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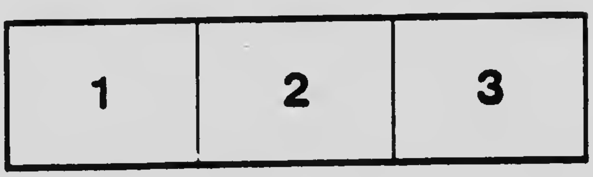

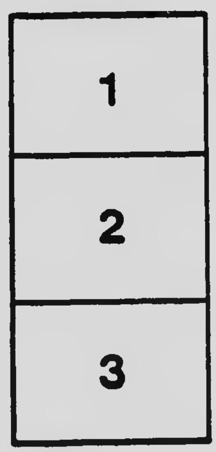

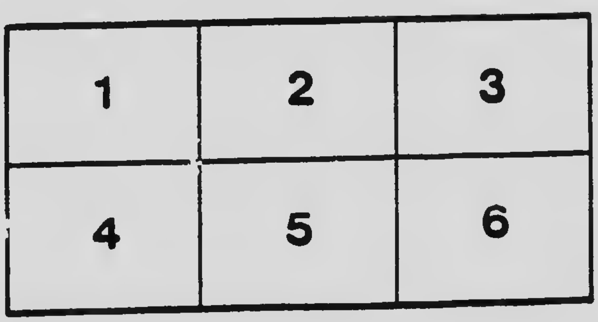

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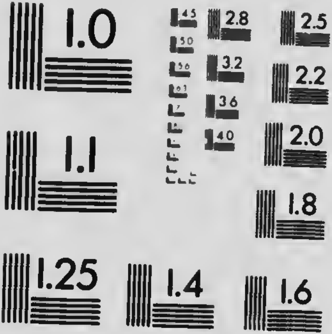

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PLATE I

Basic copper converters, Canadian Copper Co., Copper Cliff, Ont.

CANADA
DEPARTMENT OF MINES
Hon. Louis Coderre, Minister; A. P. Low, LL.D., Deputy Minister;

MINES BRANCH
Eugene Haanel, Ph.D., Director

The Copper Smelting Industries of Canada

By
Alfred W. G. Wilson, Ph.D.
Chief of the Metal Mines Division

OTTAWA
Government Printing Bureau
1913

35783—1½

No. 209

LETTER OF TRANSMITTAL.

To Dr. Eugene Haanel,
Director Mines Branch,
Department of Mines,
Ottawa.

Sir,—I beg to transmit, herewith, a report on the Copper Smelting Industries of Canada.

I have the honour to be, Sir,
Your obedient servant,
(Signed) **Alfred W. G. Wilson.**

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THE COPPER SMELTING INDUSTRIES
OF
CANADA

THE
COPPER SMELTING INDUSTRIES
OF
CANADA.

INTRODUCTORY.

This report presents an historical review of the development of the copper smelting industries of Canada, and includes descriptions of the plants that are now in operation. The first chapter is devoted to the historical treatment of the development of the copper smelting industries within the limits of the various provinces of the Dominion of Canada. Each of the next six chapters is devoted to the description of some one of the individual plants which were in operation (or were ready to operate) at the close of the year 1912. Thus the bulletin presents a fairly complete statement of the status of this industry in Canada at that date.

It is hoped that the description of the various plants, and the general account of their present practice which accompanies each plant described, will be found fairly complete. It is, however, obviously impossible to present a statement in minute detail of either equipment or practice. In some instances, local practices, which it appeared to the author might be of more than local interest, have been briefly described. For the most part the custom of very freely interchanging ideas, which commonly prevails among smelter men in America, results in the speedy spreading of a knowledge of new improvements invented, or discovered in any one plant: and most technical men are conversant with these improvements long before they could learn of them through the medium of a report like this. The period of time which necessarily elapses between the writing, and the publication and distribution of government reports, is usually too long to make them an important medium for the distribution of new knowledge in an old and well established industry. A report such as this, however, will serve several useful purposes: (1) it forms a record of the status of the industry at the time it was prepared; (2) it will serve to disseminate through foreign countries a knowledge of our industrial progress along the lines discussed; (3) it will offer to our home people the opportunity of acquiring a more comprehensive knowledge of those industries the magnitude and extent of which are little realized or appreciated, and (4) it may possibly be found useful to parties who are contemplating investments in the development of similar industries in other sections of the country.

The following descriptions have been compiled by the author from data obtained by personal visits to the various plants in question, and also from many articles published in the technical press. Every operating plant has been visited on at least two occasions. The final revision of the descriptive portions of the manuscript of this report was made at the plants described, during the months of November and December, 1912. The author is greatly indebted to the managements and to the principal technical officers of the various operating plants in Canada for the invariable courtesy which he has received at their hands; for the freedom with which he has been permitted to inspect their plants; and for their willingness to provide him with practically all the data for which he applied. In nearly every case he has had the most unusual advantage of having his manuscript revised at each plant by one of the principal technical officers at that plant.

The art of copper smelting is now a well known and well established industry. It is probable that more than 95 per cent of the metallurgical methods, appliances, and machinery employed at any one plant were evolved from the ideas of many investigators working at many different places. Only a very small percentage of the ideas involved in the construction and operation of any one plant are attributable strictly to local talent. The day has long since passed when the efficiency of any copper smelting plant, and its superiority to its fellows depends, except in rare instances, upon the careful guarding of its operating secrets. This conception is now so well recognized in the American copper industry that, practically, no copper smelting plant is closed to technical men who present proper credentials when applying for admission. The management of nearly all the larger industrial plants recognize that free interchange of ideas is of mutual advantage. In preparing this report every effort has been made to avoid introducing any descriptions of processes or methods which are considered business secrets by the operators. To make assurance doubly sure every chapter has been submitted to the executive staff of the works concerned for revision. The author is pleased to be able to state that while numerous small additions and corrections were added, no important sections were deleted in this revision.

A discussion of the general principles and practice of copper smelting and refining does not come within the scope of this report. The subject is too broad and too intricate, and there are already many valuable works on this subject prepared by abler and more experienced writers. Nearly all technical men actively engaged in these industries in Canada, have ready access to these works when they require them.

Chapter VIII is devoted to the discussion of several miscellaneous matters that seemed german to this report, but which could not well be taken up in the preceding chapters. One of these presents comparative data relative to the construction of the various water-jacketed smelting furnaces used in Canada: another relates to the use of basic lined converters.

This report is to be followed by a companion volume, descriptive of the copper mines and mining methods in Canada. In the next volume, descriptions of several important electric installations which supply power to both mines and smelters will be included. It was not considered advisable to include them in the present publication.

The author wishes to express his appreciation of the courtesies which he has received from the managements and principal technical officers of nearly all the important copper smelting plants in the United States which he visited for the purpose of making himself conversant with current practice. He is also indebted to the manufacturers of certain types of machinery, both for courtesies extended when certain of their plants were visited and for drawings from which some of the plates and figures in this report were prepared.

Reference should also be made to the courtesy of Mr. W. J. Carpenter, photographer, of Vancouver, who provided the original pictures from which Plates III, IV, and V were prepared, and to Mr. J. A. Macdonald, photographer, of Sudbury, who provided the original picture from which Plate II was prepared.

Other individual acknowledgments are made in the text.

CHAPTER I.

DEVELOPMENT OF THE COPPER SMELTING INDUSTRY.

Discoveries of copper ores in commercial quantities have, from time to time, been made in regions of Canada more or less remote from the settled districts and lines of transportation. With the development of the country, these localities have become more and more accessible, and it has followed that deposits of a grade so low that in early days they were valueless can now be operated at a profit. Be a deposit either remote or easily accessible, except in rare instances, it is always desirable to employ some method of concentration whereby transportation charges will accrue only on shipments of the more valuable portion of the ore. The various attempts that have been made to accomplish this, since the beginning of copper mining in Canada, have always had in view the purpose to recover the valuable constituents of the ore and make them commercially available at the lowest possible cost. In reviewing the history of the development of copper mining in Canada, we find that in nearly every centre where copper ores were discovered, various attempts were made to reduce the copper to the form most convenient for transportation. Thus, smelting or lixiviation processes were introduced at many different times and at many different centres. In only a very few instances were those plants operated for any length of time. Usually either the process was a failure or the supply of ore was not adequate.

The first copper smelting operations attempted in Canada were those of the Montreal Mining Company at the Bruce Mines near the end of the year 1848. The President of the Company, the late Honourable James Ferrier, brought a copper refiner and three furnace men from Wales. The first engine house was erected and the machinery installed in the autumn of that year. The firebricks for use in these furnaces were brought from England by sail boat to Montreal, and thence transhipped by boat up the St. Lawrence and through the Great Lakes to Bruce Mines. I have seen it stated that these bricks cost about twenty-five cents each laid down at the mines. The furnace no doubt was of the reverberatory type as used at Swansea for many years. No description of this first plant is available. The operations were not successful and the smelter was destroyed by fire a year or so later—probably in 1850. In later years, the slag made was sorted over, and the richer portion was shipped to England. Analyses made on portions of this slag, still on the ground in 1906, showed a copper content of about 2 per cent.[1]

[1] H. J. Carnegie Williams, Trans. Can. Min. Inst., Vol. X, 1907, p. 149.

During the next fifty years, we find that other plants were started at many points. As these plants were usually quite independent of each other, it has been found convenient to group those of each province by themselves, rather than to describe them chronologically.

It may be noted that the progress of development of the copper smelting industry in Canada has kept pace with developments elsewhere. It will be found that not a few of the improvements in practice, now widely used, were first worked out and perfected by smelter men working in Canadian plants.

The first large rectangular copper smelting furnace on the American continent was built at Eustis, Quebec, on the site of the present concentrating mill. This furnace was approximately 10 feet in length and 4 feet in width at the tuyères.[1]

Canada at present possesses two of the finest and most complete smelting plants in the world. Plans are under way for doubling the capacity of one of these plants. Two modern and fully equipped plants, each of about 2,000 tons capacity per day, are now under construction, and will probably commence operations some time in 1913. A third new plant is also under advisement for the Sudbury region, but it will probably be three or four years before it is in full operation. The original plant of the Canadian Copper Company began operations in 1888. This plant has been rebuilt several times, but it may be said to have been in continuous operation for twenty-five years, and it is accordingly the oldest plant in Canada. The ore reserves of the properties tributary to this plant are so enormous that it will probably be in operation in some form or other more than 100 years hence.

MARITIME PROVINCES.

The copper mining industry has always languished in the Maritime Provinces. Small deposits of cupriferous ores have been exploited from time to time, but no large deposit has ever been developed. Several attempts have also been made to recover the copper from its ores. The first of these appears to have been that of the Copper Crown Mining Company, who owned a number of prospects in Cumberland and Colchester counties, Nova Scotia. This Company was erecting reduction works a short distance east of the town of Pictou, Nova Scotia, in 1899, and the works appear to have been completed in 1900. In addition to a power plant, engines, and blowers, they were equipped with a hand operated roasting furnace, two small reverberatories, and a water-jacketed blast furnace. The principal dimensions of this furnace were as follows: size at tuyères, 36″ × 60″; hearth area, 15 square feet; centre of tuyères to feed floor, 8′-9″; centre of tuyères to tapping floor, 5′-2″; height of jackets, lower

[1] Personal letter, W. E. C. Eustis.

108″, upper, 27″; centre of tuyères to lower line of bosh, 6″; centre of tuyères to upper line of bosh, 70″; centre of tuyères to lower edge of jackets, 30·5″; bosh 6″; width of lower side jackets 60″; tuyères, 12 in number, each 4″ in diameter, and placed 12″ between centres, having a total tuyère area of 125·7 square inches.[1] It is probable that this furnace was in operation for a short time in 1901 on ores obtained from the district. I have not been able to recover any record showing the output of the furnace. The plant lay idle until 1907, in which year it was in operation for several months. Several hundred tons of ore from Newfoundland comprising one schooner load, together with a small amount of siliceous ore from a New Brunswick mine, were treated at this time. Shortly afterwards, the plant appears to have been dismantled.

The report of the Nova Scotia Department of Mines for 1902[2] refers to the operations of the Munro-Thompson Ore Reduction Co., near Westville in Cumberland county. It is stated that a leaching plant was under construction. This plant was to consist of two units of four tanks each, arranged in series, one above the other; one roaster has already been built and a smelter building was under construction. At that time it was expected that this plant would be ready for operation in 1903. In 1903 the name of the Company was changed to the Cumberland Copper Company, but we find no further reference to the operation of the plant.

The Intercolonial Copper Company, which owned claims near Dorchester, New Brunswick, was erecting an extensive plant in 1899 and 1900. This plant is said to have cost in the neighbourhood of $600,000. The ore found in this locality is a coarse grit or conglomerate in which small veins and masses of chalcocite occur in association with carbonaceous matter. The percentage of copper in the ore, as seen on the old dumps, appears very low. It was proposed to crush the entire output, and subject it to a roasting process. The roasted ore was to be treated with acids and the copper was to be recovered from solution by an electrolytic process. Soon after the completion of the plant, the manager died, and no further work appears to have been done. About 1909 the property was leased by the North American Reduction Company, of which Clarence Rogers[3] was secretary.

In October of this year, parties were operating an experimental plant here, trying out a sintering process. The plant in use consisted of a small upright furnace, 3 feet square in cross section, and about 6 feet in height, the top running to a straight stack. One 6″ tuyère entered the furnace from the back, at a point about 2·5 feet from the base; on the opposite side was a door. A sliding grate, operated by cams, was placed a short distance above the base of the furnace. On one side, about 5 feet above

[1] Peters, Practice of Copper Smelting, p. 146-7.

[2] P. 70.

[3] 1246 Commonwealth Ave., Alstown, Mass.

the base, a square feed trough connected with an automatic feeder leading from a mixing trough. The experiments are said to have been successful, but no details of the process are available, and no further operations appear to have followed these experiments.

Mention should also be made of the fact that about 1891, plans were prepared by Dr. E. D. Peters, Jr., for an extensive smelting plant to be erected near Watson point, on the North Arm of Sydney harbour. The chief supply of ore for this smelter was to be derived from the mine at Coxheath. A plot of ground, some 20 acres in area, lying between the Cameron road and the water front, and traversed by the Intercolonial railway, was selected as the site. This location was convenient for receiving fuel from the Cape Breton coal fields by either rail or water; it is about 6 miles from the mines, which were to be connected with it by rail. The plant was never constructed.

