire of copper and copper alloys, simply rolled or drawn, of a thickness of 1 to 10 mm. (1):		
Cold drawn.....	net wt. 78	0·98
Other.....	net wt. 60	0·76
Bars and wire of copper and copper alloys, simply rolled or drawn, of a thickness of less than 1 mm. (1)....	net wt. 97·5	1·23
Bars and wire of copper and copper alloys, other (polished, lacquered, varnished, nickelled, etc.).....	net wt. 210	2·64
Pieces of stamped sheet metal of copper (including machine parts), unworked, weighing each:		
50 kg. and more.....	net wt. 105	1·32
From 25 to 50 kg.....	net wt. 126	1·59
From 10 to 25 kg.....	net wt. 140	1·76
Less than 10 kg.....	net wt. 154	1·94
Cast, stamped, or forged pieces of copper and copper alloys, unworked, weighing each:		
(a) 10 kg. and more.....	net wt. 82·50	1·04
(b) From 1 to 10 kg.....	net wt. 99	1·25
(c) Less than 1 kg.....	net wt. 110	1·39
Cables and cordage of copper wire, not insulated, of wire of a diameter of:		
(a) 1 mm. and more.....	net wt. 105	1·32
(b) Less than 1 mm.....	net wt. 140	1·76

(1) The thickness is determined by the smallest dimension of the cross-section.

Imports of Copper, etc., into Belgium-Luxemburg, E.U., 1927 and 1928*

(Long tons)

	1927	1928
Ore.....	47,924	59,529
Rough copper.....	36,206	73,667
Sheets, wire, etc.....	4,135	5,061
Sulphate.....	45	111

*Imperial Institute publications.

France

The franc equals 3.92 cents Canadian; 100 kilograms equal 220.4 pounds; one millimetre equals 0.0393 inch.

Canada receives the benefit of the minimum tariff for the tariff items quoted below:

Article	Minimum Tariff, francs per 100 kg.	Approximate Canadian equivalent, cents per pound
Copper, pure or alloyed with zinc, tin, aluminium, or manganese:		
Ore and by-products (roasted ore, matte, slag, etc.).....	Free	—
Cementation copper, copper cast in lumps, grains, ingots, slabs, anodes.....	Free	—
Copper alloyed with zinc, tin, aluminium, or manganese, cast in lumps, ingots, or slabs.....	Free	—
Rolled or hammered in bars of any section, of which the greatest diameter is:		
50 mm. and more.....gross wt.	45	0.80
Less than 50 mm.....gross wt.	50	0.89
Drawn in bars, not exceeding 5 metres (16.4 ft.) in length, having a diameter of:		
50 mm. and more.....gross wt.	49.5	0.88
Less than 50 to 5 mm.....gross wt.	55	0.89
Less than 5 mm.....	Dutiable as wire of copper, pure or alloyed	
Rolled or hammered (1), in sheets of a thickness of:		
0.5 mm. and more.....gross wt.	57	1.01
Less than 0.5 mm.....gross wt.	75	1.33
Wire, polished or not, other than gilt, silvered, or nickelled, of a diameter of:		
Over 3 mm.....gross wt.	75	1.33
0.1 mm. to 3 mm. inclusive.....gross wt.	100	1.78
Less than 0.1 mm.....gross wt.	150	2.67
Gilt or silvered, in lumps or ingots, hammered, drawn, rolled, or in wire..... net wt.	800	14.22

(1) Copper, pure or alloyed, in leaves without consistence, pays two-thirds of the duties applicable to "hammered copper, gilt or silvered."

Imports of Copper, etc., into France, 1927 and 1928*

(Long tons)

	1927	1928
Ore and concentrates.....	7,256	3,969
Precipitate, ingots, etc.....	81,077	123,972
Scrap.....	6,216	20,786
Bars, sheets, and wire.....	3,740	5,450
Sulphate.....	21,050	25,820

*Imperial Institute publications.

Germany

In the following table, the figures in the paragraphs headed 'tare' represent the percentage to be deducted from the gross weight to arrive at the net weight for duty purposes.

There are no conventional duties for the items listed.

One reichsmark equals 23·8 cents Canadian.