In 1902, the Colonial Copper Company was organized to exploit the native copper deposits in the vicinity of Cap d'Or, on the north side of the Bay of Fundy. Apparently it was planned to dress the ores, and to smelt the concentrate on the ground. A dressing plant was erected on a hill, high above the water supply, and appears to have been operated experimentally for a time. The smelter was not erected.

A small water-jacketed matting furnace was erected at the Freeze mine, in the township of Ireland, 8 miles south of Elgin, N.B. The capacity of this furnace was 25–30 tons of ore per day: matte made in the furnace was cast into pigs and carted to the railway for shipment. The date of the operations at this locality has not been ascertained, but it was probably about 1904 or 1905 since no mention of this mine is made by Dr. Ells in his bulletin on the Copper Ores of Nova Scotia, New Brunswick, and Quebec, published in 1904.

QUEBEC.

Lennoxville Smelter.—Discoveries of copper ores were made at several places in the Province of Quebec prior to 1860, and some ore was mined and shipped to Wales. One of these discoveries was that of the Ascot mine, by the late Thomas McCaw of Montreal. This property was prospected for some years by the owner, and in 1863 was sold to the Sherbrooke Mining and Smelting Company, a United States corporation. This organization also owned the Suffield and Hepburn mines. These operators erected a smelting plant near Lennoxville, Quebec, about 1864—at least they were operating a plant at that date. Mr John McCaw of Sherbrooke informs me[1] that in 1862 his father Thomas McCaw, and Walter Shanly erected two brick furnaces at Lennoxville to reduce the Ascot mine ore to a 50–55 per cent matte. He states that they also smelted

[1] Personal letter to the author, 1913.

a large quantity of ore from the Acton mine, the Ascot ore being used as a flux. The plant closed about 1865, owing to the drop in price of copper and the imposition of a heavy import duty on matte by the United States Government.

Adams Smelter.—About 1866 a furnace was erected by the late Captain R. C. Adams about a mile west of the site of the present concentrating mill at the Eustis mine. The ores for this plant were obtained from the Hartford mine about a mile and a half away.

Dr. James Douglas states[1] that these operators were using a small brick furnace with a capacity of about 10 tons of ore per day. The length of a campaign, to his recollection, was about 10 days, after which the furnaces had to be blown out and repaired.

Up to June, 1869, about 20,000 tons of ore had been smelted to 40 per cent regulus on the spot. This regulus was probably shipped to Bergenport, New Jersey, for further treatment. At about this time Captain Adams, anxious to conserve the sulphur, started a small sulphuric acid works near St. John, Quebec. There was, at that time, no market for the acid and the operations were soon abandoned. For the short time the plant was in operation, the copper was recovered from the cinder by Dr. James Douglas, using the Hunt and Douglas method.

Huntingdon Leaching Works.—Copper ore was first discovered at the Huntingdon mine (lot 8, con. VIII, Bolton) in August, 1865. In 1871 the mine was bought by a Glasgow corporation operating under the title of the Huntingdon Copper and Sulphur Co., Mr. John Rudda, of Cornwall, being local superintendent. The ore mined was shipped in part to Wales and in part to the United States. In 1872 a plant was erected for recovering the copper by the Henderson process. In brief the method of treatment consisted in roasting the ore on shelf burners to drive off most of the sulphur. The calcined ore was then recrushed, mixed with common salt, and recalcined. The product from these calciners was placed in vats and treated with hot water and dilute sulphuric acid, the latter being prepared on the ground. The solution thus obtained was drained off into other vats containing scrap iron, in which the copper was recovered as cement copper. Many tons of this precipitate containing 65-75 per cent copper are said to have been produced and shipped. In 1873 this plant was destroyed by fire with a loss of about $75,000. It was afterwards partly rebuilt and mining was carried on in a desultory fashion for several years more. The Company finally ceased operations in 1883. Some years later, in 1888, the property was reopened by the Nichols Chemical Company, and operated for a short time. It is probable that this firm erected a small brick smelting furnace about three-fourths of a mile south of the mine. An old slag pile and one sow, consisting largely of metallic iron, are still to be seen on

[1] Personal letter to the author, 1913.

the ground, and testify to smelting operations. No other record appears to have been preserved.

Orford Smelter.—In 1877 the Orford Nickel and Copper Company made an attempt to open a nickel mine on lot 6 of concession XII of the township of Orford, the ore being millerite in a gangue of chrome garnet, calcite, and actinolite. A small brick furnace erected at this time was in use experimentally for a very short time. No commercial development followed.

Eustis Smelters.—This same corporation, later reorganized as the Orford Copper and Sulphur Company, commenced operations in 1879 on lot 2, concession IX, of the township of Ascot, having leased the number 5, or Hartford shaft, of the Canadian Copper and Sulphur Company. This shaft at that time had a depth of about 500 feet. The ore body on which it had been sunk had an inclination towards the southeast, and had passed outside the boundaries of the lot on which the shaft collar was located. Mr. Eustis, who was actively connected with the Orford company, writes as follows with reference to the early operations of this Company[1] "I began my operations at Capelton, having at that time a lease of the old Scotch Company's mine and plant. A battery of pyrites burners was used; the cinder resulting from this was smelted in a blast furnace, and some of the resulting copper was refined into ingot at that point. I regret that I have not the data before me to state just how long operations were continued there, but probably not much after 1880. Smelting was continued at this point until the new smelting plant was built at Eustis where the present concentrating mill stands. It may be of interest to state that at Capelton was built, I believe, the first large rectangular copper smelting furnace on the American continent. I believe this furnace was approximately 10 feet long and 4 feet wide at the tuyères. It was built in about two weeks as an experiment. It was provided with two tapholes and I believe was operated with two No. 9 Sturtevant fans, or their equivalent. I remember distinctly to-day, Mr. John L. Thompson, who was in charge of operations, running down to the office and telling me that the double elephant was in operation, and to come up quick and see it. To my astonishment, I found, on arriving, two streams of slag and metal rolling from this furnace, each of which looked as big as my leg. It was a most surprising sight at that time."

"The plant at Eustis consisted of a battery of pyrite burners and two or more smelting furnaces, similar to the ones described above. This was operated for a few years, but we very soon got into trouble with the farmers over the smoke that was thrown out by the burners. The copper contents of the ores also diminished, and a market for the sulphur having developed, smelting operations at this point were discontinued. This plant has now

[1] Personal letter to the author, 1913.

been entirely removed and a large concentrating mill built in its place." From other sources it is learned that the roasting ovens had a capacity of about 1,200 tons per month, and the two cupola furnaces subsequently erected at Eustis a capacity of about 2,000 tons per month. The smelting plant was operated until about 1890. Since that date nearly all the ore has been shipped to United States points, the sulphur being utilized for acid making and the copper being afterwards recovered from the cinder.

Capelton Smelter.—The mines at Capelton were acquired[1] from the original owner, Mr. George Capel, by a Montreal company in 1863. Soon thereafter they passed into the hands of John Taylor and Sons, of London, England. The Taylors installed a plant to treat the ore by the Henderson process, but this did not give satisfaction, and the mine was closed. It subsequently changed hands several times and was finally purchased by G. H. Nichols and Company about 1885. In the year 1887 the chemical works at Capelton were first constructed after designs by J. B. F. Herreshoff. Eventually a fifty ton Herreshoff water-jacketed furnace was erected at the works to treat the cinder residues from the acid plant. A small amount of custom ore was also treated at this plant from time to time. The furnace was only operated intermittently for some years before the mines were finally closed in 1907.

Harvey Hill Concentrators and Smelter.—The copper deposits at Harvey Hill in the township of Leeds have been the subject of investigation by several different corporations since their discovery some time prior to 1850. The English and Canadian Mining Company, which was organized in 1858, erected a dressing floor after the oldest English models, using hand jigs and disregarding all labour saving appliances. The water supply was variable and inadequate, being derived from hillside reservoirs.[1] This Company got into financial difficulties, and was bought out by a Canadian company. The purchasers planned to erect a better dressing plant on the Palmer river about a mile from the mine. This plan was, however, abandoned in favour of the leaching method of Welply and Storer. This method, according to Dr. Douglas, "was based on sound chemical principles but was carried out by the adoption of as many mechanical complications as perverse human ingenuity could devise to frustrate success. Pulverized charcoal was added to the ore to create an intense heat in a shaft furnace where a most moderate heat was required. Storing pulverized charcoal in a room lined with canton flannel is as dangerous as storing lighted matches, and the mill, when it mysteriously caught fire, exploded rather than burned up, before the process had really had a fair trial." This was about the year 1866.

Work was suspended until 1870 when Dr. James Douglas, Sr., leased the property from the proprietors. The engine and boiler had been saved

[1] See Early Copper Mining in the Province of Quebec, by James Douglas. Jour. Can Min. Inst., Vol XIII, page 254.

from the fire and a good concentrating plant, provided with Rittenger jigs and designed on his general plans, replaced the Whelply and Storer leaching method. In 1872 the property was taken over by the Consolidated Copper Company of Canada. This Company expended most of its capital in barren exploitation, and eventually went into liquidation in 1879.

The property passed into the possession of a New York company. In 1882 this Company employed three men for about 10 months in unwatering one of the shafts with a windlass and bucket. Apparently the mine was examined at that time but no other work was done.

In 1888 the Excelsior Copper Company was organized to take over the property. They cleaned the shafts of water, repaired the timbering and buildings, and otherwise prepared for operating. They are said to have erected a crushing and concentrating plant, remains of which are still to be seen. They also put in a small blast furnace in which a considerable amount of ore, some of which was recovered from the old waste dumps, was reduced to matte. Coke for this purpose was brought from Nova Scotia, limestone was procured at Dudswell, Quebec, and some magnetic iron ore was brought from McVeity's mine near Kinnears Mills, Quebec. The plant was in operation in 1891, but appears to have closed down in the following year. The operations were not extensive and no record of the output is available. The expenses incident to the importation of coke and fluxes must have been too high to render the venture a profitable one.

Subsequently the property passed under the control of the Copperfield Mining and Milling Company, of which the late Dr. James Reed appears to have been the chief owner. A small amount of work was done in subsequent years and some ore was shipped. The mine was closed about 1899 and has been idle ever since.

Acton Smelter.—In the summer of 1909 a small 40 ton water-jacketed furnace was erected by Pierre Tetrault at the old Acton mine, lot 32, concession III, township of Acton. This furnace is circular in section, 50″ in diameter at the tuyères, and is provided with eight tuyères. The purpose in view was the recovery of the copper from the waste dumps of the old Acton mine. The rock associated with the copper ore is a dolomitic limestone, containing approximately 87 per cent calcium carborate and 10 per cent magnesium carborate, with about 1·6 per cent insoluble material, the balance being chiefly oxides of iron and alumina. There is also a small amount of copper, probably less than one per cent. No provision appears to have been made for concentrating the ore, or for procuring siliceous ores. So far as I am aware, there has been no production.

ONTARIO.

Bruce Mines.—The first copper smelting operations attempted in Canada were those of the Montreal Mining Company, at Bruce Mines in Ontario. The Bruce Mines location was purchased in 1847. In 1848 the late Honourable James Ferrier, president of the Company, brought a copper refiner and three furnace men from Wales. The Company also imported the bricks and machinery for constructing the plant. These supplies were sent to Montreal by sailing vessels and were thence transhipped up the St. Lawrence river and through the Great Lakes to Bruce. It is said that the bricks for the furnaces cost about twenty-five cents each delivered at the plant. The first engine house was erected and the machinery was installed in the autumn of 1848.[1] The furnace, no doubt, was of the reverberatory type as used at Swansea for many years. No description of the first plant is available. The operations were not successful and the smelter was destroyed by fire a year or so later—probably in 1850. In later years the slag was sorted over and the richer portion was shipped to England. Analyses made on portions of the slag, still on the ground in 1906, showed a copper content of about 2 per cent.

Wellington Leaching Plant.—The Bruce location and the adjoining Wellington location passed into the control of the West Canada Company. About 1860 they erected a crushing and dressing works, which was in operation, with some interruptions, until about 1875. About 1869 or 1870 the Company erected roasting furnaces and other appliances at the Wellington mines for the purpose of extracting the copper by a roasting and leaching method, probably the Henderson process. They also smelted all the precipitate from the reduction works, and parts of the sulphide. The experiments were not successful, probably in part because of the high price of salt and the difficulty of procuring scrap iron. This plant was in operation only during 1871-73.[2]

Ontario Smelting Works.—The discovery of the copper nickel deposits of the Sudbury region resulted in many attempts to treat these ores.[3] The first smelting plant installed in this district was that of the Canadian Copper Company. The first furnace was a 100 ton Herreshoff furnace, erected at the old, or East smelter under the direction of Dr. E. D. Peters, Jr., in 1888. This furnace was blown in on December 24, 1888. The

[1] Consult 'The Bruce Mines,' by H. J. Carnegie Williams. Trans. Can. Min. Inst., Vol. X, 1907.

[2] Compare Report of the Royal Commission, Ontario, 1890, page 403.

[3] See reports on Nickel and Copper Deposits of the Sudbury Mining District.
Dr. A. E. Barlow, C.G.S. 1904.
Dr. A. P. Coleman, O.B.M. XIV, part III, and The Nickel Industry published by Mines Branch, Ottawa, 1913.
Data compiled from these reports, from the Bureau of Mines reports, Ontario, and from other sources.

plant has been rebuilt several times in the last twenty-five years and is still in operation. It is described in chapter II of this report.

Murray Smelter.—The next plant erected in the Sudbury district was that of H. H. Vivian and Company at the Murray mine 3·5 miles west of Sudbury, on lot 11, concession V, McKim township. The plant consisted of two Herreschoff furnaces of about 80 tons capacity each. The first furnace was blown in near the end of September, 1890, using ore which had been heap roasted. The practice at that time was to produce a low grade blast furnace matte (Ni 9·4 per cent; Cu 4·7 per cent = 14·1 per cent) to reduce the slag losses. This matte was subsequently blown in a converter to a 75 per cent matte (Ni 49 per cent; Cu 26 per cent). The Vivians installed a Manhès converter for bessemerizing their furnace mattes; this converter, the first of its kind used in America, was installed in 1891. The mining and smelting operations were continued, with some minor interruptions, from 1889 to 1894, when the works were finally closed. The smelter was again operated between August, 1896, and January, 1897, in producing matte from about 6,000 tons of ore which had been mined by the Vivians. The matte was sold and shipped to Joseph Wharton, Camden, N.J.