Article	Reichsmarks per 100 kg.	Approximate Canadian equivalent, cents per lb.
Unwrought copper (in cakes or so-called 'rosettes,' blocks, bars, or slabs, in powder, etc.); copper coins; copper alloys, unwrought.....	Free	—
Rods, sheets, shells, and other forms, forged or rolled..... Tare.—Cases: brass sheets, 8; otherwise, 13. Casks: brass sheets, 5; otherwise, 13. Baskets, 6.	12	1·29
Wire (except cemented wire); iron wire with wire of copper or copper alloys wound round or plaited or twisted thereon,.... Tare.—Cases: weighing more than 50 kg., containing brass wire, 9; otherwise, 13. Casks: bronze wire, 3; weighing more than 50 kg., containing brass wire, 7; otherwise, 13. Baskets, 6.	12	1·29
Cemented wire..... Tare.—Cases, 13. Casks, 13. Baskets, 6.	40	4·32
Wire cable and rope, neither lacquered, polished, nor nickelled.. Tare.—Cases, 13. Casks, 13. Baskets, 6.	15	1·62

Imports of Copper, etc., into Germany, 1927 and 1928*

(Long tons)

	1927	1928
Ore, matte, etc.....	254,805	358,496
Rough copper.....	227,193	223,398
Coin and scrap.....	25,407	25,626
Bars, sheets, and tubes, etc.....	1,392	2,187

*Imperial Institute publications.

Italy

Canada receives the benefit of any Italian conventional duties.

The gold lire equals 19·3 cents Canadian; 100 kilograms equal 220·4 pounds; one millimetre equals 0·0393 inch.

Article	General tariff, gold lire per 100 kg.	Approx. Canadian equivalent cents per lb.	Conven- tional tariff, gold lire per 100 kg.	Approx. Canadian equivalent cents per lb.
Copper and alloys in ingots and scrap..... NOTE: By copper alloys are understood those in which copper is contained in a greater proportion by weight than any of the other metals constituting the alloy exception being made as regards alloys of copper with nickel, which are classified as alloys of nickel, whatever may be the proportion of that metal. Cast and electrolytic copper, rough, in ingots and in bars or plates, over three centimetres (1·18 inch) in thickness, are also classified as copper ingots.	4·0	0·35	—	—

Article	General tariff, gold lire per 100 kg.	Approx. Canadian equivalent cents per lb.	Conven- tional tariff, gold lire per 100 kg.	Approx. Canadian equivalent cents per lb.
Rods or bars of copper and its alloys:				
In the rough, of circular section.....	20.9	1.83	17.0	1.49
In the rough, of square, rectangular, or hexagonal section.....	24.2	2.12	20.0	1.75
In the rough, of other section.....	38.5	3.37	30.0	2.62
Rods or bars of copper and its alloys, polished tinned, nickelled, or otherwise worked....	Duty on rods or bars in the rough increased by:			
	10.0	0.875	—	—
NOTE: Rods and bars simply short- ened or rounded at the end are not con- sidered as worked.				
Leaves or sheets of copper and its alloys, in the rough, not cut (square or rectangular leaves and sheets are considered as not cut, even if they are trimmed) with a thickness of:				
0.6 mm. or more.....	19.2	1.68	16.0	1.40
Less than 0.6 mm. (excluding very fine ones for imitation gilding)....	30.0	2.62	25.0	2.19
Leaves or sheets of copper and its alloys, in the rough, cut or in rolled strips (leaves and sheets cut in any other form than rectangu- lar are considered as cut), of a thickness of:				
0.6 mm. or more.....	24.0	2.10	20.0	1.75
Less than 0.6 mm.	54.0	4.73	39.0	3.41
Leaves or sheets of copper and its alloys, pol- ished, tinned, or nickelled.....	Duty on corresponding plates, in the rough increased by:			
	10.0	0.875	—	—
Leaves or sheets of copper and its alloys, polished.....	—	—	Duty on corresponding plates in the rough in- creased by: 5.0 0.437	
Wire of copper and its alloys, as such, are con- sidered copper and its alloys passed through the drawing plate, of a diameter not greater than 4½ mm. Ribbon and strip of copper and its alloys, whether wound or not on threads of textile materials, receive the same tariff treatment as wire of copper and its alloys.				
Wire of copper and its alloys, in the rough, of circular section, with a diameter of:				
1 mm. or more.....	22.0	1.93	18.0	1.58
0.5 mm. or more, but less than 1 mm. .	33.0	2.89	28.0	2.45
0.2 mm. or more, but less than 0.5 mm.	44.0	3.86	38.0	3.33
Less than 0.2 mm.	66.0	5.79	55.0	4.82
Wire of copper and its alloys, in the rough, of other section.....	Duty on wires of circular section of similar diameter increased by:			
	10.0	0.875	8.0	0.7
NOTE: In determining the duty on wires of other section, the smallest thick- ness will be taken as diameter.				
Wire of copper and its alloys, varnished, tinned, or nickelled.....	Duty on wire in the rough increased by:			
	10.0	0.875	—	—
Wire of copper and its alloys, tinned.....	—	—	Duty on wire in the rough, increased by: 7.0 0.613	