Recently a new ore body has been discovered in the old Murray property by diamond drilling. It is said to contain over 5,000,000 tons of ore averaging fairly high in copper-nickel, but also containing considerable excess of silica. It is probable that a new smelting plant will be erected to treat this ore and ores from other mines owned by the same corporation.

Blezard Smelter.—The Dominion Mineral Company, owning the Blezard mine, lot 4, concession IV, Blezard township, erected a single Herreschoff furnace of about 110 tons capacity in 1890. The matte produced contained about 27·5 per cent nickel and 12·5 copper. It was marketed without converting. The Blezard mine was closed in 1893, but the furnace was kept in operation until 1895, chiefly on ore from the Worthington mine.

Drury Smelter.—In 1891 the Drury Nickel Company purchased the Chicago or Travers mine on lot 3, concession V, township of Drury, about 5 miles north of Worthington station on the Sault Ste. Marie branch of the Canadian Pacific railway. Mining operations were begun in February, 1891. They also erected a 60 ton water-jacketed furnace and established roast yards. In addition to the furnace the plant comprised three converters, two blowers, one double cylinder air compressor, one 45 H.P. engine, two 85 H.P. boilers, and two steam pumps. About 3,500 tons of ore were treated before it closed down in 1892. The following year, after nearly a year's idleness, some additional mining and smelting operations were undertaken for a short time. In May, 1896, the Trill Nickel Mining and Manufacturing Company took over the property and resumed both mining and smelting. Their operations ceased in July 1897.

Mount Nickel Smelter.—The Great Lakes Copper Company, in October 1899, purchased the Mount Nickel mine on lots 5 and 6, concession , Blezard township, and also the Trill mine, on lots 9 and 10, of concessions II and IV, Trill township. In 1900 they erected smelting works, on the design of Anton Graf of Vienna, where it was proposed to produce a high grade matte from green ore at one operation. The furnace house, 40′ × 36′ in area, contained two batteries of 5 furnaces each, the capacity of each furnace being 1,500 pounds of ore. The furnaces were to be fired by gas using also a small quantity of charcoal in the charge. The gas was to be produced by a more or less secret process from some of the more volatile distillates of crude petroleum. The gasometer provided in the gas house is said to have had a capacity of only 120 cubic feet. Air blast was to be supplied to the furnaces by two 14″ Sturtevant blowers. The process did not prove satisfactory and all operations ceased in May, 1901.

Mond Nickel Company's Smelters.—The Mond Nickel Company began operations in 1899. Their first smelter was erected in 1900 by Hiram W. Hixon. The site chosen was at Victoria Mines, close to the Canadian Pacific, Sault Ste. Marie branch, about 22 miles west of Sudbury, on the north half of lot 8, concession II, Denison township. The furnaces were first blown in early in 1901. This plant, with some minor interruptions, has been in continuous operation ever since. In 1912 the Company began the erection of a new plant at Coniston, about 7 miles east of Sudbury, on the main line of the Canadian Pacific railway. This plant will probably be ready for operation in July 1913, when the old plant at Victoria Mines will be closed down. The plants at Victoria Mines and Coniston are described in chapter III of this report.

Worthington Refinery.—The Hoepfner Refining Company of Hamilton erected a refining plant near Worthington station on the Canadian Pacific, Sault Ste. Marie branch, in 1889. This plant was designed for the electrolytic refining of nickel and copper. The process was not successful and the works were taken over by the Nickel Copper Company of Hamilton. Early in 1901 they erected a self-roasting plant designed to recover nickel and copper by the Frash process. This venture also did not prove a commercial success, and the plant was closed before the end of the year.

Gertrude Smelter.—The Lake Superior Power Company began operations at the Gertrude mine, south half of lots 3, 4, and 5, concession I, Creighton township, in 1901. Roast yards were prepared and a 150-ton Herreschoff furnace was erected. This plant was completed in June, 1902, and afterwards ran steadily throughout the year. Work was suspended in November, 1902. It had been planned to erect converter plant at Sault Ste. Marie, but the general suspension of the Company's numerous activities at this time appears to have caused these plans to be abandoned. The matte produced at this plant contained about 29 per cent nickel-copper, there being about twice as much nickel as copper.

Eldorado Smelter. The only copper smelting plant that has been erected in eastern Ontario is that of the Medina Gold Mining Company of Syracuse. The furnace is a water-jacketed cupola, 18″ in diameter at the tuyère, manufactured by the Allis Chalmers Company. It is provided with a 3-ton forehearth of the ordinary type from which the matter was tapped at intervals. The overflowing slag was received in unlined settling pots which were handled on small trucks. The charging floor is 12 feet above the matte floor. The furnace was blown in June 25, 1906, and was operated intermittently for some months. The ore contained 1-10 per cent of copper and was smelted without roasting; limestone and quartz were charged with the ore to form slag. The following is an analysis of one lot of ore somewhat higher in copper than the average[1]: Cu 16·10 per cent, Fe 21·90 per cent; S 28·51 per cent; Fe_2O_3 17·70 per cent; CaO 1·00 per cent; MgO 2·12 per cent; SiO_2 5·58 per cent; undetermined 3·76 per cent. The average charge consisted of ore 750 lbs.; coke 130 lbs.; low grade matte 110 lbs.; silica 135 lbs.; slag 175 lbs. The first matte produced varied from 15 per cent to 25 per cent copper. This was raised to 40 45 per cent matte by a second smelting. The plant was not operated in 1907 and has been idle ever since.

Thessalon Smelter. In the summer of 1907 the Algoma Custom Smelting and Refining Company erected a small reverberatory furnace at Thessalon on the shores of Lake Huron and about 1·5 miles from the railway. The furnace was built of brick; the hearth had an area of 12′ × 22′ approximately. There were three operating doors, and a matte outlet on one side and a slag outlet on the other. It was evidently intended to granulate the slag. The furnace was to be fired with producer gas furnished by a Nedell plant. The plant installed consisted of two pots 10 feet diameter and 15 feet high and accessory apparatus.

Eight ore bins were provided, into which ore could be dumped directly from railway cars, running on a track carried above the bins on a trestle. It was evidently the intention to install two jaw crushers on the feed floor below the discharge chutes of the bins.

The plant was provided with a large boiler, bricked in, an engine for driving the power shafting, and a smaller engine for operating a lighting dynamo.

There was also a Fairbanks car scale in the ore yard, a wagon scale in the coal yard, and a smaller scale on the charging floor.

A derrick, using clam shell buckets, was provided at the docks for unloading coal. The coal was distributed to storage heaps by small cars running on an elevated track. The coal yard lies nearly 100 yards from the producer house. Apparently coal was to be carried to the producer plant by wagons, being first loaded by hand, and then hauled completely

[1] O. B. M., 1907, XVI, part 1, p. 76.

around the house to a mast and boom derrick. Here it was elevated in buckets to the charging floor level and run into the feed hoppers of the producers.

The buildings on the ground are the ore bins, a smelter house, a producer house, an engine house, and an office building containing office, draughting room, chemical laboratory, and assay room. There were also three dwelling houses.

The smelting mixture used in the experimental work appears to have consisted of siliceous ore from the Herminia mine, limestone, and red iron ore; the latter seems to be rather siliceous. So far as could be learned the results obtained were not satisfactory. From the appearance of the furnace it is inferred that a freeze up took place soon after it was blown in, and the slag then formed was not cleared away.

BRITISH COLUMBIA.

Revelstoke Smelter.—The Kootenay Smelting and Trading Company erected a custom sampling and smelting works at Revelstoke in 1889. The plant was situated a short distance below the town of Revelstoke and convenient to the river to facilitate the unloading of ores and other freight from the river steamers. The sampling works had a capacity of 100 tons per day, and the smelting furnace about 60 tons. No further details appear to be available. There does not seem to have been a sufficient supply of ores in prospect, and the plant does not appear to have ever produced either copper matte or lead bullion commercially.

Golden Smelter.—A small smelting furnace appears to have been erected on Hospital creek near the town of Golden, in the year 1890. The next reference to this plant that I have been able to find, occurs in the report of the Provincial Mineralogist, for 1903. He states that the Labourer's Co-operative Gold, Silver, and Copper Mining Company, Limited, owned the Good Luck group of eight claims on the south fork of Canyon and MacLean creeks. In this year about 100 tons of ore were packed down from the claims to Golden for trial in the Company's own smelter. No results from this test are available; the smelter does not appear to have been operated commercially.

The furnace was a rectangular water-jacketed cupola, 38″ × 78″ at the tuyères, having a rated capacity of about 65 tons per day. The lower water-jackets rested on a cast-iron sole plate; the upper jackets were suspended from I beams carried on 4 columns. The upper portion of the furnace was of boiler plate and brick. Electric power to operate the plant was obtained from a water fall on Hospital creek, about 2 miles above the works.

Hall Mines Smelter.—The first important copper smelting plant to be erected in British Columbia was that of the Hall Mines, Limited, which was built in the year 1896, under the direction of Paul Johnson. The Company had been organized in England in 1895, as the Hall Mines, Limited, to operate the Silver King group of claims on Toad mountain, near Nelson, B.C. A Hallidie rope tramway 4·5 miles in length, having a descent of 4,500 feet, was constructed to convey ore from the mine to the smelter. The first furnace, having a capacity of 160 tons per day, was blown in on January 14, 1896. A second furnace, designed by Mr. Johnson, was blown in on September 5, 1896. This furnace had a daily capacity of over 275 tons of charge and was at that time probably the largest of its kind in the world.

In 1897 the smaller furnace was provided with a crucible, and some experimental work was done on lead ores, the result of which was the establishment of a custom business in lead smelting. Two roasting hearths, 16′ × 50′ each, and two reverberatory furnaces, 13′ × 17′ each, were also added to the equipment. These latter were used for refining copper matte to 98 per cent copper; the blister copper thus produced was sent to the Balbach refinery at Newark, N.J.

In 1900 the ore from the Silver King mine began to show deterioration in quality and decrease in quantity and it was decided to prosecute extensive development work at the mine. To procure additional capital the Company was reorganized as the Hall Mining and Smelting Company, Limited. The production of copper ores being small the large furnace was altered to make it suitable for lead smelting, and the small furnace was used for treating the Silver King ores. Two years later the Silver King mine ceased to be operated by the Company and operations were confined to custom work on lead ores. Meanwhile the mine was leased by a former superintendent, who succeeded in extracting a very considerable tonnage from the upper levels. Some of this was sent to Trail for treatment, and the bal[illegible] was treated at the Hall Mines smelter. In the ten year perio[illegible] December 31, 1906, this mine produced 200,466 tons of ore carryi[illegible] 963 ounces of silver and 13,948,178 pounds of copper, the average [illegible]ing 21 ounces of silver and 3·5 per cent copper per ton. In 1907 shipments were 2,279 tons of ore, containing 28,330 ounces of silver and 159,613 pounds of copper. Nearly the whole of this output was treated at the Hall Mines smelter. In 1905 it was decided to modernize the smelter; the plant was overhauled and some additions were made to the equipment for treating lead ores. The roasting equipment proved inadequate, but the Company's finances did not admit of further expenditures at that time. Eventually, a final clean-up was made and the plant went out of [illegible]mission in September, 1907.

During the height of its operations, this Company purchased ores from the Slocan, Lardeau, and East Kootenay districts, as well as from the territory tributary to the Nelson and Fort Sheppard railway. During the year 1905, ore supplies were drawn from 125 different mines; in 1906 these supplies came from 127 different properties. The majority of these were silver-lead producers.

Number 1 blast furnace was taken down in 1907. The valuable portions of the plant were sold, following the shut-down. The buildings were destroyed by fire on September 2, 1911.

Number 1 furnace at the Hall Mines smelter was erected in 1895 and was blown in on January 14 the following year.[1] It was a water-jacketed furnace, 42″ × 100″ at the tuyères. The feed floor was 17 feet above the matte floor, and 13′-1″ above the tuyères. The lower water-jackets were each 4′-6″ in height; they were suspended from I beams by legs and hangers. There were 12 tuyères, 6 on each side, each 3″ in diameter. The original hearth was built of brick on a solid foundation. This foundation was later replaced by a movable crucible, built within a steel plate frame, 21″ high, and resting upon a strongly braced cast-iron bottom. Pipes, 2″ in diameter, to carry cooling water, were laid above the cast-iron sole plate and tightly rammed in fireclay. On this a layer of firebricks was laid on end, the bottom of the crucible coming to within about 3″ of the water-jacketed tapping-hole. The crucible was mounted on jack screws having a 6″ play, and the whole was carried on a strong truck running on rails laid lengthwise beneath the furnace, and extending each way. The track in front was covered with iron plates, that at the back carried a duplicate hearth, thus permitting a quick replacement, when necessary.

The forehearth, 5 feet square, 2′-6″ in depth, was mounted on a truck, and was lined with red brick. Slag ran from the furnace into the forehearth and thence into a large wheeled slag pot, which trapped a small amount of matte; thence it dropped from a long iron spout into an iron lined water box, 4 feet below, where it encountered a strong stream of water by which it was granulated and washed away to the slag dump.

Matte from the forehearth was run along an 8 ft. solid iron gutter to a series of moulds mounted on a carriage, 18″ wide and 12′-8″ long. Each mould held 220 pounds of matte.

Number 2 furnace was erected from plans by Paul Johnson, and was blown in on September 5, 1896. It had a tuyère area of 44″ × 144″. The lower jackets were 5′-6″ in height, and at the level of the tops of these jackets the furnace cross section had an area of 64″ × 144″. At the level of the feed floor, 12′-6″ above the crucible, the section area was 72″ × 160″. There were eight tuyères, each with thimbles, 4·75″ in diameter, on each side. A side tap hole and an end tap hole were provided, the latter being the only one used, however. This furnace had a capacity of about 275 tons of charge per day.

The dust chamber was built of brick resting on a stone foundation. It was 175 feet in length, 8 feet in width, and 10 feet high. The stack

[1] Abstract, Report Provincial Mineralogist, 1896, Bulletin 3, pp. 80-82.

was built of red brick, resting on a granite foundation; the top was 177 feet above the base, and nearly 200 feet above the furnaces.

The refinery, as at first constructed, was a building 60′ × 100′, containing a hand-operated calcining furnace, 16′ × 50′, using wood fuel, and a reverberatory smelting furnace, 13′ × 17′. Both furnaces were built on slag foundations. They had an independent stack 65 feet in height. Subsequently, an additional furnace of each type was installed. In 1901 a straight line double hearth mechanical roasting furnace was constructed, apparently displacing the two older calciners. In 1905 a three decked Merton calciner, 9′ × 35′, was introduced, for treating lead ores.

The engine room was supplied with the necessary boiler and engine equipment. Root blowers were used for the blast furnaces, a number 6 blower supplying air at 20 ounces pressure to number 1 furnace.

The sampling plant was installed in a two story building, 40′ × 60′ in area. For matte sampling, a Blake crusher, 15″ × 20″ and Cornish rolls, 15″ × 30″, were used for crushing. Ore passed through a Fraser Chalmers, 10″ × 18″ crusher, and thence to rolls also 10″ × 18″.

The following are typical analyses of Silver King ores, as treated in number 1 furnace during the first year of its operation[1].

TABLE I.

Silver King Ore, Analyses, 1896.

	1.	2	3	4
Insol.	48·00	40·60	40·50	46·50
SiO_2		32·30	29·70	33·70
S	3·70	4·39	3·00	3·00
Al_2O_3	2·37 (?)	12·50	....	......
Fe	6·48	6·92	8·04	8·42
MnO	10·97	9·44	6·80	8·30
CaO	6·40	10·50	7·20	5·70
MgO	4·01	3·56	......	......
Cu	5·06	5·59	1·40	1·30
Ag	35·05 oz.*	30·00 oz.*	22·08 oz.*	32·00 oz.*

In smelting, about 10% of limestone was added to the charge. This limestone was a very pure crystalline limestone, brought to the works on scows from a point on Kootenay lake, 9 miles above Kaslo. The slags

* Per ton.

[1] Analyses given Bull. 3, B.C. Minister of Mines' Report, 1896, p. 82.

produced were very acid. The following are typical analyses: SiO_2, 41–44%; Al_2O_3, 15–25%; Fe, 7–10%; MnO, 8–10%; CaO, 11–14%; Ag, 7–9 ounces per ton; Cu, 0·025–0·035%. The mattes contained 45–50% copper, and 175–310 ounces of silver per ton. A typical matte analysis was: Cu, 43·00%; Fe, 19·7%; S, 23·6%; As, 0·06%; Sb, 0·50%; Mn, 4·90%; Zn, 1·5%; Ag, 1·0%; Au, trace (or 0·12 oz. per ton). The flue dust assays showed: Insol. 33·9%; C, 7·8%; Cu, 6·12%; As, 3·2%; Sb, 2·9%; Fe_2O_3, 10·3%; CaO, 4·7%; MgO, 5·8%; Al_2O_3, 1·9%; S, 9·52%; ZnO, 3·1%; Mn, trace; Ag, 37·6 ounces per ton.

In describing the practice in 1897 with the large furnace, Hedley gives the following analyses: [1] the ore was chalcopyrite, bornite, tetrahedrite, with a variable gangue. An average analysis gave: SiO_2, 33%; FeO, 9·5%; MnO, 8%; CaO, 7%; MgO, 4%; Al_2O_3, 15%; Cu, 4%; S, 3·2%; the limestone contained 10% SiO_2. The slag produced averaged SiO_2, 43%; CaO, 15%; FeO, 12%; MnO, 9%; Al_2O_3, 18%. In the two months' run that was being described they averaged 0·345% Cu and 1·15 ounces of silver per ton. The matte produced during the 60 day period, Sept. 5 to Nov. 5, 1896, was 1,029 tons, averaging 49% Cu, wet assay. The concentration was about 14·25 parts of charge into one of matte; at times a concentration of 20–1 was attained. During this 60 day period, 14,676 tons of charge, of which 1,587 tons were barren flux, chiefly limestone, were smelted. The coke varied 14·5–16 of the charge, according to the quality of the coke and the amount of S in the charge.

In 1898, when using custom ores, notably War Eagle ore, which at that time made 20% of the charge, the grade of the matte fell to 25%. This matte was crushed and roasted, and after grouting with quicklime was recharged to produce a 50% matte for the reverberatory refinery.[2]

The practice in refining was to calcine one-half of the matte produced. The first reverberatory was then charged with about 8,000 pounds of calcined, and 8,000 pounds of raw matte, and 1,200–1,500 pounds of quartz or siliceous material. In 12 hours this would tap a good bed of white metal (about 75% copper) and form a slag containing 1–1·5% copper, which was returned to the blast furnace. The white metal was then crushed and a portion of it calcined. The second reverberatory was then charged with 32,000 pounds of calcined and 8,000 pounds of raw white metal, with 600–800 pounds siliceous material. With the furnace in good condition and all things favourable, this would produce about 15 tons of copper in anode form in 24 hours. This anode copper averaged 97–98% copper and carried 300–800 ounces of silver and 5–30 ounces of gold per ton, according to the ore treated. The slag from the second reverberatory, carrying 12–16% copper, with some silver and gold, was charged to the

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[1] "Eng. and Min. Jour," 1897, Dec. 11.

[2] Hedley in report of Minister of Mines for B.C., 1898, p. 1087.

first reverberatory or to the blast furnace, it being particularly desirable in the latter under certain conditions. The anode copper was shipped to the Balbach Smelting and Refining Company at Newark, New Jersey. In later years, reverberatory furnace refining was discontinued and furnace matte was shipped to the Granby Company at Grand Forks for treatment in the Bessemer converters.

Trail Smelter.—The British Columbia Smelting and Refining Company, Limited, commenced the construction of the works at Trail about October 10 1895. The promoter and principal owner was F. August Heinze. The first furnace was fired in February, 1896, towards the end of July five furnaces were in operation. The main building was 310′ × 60′, and it covered the power plant as well as the furnaces. The plant originally installed consisted of four reverberatories and one blast furnace. The reverberatories each had a hearth area of 14′ × 22′, and a capacity of about 40 tons of charge per 24 hours. The charge consisted of roasted and green ore, slag, and limestone. The fuel used was wood, though some coal was also employed; this latter was brought from Anthracite, on the Canadian Pacific Railway main line, to Revelstoke and Arrowhead by rail, and thence by scows down the Arrow lakes and Columbia river to the smelter at Trail, where it was raised 160 feet up an incline by a small steam hoist and delivered to the storage pile. The furnace was a 40″ circular water-jacketed blast furnace, having six 3″ tuyères. The feed floor was placed 12 feet above the matte floor. This furnace had a capacity of 45-55 tons of raw ore per 24 hours. The coke used was brought from Fairhaven, Washington, and contained 20 24% ash. A small amount of limestone was added to the charge in smelting. The following is an analysis of slag obtained in 1896: SiO_2, 12 46%; FeO, 12 19%; Al_2O_3, 11 19%; MgO, 1 6%[1]. At this time ore was brought to the smelter from Rossland over a tramway.

In 1896, a new 200 ton water-jacketed blast furnace was installed. This furnace was 38″ × 120″ at the tuyères. The jackets were 5′-6″ in height; there were fourteen 6″ tuyères with thimbles of smaller size for experimenting. The feed floor was 14 feet above the matte floor.

On March 1, 1898, the Canadian Pacific railway took over the smelter at Trail. Since that time the plant has been remodelled several times.

The practice in 1898 was to stall or heap roast the ore, followed by smelting in a water-jacketed blast furnace. The resulting low grade mattes were crushed and roasted in Brückner cylinders and again smelted. The high grade matte was shipped to the United States.

In 1904 the plant consisted of 3 copper blast furnaces, 3 lead blast furnaces, 1 softening furnace, 2 O'Hara roasters, 6 Brückner roasters,

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[1] Carlyle in Bulletin 2, p. 19. Report Minister of Mines, B.C., 1896

10 hand roasters for lead ores, 24 roasting stalls, 2 lime-kilns, and 2 briquetting plants. There were also 2 sampling mills with a total capacity of about 1,200 tons of ore per day.

This smelter is still in operation and a more detailed description of the present plant is given in Chapter IV of this report.

Northport Smelter. Mention should be made of the fact that in 1897 the Le Roi Mining Company erected a smelting plant at Northport, in the State of Washington, to treat the ores from the Le Roi mine of Rossland. Since this plant was not located in Canada, it is not described.

Van Anda Smelter. In 1898 the Van Anda Copper and Gold Company began the erection of a smelting plant at Van Anda, Texada island, to treat rich copper ores derived from the Copper Queen, Cornell, and other mines in the vicinity. The plant was erected under the direction of Mr. Thomas Kiddie. The first furnace was a 42″ copper-lined cupola furnace, having a daily capacity of about 50 tons of charge. The charging platform was 11 feet above the floor. The track platform, in which ore was brought to the furnace, was 5 feet above the charging platform. The furnace was connected with the dust chamber by a goose neck, 36″ in diameter. The dust chamber was a brick structure, 30 feet in length, 10 feet in width, and 7 feet in height, fitted with one large iron door in the end, and three side doors, to facilitate cleaning.

Power was supplied by an 80 H.P. tubular boiler. There was also a 40 H.P. steam engine and the necessary feed water pump. Air for the blast was supplied by two Connersville blowers, with 14″ discharge; cooling water was supplied by a 4″ × 8″ Jeansville pump.

A wharf 400 feet in length, having 23 feet of water at its end at low water, was built in front of the works. A wagon road connected the mines and smelter. The nature of the ground was such that an inclined tramway and hoist were required to connect the mine road with the upper levels of the smelting works. These levels, in turn, were connected with the roasting yards and limestone quarry by a trestle. Three bins for ore and dumpage for 1,000 tons of coke were provided at the head of the inclined tramway.

The sampling works were located at right angles to the ore bins. They were equipped with a 12″ × 14″ Blake crusher, delivering to an automatic sampler. The sample passed a pair of 24″ rolls, and finally through a grinder.

The ores treated were a mixture of chalcopyrite and bornite, in a somewhat siliceous gangue. The practice was to roast in open heaps and then to smelt in the blast furnace. The limestone used as a flux was obtained from a nearby quarry.

The furnace was first put in blast on July 15, 1899. During the next $5\frac{1}{2}$ months, it treated about 5,000 tons of ore, and 450 tons of matte were shipped to an eastern refinery.

In 1900 a new 75 ton furnace was erected. The plant was operated periodically for the next two years, and appears to have finally closed in 1903.

Granby Smelter. The smelting works of the Granby Consolidated Mining, Smelting, and Power Company, Limited, are located at Grand Forks, British Columbia. Grading for the works was begun in October 1898, and construction commenced immediately thereafter. The plant was completed in August, 1900, and the first furnace was blown in during the latter part of that month; the second furnace was blown in in October of the same year. The plant has been enlarged and improved several times during the succeeding years. A detailed description of the plant is given in chapter V of this report.

Greenwood Smelter. The British Columbia Copper Company commenced preparations for their smelter plant at Anaconda, near Greenwood, in October, 1898. The plant was built under the superintendence of the designer, Paul Johnson, and was completed towards the end of the year 1900. The first furnace was a water-jacketed stack furnace, 42″ × 150″ at the tuyères. There were ten 3·5″ tuyères on each side. It was blown in on February 18, 1901. From February 18 to December 31, 1901, this furnace smelted 117,077 tons of ore from which were produced 3,714 tons of matte, assaying 45·60% copper, 2·6 ounces of gold, and 10·300 ounces of silver. These ores were Motherlode and Boundary ores, and some gold-quartz ores, containing 80–90% SiO_2, utilizing the basic character of the Motherlode ore. The largest tonnage was in December, when 13,098 tons of ore were smelted, giving a month's average of 422·5 tons per 24 hours. On January 10, 1902, this furnace smelted 459 tons of ore. Johnson gives the following as typical ore analyses:—

TABLE 11.

Analyses of Motherlode Ores, 1901.

	Ore rich in iron.	Ore rich in lime.	Sulphur ore
Cu	2·8 %	2·2 %	2·7 %
Au	0·11 oz.	0·09 oz.	0·15 oz.
Ag	0·58 oz.	0·18 oz.	0·43 oz
Insol.	28·7 %	35·2 %	29·8 %
Fused silica	16·9 %	29·2 %	21·5 %
Iron	32·7 %	11·7 %	17·5 %
Lime	5·6 %	19·8 %	16·0 %
Sulphur	3·7 %	5·3 %	13·7 %

The Motherlode ores were found to be exceptionally free from arsenic and antimony.

The following are some slag analyses obtained during the first year of operation of this furnace:—

TABLE III.

Analyses of Slags, Greenwood Smelter, 1900-1902.

	1900 Nov. 7.	1901 Apr. 1.	1901 July 7.	1902 Jan. 10.
SiO_2	42·7 %	33·8 %	30·9 %	37·8 %
Fe	21·1 %	25·4 %	32·5 %	24·5 %
CaO	20·0 %	25·7 %	16·8 %	20·9 %
Cu	0·33%	0·25%	0·11%	0·35%
Cu in matte	11·00%	49·00%	53·00%	49·00%
Tons ore smelted	393	402	399	159

The amount of coke used was 11·5–12% of the weight of the ore. The blast pressure was 14 ounces; the ore column gave the best results when maintained between 7–8 feet.

A second furnace was erected about 1902. A bessemerizing plant was installed in 1904. The plant was entirely remodelled in 1907. The works are still in operation, and a detailed description of the present plant is given in chapter VI of this report.

Crofton Smelter.—The smelter at Crofton, on Osborne bay, on the east coast of Vancouver island, was built by the Northwestern Smelting and Refining Company in 1901. It was originally constructed to treat ores from the Lenora and other properties on Vancouver island. A narrow gauge railway connected the mines with the smelter. Ore bins, 1,600 tons capacity, and a crushing and sampling mill were provided. The sample mill delivered to the furnace bins, from which ore was transferred to the furnace in hand barrows. The power plant included three 200 H.P. boilers, and one 500 H.P., 18″ × 42″ Corliss engine. The smelting plant comprised one 450 ton water-jacketed furnace, one 65-ton water-jacketed cupola, and a Bessemer converter. There was also a Garrettson furnace, which was designed to smelt and convert in practically one operation. The capacity of the plant was 400–500 tons of ore per day, and provision was made for further expansion, when necessary. The main flue was 200 feet in length and 12 feet in width, and was provided with an expansion chamber. The brick stack was 12 feet in diameter and 125 feet in height. The plant was completed in 1902, but lay idle for some years through lack of ore.