Imports of Copper, etc., into Italy, 1927 and 1928*

(Long tons)

	1927	1928
Cupreous pyrites.....	5,258	10,313
Other ore.....	37	78
Ingots and scrap†.....	62,360	77,692
Bars, sheets, wire, etc.†.....	3,816	3,627
Sulphate.....	12,598	15,347

†Including brass and bronze.

*Imperial Institute publications.

Switzerland

Switzerland has a single column tariff. No reduced duties are shown as being granted to any country.

The Swiss franc equals 19.3 cents Canadian.

Article	Rate of duty, francs per 100 kg.	Approximate Canadian equivalent, cents per lb.
Pure copper and copper alloys, in bars, pigs, slabs, disc, etc.....	0.30	0.026
Pure copper and copper alloys, hammered, rolled or drawn, in bars or sheets, copper solder.....	10.00	0.87
NOTE.—Tubes merely shaped of copper and copper alloys are included in item No. 817.		
Copper solder (Hartlot) for soldering iron, copper, etc., is composed of copper, zinc, tin, and lead.		
Wire in coils, rolled, of copper and copper alloys.....	5.00	0.44
Wire in coils, drawn, of copper and copper alloys, having a diameter of:		
6 mm. or more.....	10.00	0.87
Less than 6 mm.....	15.00	1.31

The first item only is dutiable on gross weight; the other items have a minimum tare percentage of 10 to be added to the net weight. In cases where unpacked goods are presented for clearance, the tare percentage above shall be added to the net weight. If the packing of a consignment of goods does not, in regard to the weight of goods, reach the minimum tare percentage of 10, a further percentage up to the amount of such minimum tare may be added. If the tare percentage of a consignment is in excess of the minimum rate, the duty will be charged on the gross weight, and the unpacking of goods to ascertain the net weight to add on the minimum tare will not be allowed.

Imports of Copper, etc., into Switzerland, 1927 and 1928*

(Long tons)

	1927	1928
Ore, filings, and turnings.....	2,396	2,186
Bars, ingots, etc.†.....	13,312	15,754
Scrap†.....	895	664
Sheets, solder, wire, etc.*.....	4,940	6,276

†Including brass and bronze.

*Imperial Institute publications.

Japan

The rates quoted below apply equally to imports into Japan from all countries.

100 kin equals 132.3 pounds. The par value of a Japanese yen is 49.85 Canadian cents.

Article	Rate of duty, Japanese yen, per 100 kin	Approximate Canadian equivalent, cents per lb.
Copper ingots and slabs.....	7.00	2.64
Copper bars or rods.....	15.00	5.65
Copper plates and sheets.....	16.20	6.10
Copper wire not coated with metals and not exceeding one-half millimetre in diameter.....	19.30	7.27
Copper wire not coated with metals, exceeding one-half millimetre in diameter.....	15.70	5.92
Copper wire coated with base metals.....	20.40	7.69
Old or waste copper (fit only for remanufacture).....	7.00	2.64
Ore (including those calcined), matte, bottom, and slag.....	Free	—

Imports of Copper, etc., into Japan, 1927 and 1928*

(Long tons)

	1927	1928
Ingots and blocks.....	9,636	14,433

*Imperial Institute publications.

China

The rates quoted below would apply, as far as we know, equally to imports into China from all countries.

A picul equals 133½ pounds. On the present basis of conversion, a Haikwan tael is equivalent to 70 Canadian cents.

Article	Rate of duty, Haikwan tael per picul	Approximate Canadian equivalent, cents per lb.
Copper bars and rods.....	3.40	1.78
Copper ingots and slabs (including old copper remelted).....	2.20	1.15
Old or scrapped copper (fit only for remanufacture).....	10% ad valorem	
Copper sheets and plates.....	4.00	2.10
Copper wire.....	3.00	1.58
Unenumerated copper.....	10% ad valorem	
Ores, not otherwise enumerated.....	10% ad valorem	

Imports of Copper, etc., into China, 1927 and 1928*

(Long tons)

	1927	1928
Ingots and blocks.....	5,256	4,151
Bars, sheets, wire, etc.....	1,850	1,952

*Imperial Institute publications.

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