In 1905 it was acquired by the Britannia Copper Syndicate, who utilized it to smelt ore from the Britannia mine and from the Mount Andrew mine on Prince of Wales island. Ore was brought to the smelter dock in barges; it was unloaded by 10 ton grab-buckets, operated by two donkey engines, and loaded into bottom dump cars. Loaded cars were hauled by a 30-ton saddle-tank locomotive, over a narrow gauge track, to the main ore bins. From these bins the ore was drawn to the sample mill and thence to the furnace bins.

The Corliss engine operated a 70 K.W. generator, which supplied current for motors and for lighting, and the two Connersville blowers that supplied air to the furnaces.

The sample mill was equipped with Blake crushers and rolls; Vezin and Snyder samplers were both used. It was operated by an electric motor.

The large blast furnace was 44″ × 160″ at the tuyères, and was used for smelting ores. The Garrettson furnace was originally designed to smelt and convert in practically one operation. It was built in Victoria, and was provided with copper jackets, of which 11 were placed on each side and three at each end. It was surrounded by a wind box, and there were twenty-six 1·75″ tuyères on each side. The crucible was also provided with tuyères, 1″ in diameter, for delivering air at high pressure. The operation of this furnace as a smelter and converter combined was not satisfactory, and it was altered to adapt it to the requirements of ordinary smelting practice. The small 36″ water-jacketed cupola was used occasionally for remelting matte or for smelting ore.

The converter plant comprised one stand and four shells. The shells were 84″ × 120″ bowls, having a capacity of 15 tons of copper from 45% matte per 24 hours. Selected siliceous ores from the Britannia mine were used for lining. The converter, and several elevators, were operated by hydraulic power under 225 pounds pressure, supplied by a Smith [illegible]ile pressure pump.

The following are given by Hedley as typical analyses of materials used at this smelter in 1907: [1]

[1] Mining and Metallurgical Industries of Canada, Mines Branch publication No. 24, p. 231.

TABLE IV

Analyses of Mate ials Smelted at Crofton Smelter, 1907.

	Britannia ore	Mount Andrew ore	Limestone, Rochel harbour	Typical slag
Cu.	3·00%	2·50%		
SiO_2	56·00%	15·00%	2·5%	44·0%
Fe	15·00%	11·00%		27·0%
CaO	..	5·00%		11·0%
S	16·00%	7·00%		
Zn	2·00%			
Al_2O_3	2·50%	6·00%		
Ag per ton	0·40 oz.	0·50 oz.		
Au "	0·05 oz.	0·02 oz.		

The typical matte produced normally contained 15% copper.

The slag was granulated and flushed to the dump. Furnace matte was tapped into a converter ladle and charged into the converter.

The plant was closed about 1908 and has since been dismantled.

Boundary Falls Smelter. The Standard Pyritic Smelting Company began the erection of a smelting plant at Boundary Falls, about 3 miles below Greenwood, in 1900. The plant was completed early in 1901 and was soon afterwards taken over by the Montreal and Boston Copper Company, without ever having been used by its original owners. It was operated for some years by the new owners, with occasional interruptions, their operations ceasing on May 20, 1905. Towards the end of this year it passed under the control of the Dominion Copper Company, by whom it was intermittently operated until 1908. This Company was thrown into receivership near the end of the year 1908, and the properties were sold under foreclosure on June 1, 1909. It was reorganized as the New Dominion Copper Company, incorporated June 9, 1909; this latter Company acquired both the smelter and mining lands of the old organization. They rebuilt the power plant of the old smelter, which had been burned in 1908, but they do not appear to have operated the smelter. Ores from their mines were, in 1910 and subsequent years, shipped to the smelter of the British Columbia Copper Company. The plant has since been dismantled.

The original plant included three water-jacketed blast furnaces, 40″ × 176″ at the tuyères, with a nominal capacity of 300 tons per 24 hours. The Dominion Copper Company installed three Connersville blowers, a No. 7 and a No. 7½, each direct-connected to a 75 H.P. Erie engine, and a No. 8, direct-connected to a 125 H.P. Erie engine. Subsequently, when electric power became available, motors were installed, current being obtained from the power line of the Kootenay Power and Light Company.

In 1907 the Dominion Copper Company replaced one of the smaller blast furnaces with a larger furnace of about 600 tons capacity per 24 hours. This furnace had a tuyère area of 46″ × 255″, and was provided with 25 tuyères on either side. Air, at 18 ounces pressure, was supplied by a No. 9 Connersville blower driven by two 100 H.P. motors.

The smaller furnaces had room for an ore column of only about 6 feet above the tuyères. The new furnace had a higher stack and an available ore column of 10 feet. This furnace was also equipped with the Garous top for heating the blast. This device was used for two weeks, soon after the furnace was installed, and by its means the temperature of the blast was raised to 400° C. The behaviour of the furnace was not satisfactory, and hot blast was discontinued. Further experimentation was planned, but does not appear to have been carried out.

The plant was provided with a sample mill equipped with a Gates crusher, a Vezin sampler cutting one-tenth, rolls and a second Vezin cutting one-tenth, and rolls. The product from the last set of rolls was quartered on the sampling floor and further reduced in the bucking room.

Ore was brought to the plant in railway cars and delivered to receiving bins of 1,500 tons capacity. From these bins it passed a 36″ × 10″ Farrel crusher, delivering to an elevator, which in turn delivered to a belt conveyer which distributed to a system of 16 storage bins, each 10′ × 31′, having a total capacity of about 4,500 tons. There were also coke storage bins.

The dust flue, built of stone and brick, was 200 feet in length and the stack was 9′-6″ in diameter and 112 feet in height.

Ore was charged from side-dumping cars delivering to an inclined plate provided with swinging baffle plates within the furnace. These cars were hauled by 3-ton electric locomotives.

The slag was received in ordinary settlers, inside dimensions 10′ × 12′ × 3′ for the large furnace, and 7′ × 8′ × 3′ for the two smaller furnaces. Each furnace was also provided with a smaller secondary settler. From the small settlers the slag followed to slag cars, the bowls of which had a capacity of about 45 cubic feet and held 4 tons. A 12-ton Davenport locomotive was used for hauling these to the dump.

Matte was tapped by launder into shallow cast-iron moulds. It was sent to the British Columbia Copper Company's plant at Greenwood for converting. The matte carried about 45-50% copper.

Tyee Smelter. The Tyee Copper Company erected a smelting plant at Ladysmith, Vancouver island, in 1902, the plant being built under the superintendence of Mr. Thomas Kiddie. The original equipment consisted of one 150-ton water-jacketed blast furnace, together with a complete sampling plant, storage bins, power plant, and extensive roast yards. Subsequently an additional furnace was added. Although the plant is not in actual operation at the time of writing, it is expected that it will be working again within a short time. As the plant is one of the most important on the Pacific coast, and as it is still complete and ready for operation, a more detailed description is given in chapter VII of this report.

Kamloops Smelter.—The Kamloops Mines, Limited, who were operating the Iron Mask mine, near Kamloops, B.C., installed a small water-jacketed blast furnace in 1904. This furnace was 36″ in diameter, with an 8 ft. shaft, and a bell-hopper feed. There were three jackets, each 6 feet in height and provided with two 3″ tuyères, six in all. Air was furnished by a small Root blower. Provision was made for heating the blast by passing it through a large pipe, which completely encircled the downcomer for the waste gases from the furnace. This downcomer was carried horizontally from the chamber at the top of the furnace to the stack, some 25 – 30 feet distant. A centrifugal suction fan was used to maintain a draft. The furnace was in blast for a short time. It is said to have had a capacity of about 50 tons of ore per day, in addition to fluxes. In all, about 2,644 tons of ore, containing about 5% of copper, were treated in this furnace during the time it was in operation.

Anderson Oil Smelter.—Mention should also be made of the experimental work of the Dominion Oil Smelting Company, of Vancouver. In 1910 they erected an experimental oil-burning furnace in the building of the old smelting works at Van Anda, Texada island. This furnace was based on the patents of James J. Anderson. As the result of a series of experimental runs, the original construction was remodelled. The plan and section of the remodelled furnace are shown in the adjoining sketches (Figures 1 and 2) and will serve to give a general idea of its construction. The furnace is essentially a reverberatory furnace with a shaft-furnace stack superimposed above the distal end. Further details will be found in Canadian Patent Number 104553.

An experimental run was made under the supervision of Mr. Thomas Kiddie, M.E., of Vancouver, in July, 1911. Mr. Kiddie reports that the cost of oil consumed should approximate 30 to 35 cents per ton of ore smelted, and he estimates the saving of labour cost at the furnace at 9 cents per ton of ore smelted. The cost of oil per barrel is not stated; it would probably be around 85 cents.

As a result of this run, Mr. Kiddie made several recommendations with regard to remodelling the furnace. After being remodelled along these lines, a fuel cost of 33·6 cents per ton was attained, Mr. W. C.

FIG. 1. Anderson oil burning copper blast furnace.
Vertical section through shaft and burner.

Thomas, metallurgist, of Vancouver, being in charge. This run took place in November, 1911. So far as I have been able to ascertain, no further experiments have been made.[1]

[1] See Report of the Bureau of Mines, British Columbia, 1911, pp. 196.

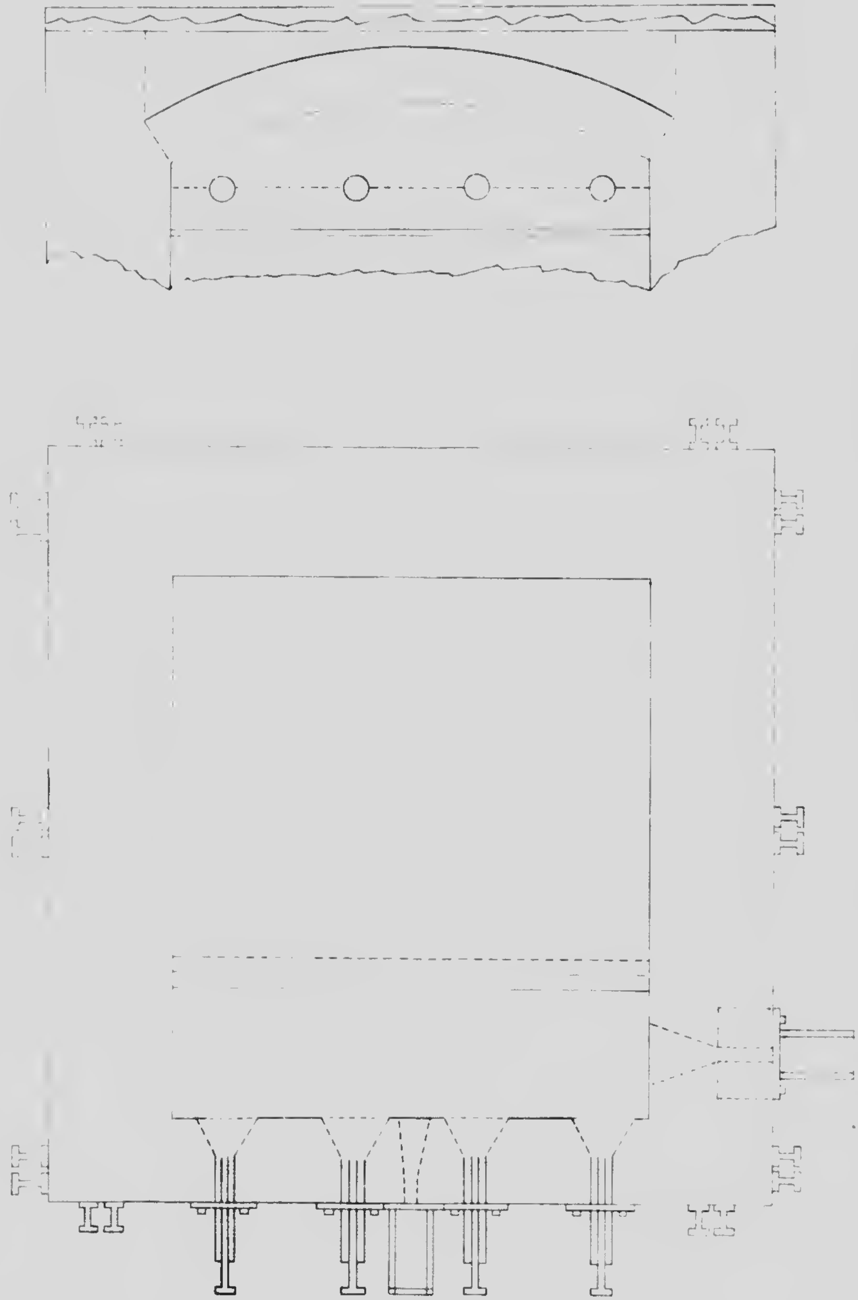

FIG. 2. Anderson oil burning copper blast furnace. Plan and elevation of hearth.

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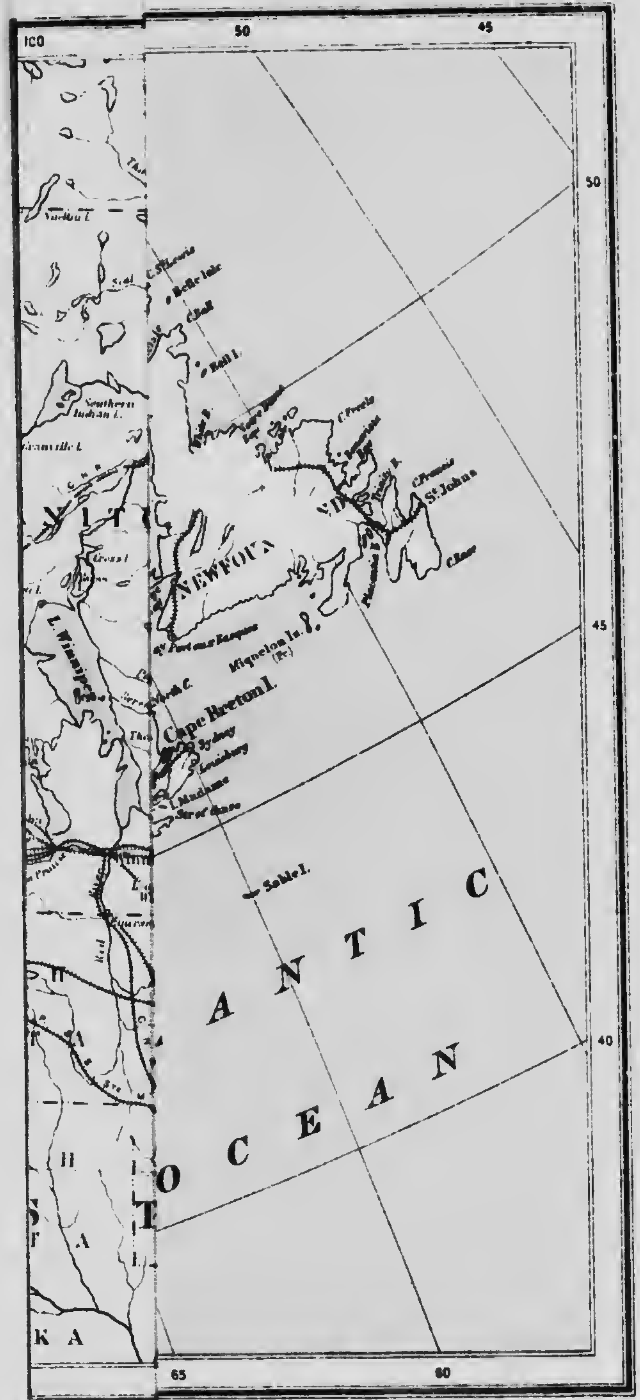

MAP No. 210

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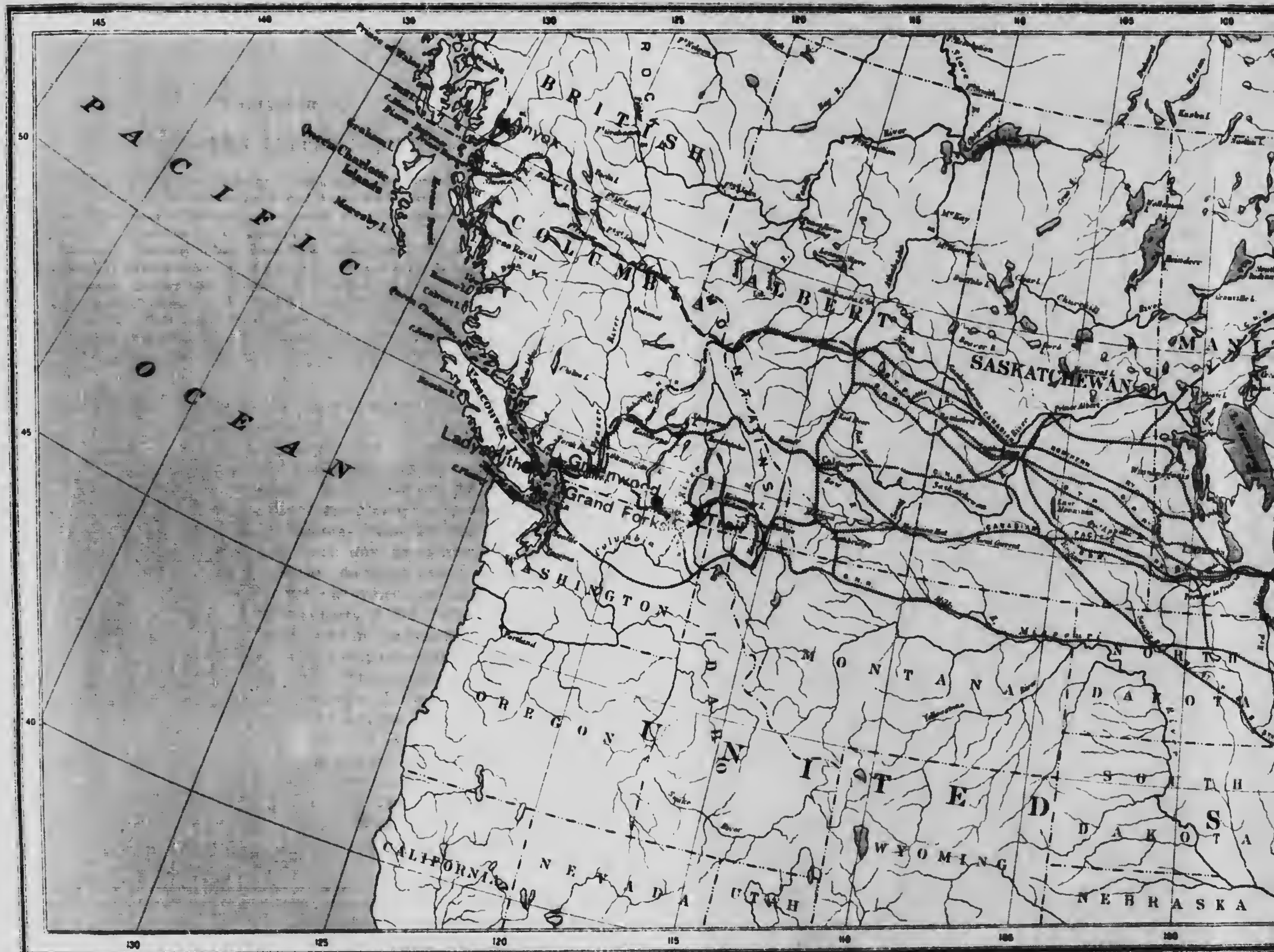


H. E. BAINE, Chief Draughtsman
Base Map Dept. of Interior

Location of Cop

Scale, 1:12,500

DEPARTMENT OF MINES

MINES BRANCH

MAP No. 11?

...of Copper Smelters in Canada

● Copper Smelter

...le, 1:12,500,000 or 197·3 Miles to 1 Inch

CHAPTER II.

CANADIAN COPPER COMPANY.

INCORPORATION.—Incorporated January 6, 1886, under the laws of the State of Ohio. Licensed to operate in Canada by special Act of Parliament. Authorized capital, $2,500,000 in shares of $100 each. All issued. *President*, John Lawson, Copper Cliff, Ontario; *Vice-President*, B. G. Slaughter, Copper Cliff; *Secretary-Treasurer*, James L. Astley, 43 Exchange Place, New York; *Metallurgical Engineer*, D. H. Browne, Copper Cliff; *Chief Engineer*, G. E. Sylvester, Copper Cliff; *General Superintendent*, J. L. Agnew, Copper Cliff; *Assistant to the President*, A. D. Miles, Copper Cliff; *Superintendent of Mines*, J. C. Nichols, Copper Cliff; *Superintendent of Smelter*, William Kent. *Head Office*, 109 Superior St., Cleveland, Ohio, U.S.A; *Mine and Smelter Office*, Copper Cliff, Ontario. This Company is controlled by the International Nickel Company of New Jersey, through ownership of practically the entire capital stock.

General.—This Company is the largest producer of nickel ores in the world, and is also an important copper producer. The Company owns large areas of mineral lands in the Sudbury district, Ontario, and holds mining leases on additional areas. It also owns the Alexo mine on lot 1, concession III, township of Dundonald, in the Porcupine Mining Division. The principal mines operated by the Company are the Copper Cliff (now idle), Number 2 mine (now idle), Creighton, Crean Hill, Stobie (now idle). Extensive development work is now under way, preparatory to reopening the old Number 3 mine, now the Frood, on which one of the largest ore bodies of nickeliferous pyrrhotite yet discovered has been located and proved by diamond drilling. A quartz quarry at Dill, about 15 miles south-east of Copper Cliff, supplies silica for use in the converters, there being no available siliceous copper ores. The Company owns and operates the Ontario Smelting Works at Copper Cliff. This smeltery is equipped with six 50″ × 204″ water-jacketed blast furnaces, of about 400 tons capacity each; two Steptoe reverberatory furnaces, hearths 19′ × 112′, coal dust fired, for treating flue dust and fine ore; four Wedge roasting furnaces, each with 7 hearths and 22′-6″ in diameter; the converter plant consists of 5 stands and 5 shells, besse.. er basic converters, of special design. These basic converters are each 37′–2″ in length and 10′ in diameter; the shells are operated by hydraulic machinery, oil being used in place of water.

The Company also owns and operates a small silver smelter, treating ores from the Cobalt district, Ontario.

The other possessions of the Company include about 20 miles of standard gauge railway and operating equipment, and a hydro-electric installation at High Falls, on the Spanish river. The latter plant is operated by a subsidiary corporation, the Huronian Power Company.

ONTARIO SMELTING WORKS.[1]

Location.—The smelting works are located at Copper Cliff, Ontario, about 4·5 miles west of Sudbury, on the "Soo" branch of the Canadian Pacific railway.

Historical.—The first blast furnace was installed at the old, or East smelter, in 1888, under the direction of Dr. E. D. Peters, Jr., and was blown in on December 24 of that year. This furnace was a 100-ton Herreshoff. A second furnace installed in the same building was blown in on September 4 of the following year. These furnaces were operated for some time on ore obtained from the Copper Cliff, Stobie, and Evans mines. Later, ore was received from Number 2 mine and from the Frood. The opening of the Creighton mine in 1901 and the increased supply of ore led to the addition of three other furnaces between the years 1900–1902. The first bessemer plant was commenced in 1891 and completed in January of the following year.

In 1899, during the superintendence of James McArthur, the West smelter was erected near Number 2 mine. This smelter at first contained only four furnaces; soon afterwards four additional furnaces were added. The old or East smelter suspended operations in 1902.

In 1900 the Ontario Smelting Works were erected by the Orford Copper Company, a company closely associated with the Canadian Copper Company and one of the corporations included in the amalgamation in 1902 by which the International Nickel Company took over the interests of a number of other minor corporations. The first site of the Ontario Smelting Works was a short distance west of the Copper Cliff mine, nearly a mile from the West smelter. This plant was erected at the time of the adoption of a new method of increasing the grade of the matte, bessemer converters having hitherto been used for this purpose. In this plant low-grade matte was ground in a ball mill and roasted in long calcining furnaces of the Brown type, and then resmelted in brick cupolas to a matte containing 5–8% of iron and approximately 75% of copper and nickel.

In 1902 the International Nickel Company was organized under the laws of the State of New Jersey to take over the interests of a number of mining companies and smelter companies owning properties in Canada, United States, Great Britain, and New Caledonia. This amalgamation included the properties of the Canadian Copper Company, the Orford Copper Company, the Anglo-American Iron Company, the Vermilion Mining Company, the American Nickel Works, the Nickel Corporation,

[1] The author is particularly indebted to Mr. D. H. Browne for information and assistance when this chapter was being prepared. The drawings have been prepared from plans supplied through the courtesy of the Vice-President, Mr. B. G. Slaughter, and Mr. Browne. The plates are from photographs by J. A. McDonald, of Sudbury; Plate II has been copyrighted by Mr. McDonald, and is published by permission.

Limited, and the Société Minière Calédonienne. This corporation operates its Canadian business under the charter and title of the Canadian Copper Company.

In the meantime, the new method of raising the grade of the matte proving unsatisfactory, it was decided to build a new smelter, incorporating a number of improvements—the result of the experience gained in the earlier operations. A site was selected on a hillside, about half a mile from the now old West smelter, not far from the original East smelter, but on higher ground. These works were completed in 1904. During the period of construction, both the West smelter and the Ontario Smelting Works were badly damaged by fire, greatly interfering with the work. For a period of six months preceding the completion of the new works, the smelter of the Mond Nickel Company at Victoria Mines was leased and used for bessemerizing low grade matte, pending the completion of the converter plant at the new smelter. The new plant contained two blast furnaces of about 400 tons capacity each. In 1905 it was again enlarged to a capacity of five 400-ton furnaces, and the converter plant was installed in a separate building. This converter plant consisted of 10 stands and shells, Allis-Chalmers type, 8′ × 10′, using a siliceous lining, capacity about 5-7 tons of bessemer matte without relining, according to the grade of furnace matte charged into the converter. After conducting a series of experiments, these converters were discarded in 1911 and 5 basic lined converters, a modified form of the Peirce and Smith basic converter, were installed. The new converters have proven very satisfactory and the operation of converting has been much simplified by the change.

In 1911 work was begun on the construction of two Steptoe reverberatory furnaces, hearth area 19′ × 112′ each. These furnaces are fired with coal dust blast: the first one was blown in near the end of December, 1911; the second in 1912.

In 1912 a new blast furnace and the foundation for a third reverberatory furnace were added to the smelting equipment. Four standard seven hearth Wedge roasting furnaces, each 22′-6″ in diameter, were also under construction late in the autumn. All the new plant will probably be in operation early in the present year (1913).

General Statement of Equipment.—This plant, as at present constituted, is considered to be the most complete and 'up-to-date' plant of its kind in the world. The equipment includes six water-jacketed blast furnaces, five 50″ × 204″, and one 50″ × 240″, five basic converter stands and five shells, 10′ × 37′-2″, hydraulically operated with oil instead of water. There are two coal dust fired McDougall reverberatories, hearth area of each is 19′ × 112′; and four Wedge roasting furnaces. The mechanical and construction departments are equipped to handle any work that may be required at the plant. The shops include a foundry, car and carpenter shops, machine shop, boiler shop, pattern shop, and storage.

There are also a number of warehouses. The power is electric, a transformer station being located at the works. An auxiliary steam plant is installed for emergencies. There are extensive roast yards about half a mile from the smelter and large storage bins at the smelter, above the level of the charging floor. Transportation is provided by standard gauge railway tracks on several levels, and by electric haulage lines on the charging floor level and on the converter floor level.

Smelter Site.—The site of the present smelter was chosen after very careful contour surveys had been made of all available ground. The nature of the ground made it necessary to design the plant for the most efficient handling of supplies and products on a site where the difference in elevation would be 67 feet between the tops of the storage bins and yard grade. Provision has also to be made for a slag dump. A reference to the accompanying Plate II and to the ground plan (Figure 3) will show the general arrangement of the plant. The storage bins, dust chamber, stack, sampling building, and laboratory are all built on solid rock; the furnace building, the reverberatory plant, the steam power house, and the electrical sub-station are partly on rock, and partly on built ground. The other buildings, chiefly shops and warehouses, are on built ground, made by pouring slag to a depth of 7–20, as the nature of the topography required.

Ore Bins.—The ore bins on the side hill above the furnace building, parallel to it, and 200 feet distant, are of massive timber construction, with bents resting on masonry footings at 6 ft. centres. These bins are 700 feet in length, 35 feet outside width, 30 feet inside width, and 32 feet in height. They are subdivided into pockets of different lengths, according to the material and quantity to be handled. They carry two standard gauge tracks at 15 ft. centres. They are covered with a running shed, sheeted and roofed with $\frac{3}{16}''$ asbestos lumber, and have a continuous louvre ventilator. The total storage capacity is about 400,000 cubic feet. The bin bottoms are double hoppered, with curved bin gates every 6 feet, directly over the charging tracks. These gates are a [illegible]ated type, convex on the under side and hand-operated by gear cranks. Beneath the bins, on the level of the charging floor, run the two parallel tracks, 36″ gauge and 15 ft. centres, on which the charge trains are operated. These bins receive ore from the roast yard, green ore from the mines, slag and scrap from the furnaces and converters, coal, coke, quartz, clay, and limestone.

At one end of the bins is a set of 3-ton suspender track scales, one on each track. The beams and the office for the weigh clerk are placed between the tracks. A similar pair of scales are also installed near the centre of the bins. Beside the scales are small open bins, holding ore or other material for adjusting the components of the charge.

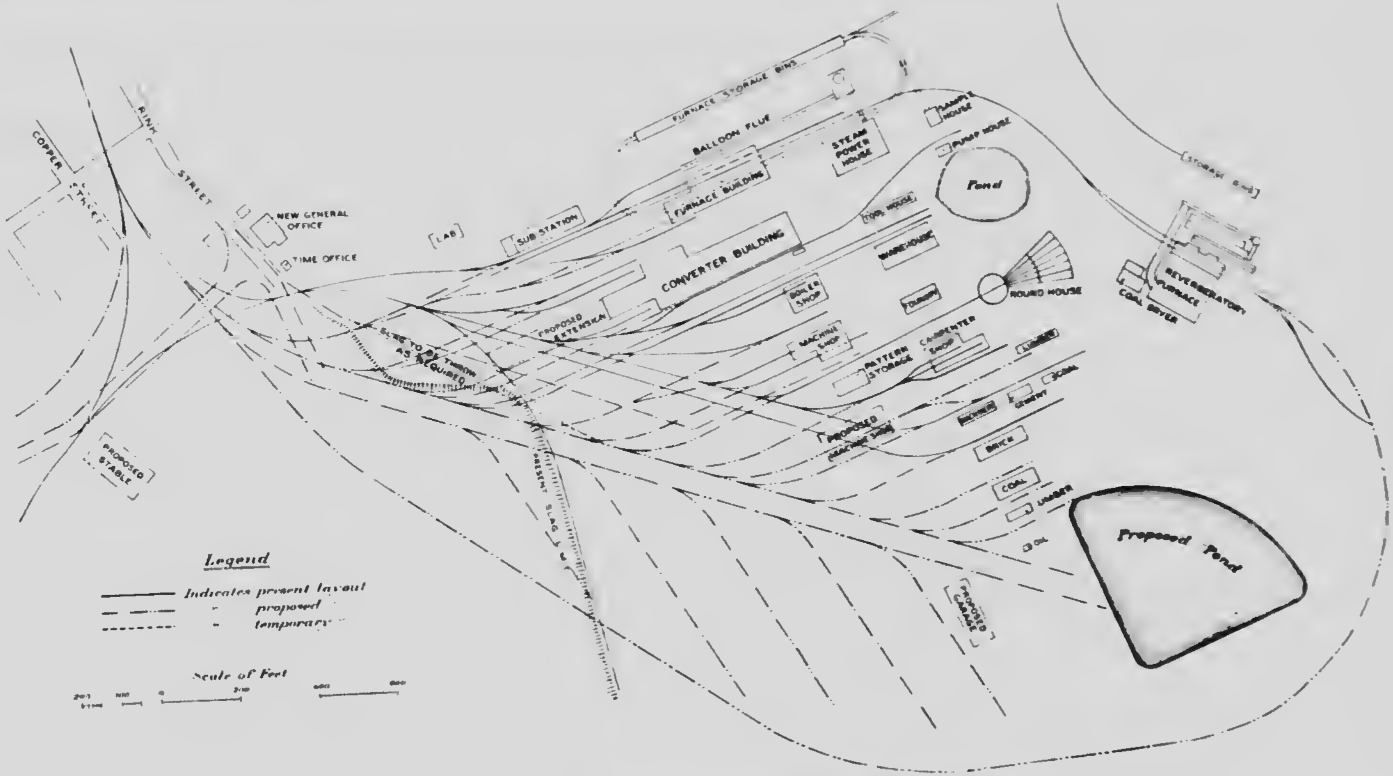


Fig. 3. Ground plan, Copper Cliff plant, Canadian Copper Company.

At the new reverberatory building, about 400 yards east of the main plant, storage bins of 7,500 tons capacity, for holding ore, flux, and coal, have been installed.

Furnace Building. The blast furnace building is 86 feet wide and 418 feet long, with a lean-to, 30 feet wide and 280 feet long, on the south side. It lies parallel to the ore bins and about 200 feet away. One side wall is built of brick, with heavy pilasters, which carry one track of the crane runway; arched doorways, 8 feet wide, are placed in this wall at 20 ft. centres. The balance of the building is of steel construction. In each space between the fur[illegible]n of the roof, 12 feet in width, is raised 2 feet above the genera[illegible] to provide for ventilation. The roof is covered with reinforced c[illegible]. A monitor, enclosed with louvres, is also carried up 8 feet above the main roof around each furnace.

The furnace [illegible]feet above the slag floor and 20 feet wide. The raised portion [illegible] masonry walls, which form the foundations for th[illegible]ers, and for the columns which carry the charge floor [illegible]. The space between these walls is filled with concrete, and th[illegible] is also floored over with concrete. The concrete flooring is carried [illegible] the matte floor on steel columns to a width of about 9 feet. This forms a continuous tapping platform and furnace runway. The charging floor is 35 feet above the matte and slag floors and 25 feet above the furnace floor. This floor is 30 feet in width and is built of reinforced concrete, carried on heavy steel framing; the sides are sheeted up to the roof, forming a separate enclosure.

The raised furnace floor divides the furnace building longitudinally into three sections. At the back of the building is the slag floor, 33 feet wide, served by two standard gauge tracks. In front is the matte floor, also 33 feet wide, and served by two 50-ton 5-motor Morgan electric cranes, 32′–10″ span and 20-ton capacity. The motors are variable speed induction motors. A standard gauge track enters the building at the west end, on the matte floor, and runs for a distance of about 80 feet.

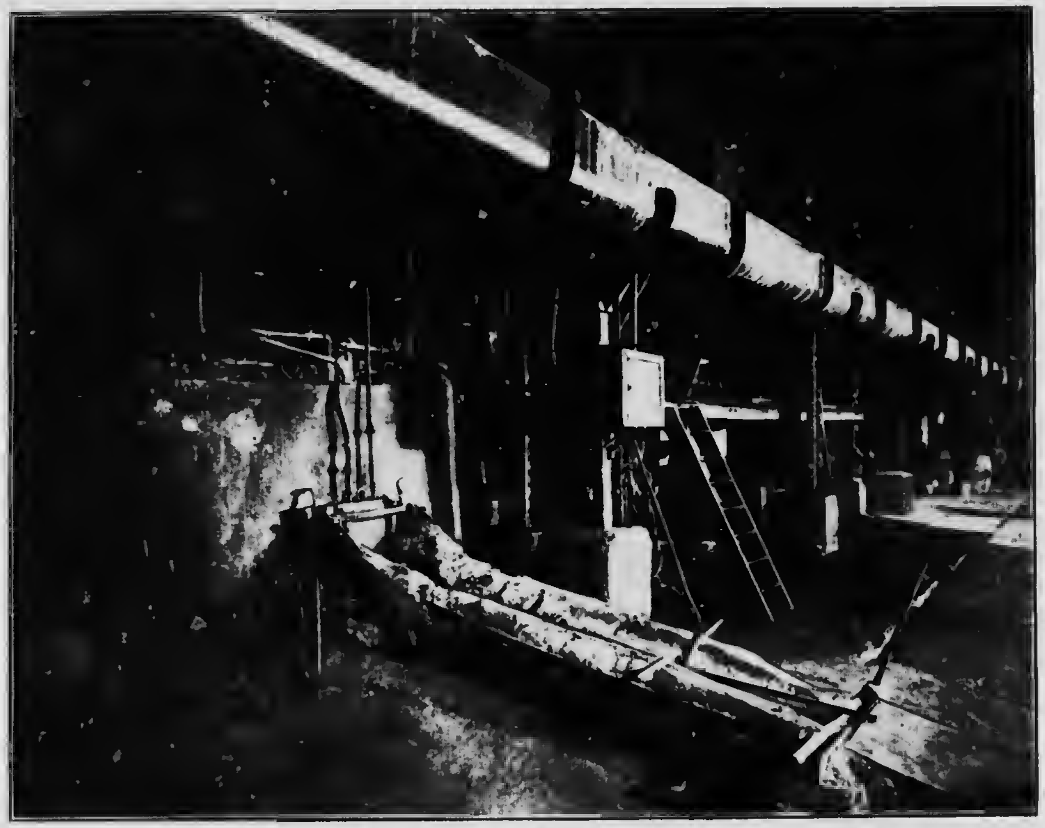
Converter Building.—The converter building lies parallel to the furnace building and about 60 feet away. It is of steel construction throughout, with special bracing to carry the heavy travelling cranes. The main building is 60 feet wide, 522 feet long, and measures 47 feet from the floor to the roof trusses. On one side is a lean-to, 30 feet wide and 392 feet long. A monitor, 24 feet wide and 8 feet high, built with louvres for ventilation, runs the entire length of the building except at the end bays. The roofing is of reinforced concrete tile, the sheathing is galvanized corrugated iron over the main part of the building covering the converters; at the relining end the greater protection against cold is given by a sheathing of cement plaster on metal.

This building contains two departments, one for drying quartz and rock fluxes, and one for blowing the five basic converters.

Blast furnace flue, Canadian Copper Co., Copper Cliff, Ont.

Charging floor, blast furnace plant, Canadian Copper Co., Copper Cliff, Ont.

PLATE VIII.



Settlers in the blast furnace building, Canadian Copper Co., Copper Cliff, Ont.

PLATE IX.

Interior blast furnace building, matte side, Canadian Copper Co., Copper Cliff, Ont.

Interior of matte shed, Canadian Copper Co., Copper Cliff, Ont.

The blowing end of the building is provided with a crane way of 55′ 8″ span. It is served by two 50-ton, 5-motor, Morgan electric cranes, equipped with variable speed induction motors. The motor speeds on these cranes are a little faster than the motor speeds of the cranes in the furnace building. The main hoist on each of these cranes is capable of lifting at the rate of 18 feet per minute; the auxiliary hoist at 36 feet per minute, and the bridge travel is at the rate of 200 feet per minute.

Reverberatory Building.—This building houses the reverberatory furnaces and the coal crushing plant. It is located about one-fourth mile east of the main plant, on the side of a hill. Back of the building the storage bins are served by the high level railway line. The slag and matte cars enter the building at yard level, through tunnels in the foundation. The site for the building was prepared by clearing the rock on the side hill and then building forward a platform of poured slag. Concrete retaining walls were built in such a way as to leave space for three tunnels to enter the slag foundations at the yard level, one between the two original furnaces, and one at either side. A light trestle, about 14 feet in height, was built, leading over the foundations, and from this slag was poured between the retaining walls. In this way a solid block of slag, about 12″ thick, was formed beneath each furnace. On this foundation the furnaces were built as described below. This foundation was extended to provide for the third furnace, the construction of which was started in 1912.

Electric Sub-station.—This building is 92 feet in width and 224 feet in length. The foundations, walls, and floors are of concrete construction; the roof is of hollow book tile, covered with tar and gravel. The roof trusses are of steel and are carried on three rows of columns, two rows built into the opposite parallel concrete walls of the building, and one row down the middle. Two parallel runways for two 10-ton hand-power cranes are carried from end to end of the building on the walls and on the middle row of columns.

This building is the main distributing station of the Company's electric system. It supplies motors, in the building itself and elsewhere, having a total capacity of over 8,000 H.P.; in addition, power for the arc and incandescent lighting in the two smelters, the shops, offices, and in the town of Copper Cliff is sent out from this station.

Most of the circuits in the furnace and converter buildings are placed underground in fibre conduits laid in cement. The other circuits are carried on aerial lines.

The transformer rooms and high tension switch tower are arranged along one side of the building, and separated by fireproof walls.

The equipment housed in this building is as follows: four banks of transformers, three to a bank; each transformer having a capacity of 667 K.W. 35,000/2,400 volts; one bank of three transformers, each 175

K.W. 2,400/575 volts. These latter supply the current for the majority of the motors outside the building, which operate at 550 volts. There is also an 8-panel switchboard and a storage battery.

The engine room of this building contains the principal blowing engines, a large fire pump, and two small generators. The blowing engines are described under that heading on page 43; the fire pump is described in connexion with the water service and fire protection system.

Direct current for operating the electric locomotives that are used on the charging floor is generated by two 40 K.W. Allis-Chalmers Bullock motor generator sets. The motor is operated by an alternating current at 550 volts, 40 amperes; the generator delivers direct current at 250 volts and 100 amperes. One 30 K.W. motor generator set taking current at 550 volts, 40 amperes, and delivering direct current at 250 volts, 90 amperes, when running at 1,200 r.p.m. is also available.

One 100 K.W. frequency changer, changing the 25 cycle current from the transformers to a 60 cycle current for use in the arc lamps, is placed in this building. About 55 enclosed arc lamps are used for lighting the buildings and smelter yard, and 25 are supplied to the town of Copper Cliff for street lighting.

A complete system of electric signals, with gongs and coloured lights, connects this building with the furnace floor and the converter pulpits. By this means the operation of the various blowing engines can be quickly adjusted to meet changed requirements.

The sub-station building is heated by air, which is blown over hot steam coils by a motor driven fan and distributed to the rooms through ducts and floor registers.

Sample Mill.—The sample mill is a three-story building, 30′ × 48′, placed near the east end of the furnace building. The upper floor is on a level with the charging floor, with which it is connected by a track tangent to the curve at this end of the belt line charging tracks, and carried to the mill on a trestle.

In the building there are 24 wooden bins, with the tops on the level of the charging floor, to which cars can be hauled by an electric locomotive and dumped directly. These bins discharge through chutes to the crusher floor. The ore is received in small cars and trammed to the crushers as required.

The ore is received from the mines or roast yards in train load lots. A 200 pound sample is taken from each car of a train and the whole lot is sampled together. The sample passes through a Gates gyratory crusher, 30″ size D, which crushes to 0·5″ size. A Sturtevant sampler cuts one-tenth, which it delivers into a sample box; the discards pass to a bin. The sample subsequently passes a 3″ × 6″ Blake crusher, breaking to 0·25″ and thence over a riffle sampler cutting one-half. This sample is passed to a 3″ × 7″ Dodge crusher and thence to a Jones riffle cutting

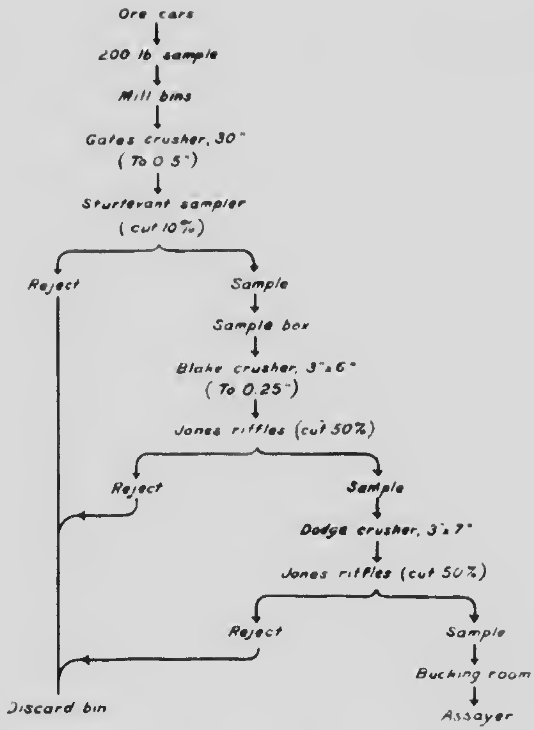


FIG. 4.—Sample mill flow sheet, Canadian Copper Co.

one-half. The final sample is then sent to the bucking room where it is treated in laboratory pulverizers.

All discards pass to a common bin at the bottom of the building; from this bin they are loaded into regular furnace charging cars and hoisted to the charging floor by an electric elevator at the end of the building. This elevator is also used for lifting to the crushing floor any samples that may arrive on the yard level.

Power to operate the plant is supplied by motors; a 15 H.P. motor is used for the crushers and elevator, a 5 H.P. motor operates the smaller machines.

Laboratory.—This building is of concrete, brick, and steel construction, with a roof of book tile carried on steel trusses. The building is only one story in height, but there is a 9 ft. basement; it covers an area of 31′ × 79′.

The principal room is the analysis room on the main floor, 32′ × 40′. This room is open to the roof and is ventilated by means of electric fans set in bull's-eye windows in each gable. The hood is of down-draft construction, with top light, and is made with concrete base, and iron and glass sides and top; draft is supplied by a suction fan in the basement. Electric hot plates are used, the temperature being controlled by a rheostat in which plugs are inserted. Either acetylene gas or gasoline gas can be used in Bunsen burners where a heating flame is required.

A narrow hallway at either end of the main working room separates the other smaller rooms, of which there are four, two at each end of the building, from the main laboratory. Each of these four rooms measures 13′ × 18′. At one end are an assay room and a sulphuretted hydrogen room; at the other a balance room and the office of the chief chemist. The balance room contains a heavy bench, set on concrete piers, which run down to bed-rock. There is space for five balances on the bench, and the room is lighted from the north.

The basement is provided with a separate entrance from the outside. It contains a large storage room for acids, etc., a small room for private research, a storage room for glassware, a large photographic dark room with two sinks and eight lockers for photographic work, and a heating system similar to that installed in the electric sub-station.

Other Buildings.—There are a number of other buildings, located in close proximity to the smelter, housing the various departments. As far as possible fireproof construction has been used throughout. A feature of some interest is the special form of reinforced concrete tiling, made at the works, which is used for roofing all new structures. This is the so-called Bonanza roofing of the American Cement Tile Company.

These buildings include the old steam power plant building, 100′ × 160′; car and carpenter shop, 60′ × 151′; machine shop, 72′ × 154′; foundry, 36′ × 98′; pattern storage, 30′ × 84′; boiler shop, 60′ × 98′;

warehouse, 60′ × 150′. They are all built of concrete, steel, and brick with cement tile roofing.

The various shops are very completely equipped with the most modern tools and machinery for handling almost all the repair and construction work needed around the plant.

The warehouse at the smelter is the central warehouse building, which serves as the main distributing point for supplies for the various plants and mines. The building is 60′ × 150′, and contains two stories and a basement. It is built of concrete, brick, and steel, and the roof is made of concrete tile. The floors are of reinforced concrete designed to carry a load of 300 and 150 pounds per square foot for the main and upper floors respectively. A railway track runs parallel to the building at the edge of the unloading platform which is 20 feet wide and 150 feet in length. A 3-ton electric elevator serves all three floors.

The purchasing office, metallurgist's office, and the electrical repair shop are also located in this building.

Power. The power employed at the works is electric, received from the lines of the Huronian Power Company, a subsidiary corporation with extensive plant at High Falls, on the Spanish river. This plant is described on page 58 of this report. Power is transferred to the transformer house at the smelter at 35,000 volts; it is stepped down to 2,200 volts for use in the heavier motors, and to 550 volts for use in most of the motors outside the smelter sub-station. The motor equipment is described in connexion with the installations in the various departments.

When the present plant was first constructed, hydro-electric power was not available, and a steam plant was installed. The various shops had their individual steam equipments, and for the first two years the smelter was operated by steam generated power. This plant has been kept in good condition as a reserve. One boiler is kept under steam, banked in summer, and supplies steam heat to the various buildings in the vicinity in winter.

The steam power house is a brick building with masonry foundations, 100′ × 160′. The roof is of the hollow book tile, made at the works, covered with plastic slate and supported by steel trusses. The engine room is separated from the boiler room by a longitudinal brick fire wall, which runs through the middle of the building. The floors are of reinforced concrete.

The boiler room was originally equipped with four pairs of Altman-Taylor water tube boilers, 400 H. P. each, each boiler being provided with a Snow feed pump; there are also feed water heaters, a hot well pump, a dry vacuum pump, 8″ × 16″, running at 120 r.p.m., and an Alberger barometric condenser, 24″ in diameter, with a 34 ft. head. The boiler room also contains a 1,000 gallon Blake underwriter pump, a 700 gallon duplex furnace feed pump, and a cross compound, 18″ × 11″ × 18″ Rand air compressor. A purifying plant, which handles all the water for the smelter and for the locomotive water tank, is also installed here.

Since the erection of the reverberatory furnace plant, two pairs of the Altman-Taylor water tube boilers have been moved to the reverberatory furnace building, where one pair has been installed in the flue at the front end of each of the first two furnaces erected. These boilers are, at present, developing steam which is used for general heating around the plant, but eventually this steam will be used for power for the furnace pumps, etc. The other two pairs are still in the power house building, and will be held in reserve for spare steam blowing engines, steam pumps, and air-compressor. They are also used for heating some of the buildings at the plant.

The engine-room equipment includes two cross-compound Nordberg-Corliss blowing engines for the furnaces, steam cylinders 13″ × 25″ and 42″ stroke, duplex air cylinders 57″ × 42″, capacity 236 cubic feet of free air per minute, or 20,000 cubic feet of air at 85 r.p.m. Air is delivered at 60 ounces pressure. In the same room are also placed the following machines, all electrically driven:—

One 300 cubic ft. Connersville blower No. 2007, driven by two Allis-Chalmers-Bullock 225 H.P. variable speed motors, with 14 ropes, 1½″ diameter, English system. This machine has a capacity of 30,000 cubic feet of free air per minute.

One 400 cubic ft. Connersville blower, No. 3457, driven by two Allis-Chalmers-Bullock 300 H.P. motors. This engine delivers 44,000 cubic feet of free air per minute, at the maximum speed of 110 r.p.m.

One cross-compound Nordberg blowing engine for the converters, steam cylinders 15″ × 30″ and 42″ stroke, duplex air cylinders 40″ × 42″ capacity 120 cubic feet of free air per revolution, or 10,000 cubic feet per minute at a speed of 85 r.p.m. Air is delivered at 15 pounds pressure.

Haulage and Distributing System.—The roast yards and smelter plant are served by the Company's own railway line. At the smelter a high line, about 67 feet above the yards, serves the smelter ore bins and the reverberatory furnace plant. Standard gauge tracks are also laid throughout the yards, connecting with the smelter, converter building, various shops, and the warehouse.

There are two standard 100-ton track scales installed, one at the roast yard, and the other in the main yard near the shops. Both are housed, the latter being within the building that also contains the transportation offices.

The charging floor is served by a 36″ gauge track laid with 56 pound rails and copper bonded throughout. The centre line of the smelter bins is parallel to the longer axis of the furnace building and about 200 feet from it. Two parallel tracks are carried under the bins and also through the furnace building; in the latter, one track passes on either side of the furnaces. At each end these tracks are joined by semi-circular curves, forming two complete ovals. Suitable cross-overs are also provided at convenient points. A tangent to the east curve connects with the sampling building. These tracks are covered with a light wooden shed between the buildings; for a considerable distance parallel to the furnace slag track, they are carried on a trestle resting on 14 ft. masonry piers, to lessen the danger from fire owing to the slopping over of hot slag. This trestle also carries, under the charge tracks, coal pockets with chutes, which discharge in front of the boilers in the steam power house. There are also two coaling pockets for locomotives.

Furnace charging trains are operated on these belt lines, running always in the same direction. Each train consists of a string of seven or eight side roll-dump cars. These cars are about 6 feet in length over all, being of the same length as the charge doors of the furnaces and the centre to centre spacing of bins gates. Each car weighs about 1,500 pounds and holds about 3,000 pounds of ore. These charging trains are also used to supply the coal pockets of the power plant before mentioned as being located in the trestles beneath the level of the charging floor. Charge trains are handled by 5-ton electric locomotives, Canadian General Electric manufacture, 1,200 pounds drawbar pull, at 6 miles per hour, taking current at 250 volts by trolley from an overhead line.

The slag floor is served by two standard gauge tracks at the back of the furnace building. Standard gauge tracks are also laid in three tunnels which lead through the reverberatory furnace building. These tracks connect with the converter building and a locomotive is used to haul 10-ton pots between the two parts of the plant.

A track is also laid between the furnace building and the converter building, on which a small iron truck is operated by a rope and an air-driven winch. This truck is used to convey pots of furnace matte to the converters while still molten.

Blowing Equipment.—The blowing equipment, with the exception of the machines already noted as being placed in the old steam power house, is located in the electric substation, which has recently been enlarged to accommodate it. It consists of the following machines and plant:—

Two Nordberg radial valve duplex blowing engines, stroke 42″, piston diameter 70″, delivering 320 cubic feet of free air each revolution, are installed. The maximum capacity of each machine is 21,000 cubic feet of free air per minute when running at 75 r.p.m.; the air is delivered at 50 ounces pressure. Each engine is provided with automatic gravity oiling system, automatic revolution counter, and automatic pressure gauge. These machines are each operated by a rope drive, on the English system, and are connected with separate motors; fourteen ropes, 1·5″ in diameter, are used for each drive. The motors are Allis-Chalmers-Bullock induction motors, one being of 600 H.P. and one of 500 H.P. These motors take the current at 2,200 volts, and are each fitted with special controllers for changing the poles and giving three speeds. At the present time each of the blowing engines is connected to one or more blast furnaces by a 48″ blast pipe which is carried to the furnace building on steel trestles. Two of these pipes are carried through the building to the steam power plant, where they are connected to the blowing engines of that portion of the plant which is placed in that building.

When work under progress is completed, there will be two more Connersville blowers, capacity 400 cubic feet of air per revolution, similar to the one at present installed in the steam power house. These machines will be driven by one 600 H.P. and one 500 H.P. motor respectively, these motors having been taken from two Nordberg radial valve blowers that have been dismantled. It is the intention to replace the other two Nordbergs by two more Connersville blowers of the same type as those already installed. It is to be noted that each of these Connersville blowers is driven by a single motor, belt connected, the other impeller on each machine receiving its power through gears.

All these blowing engines will eventually discharge their air into a common 6 ft. blast pipe connected by a nipple and valve to each of the blast furnaces. This pipe is under construction at present; furnaces Nos. 1, 2, 3, and 6 now take their air from it; the other two will be able to do so within a short time.

To summarize the furnace blowing equipment—there are at the present time, two Nordberg electrically driven blowers, two Nordberg steam driven blowers, one 300-ft. Connersville blower, and one 400-ft. Connersville blower. The arrangement in the near future will consist of two steam driven Nordbergs, five 400-ft. Connersville blowers, and one 300-ft. Connersville.

The air for the converter plant is supplied by one Nordberg blowing engine and two Allis-Chalmers engines. The Nordberg is a duplex Corliss valve type, 36″ stroke, piston diameter 40″. It is run at 100 r.p.m., and delivers 10,200 cubic feet of free air per minute at a pressure of 12 pounds; it is driven by a 500 H.P. Allis-Chalmers constant speed induction motor running at 375 r.p.m. A rope drive of 16 ropes 1·5″ diameter is used. The Allis-Chalmers engines have a 60″ stroke, piston diameter 48″, and run at 70 r.p.m., delivering 20,700 cubic feet of free air per minute at 12 pounds pressure. The motors are Allis-Chalmers-Bullock, 1,200 H.P. constant speed induction motors running at 375 r.p.m. Forty-two ropes 1·5″ diameter are used on each drive. All engines are equipped with automatic unloading devices, gravity oiling systems, automatic revolution counters, and automatic pressure gauges. They deliver to a common receiver, from which a 36″ blast pipe, carried on a steel trestle, conducts the air to the converter building.

Air for power and other purposes throughout the plant is supplied by one cross-compound 100-pound air compressor made by Laidlaw, Dunn-Gordon Company. This machine has a 24″ stroke, and the high and low pressure cylinders are respectively 15″ and 21″ in diameter. Its capacity is 1,500 cubic feet of free air per minute. It is direct connected to an Allis-Chalmers-Bullock induction motor, 300 H. P. capacity, running at 120 r.p.m. The air from this machine is piped to every part of the plant and is used for various purposes, such as blowing out motors, driving winches and hoists, operating air tools in the several shops, and as an air blast for warming the basic converters with a fuel oil flame.

All the blowing engines receive their air directly from the outside sub-station building, through a large cold-air duct in the basement; all the intake valves connect with this duct.

Flue System and Stacks.—The *down-take* from each furnace is 8 feet in diameter and is lined with 4″ of firebrick for the first 20 feet. It inclines at 30° in a straight line from the furnace to the dust chamber, passing above the slag tracks.

The ***dust chamber*** is of the balloon type, 20 feet in diameter, 34 feet in height, and 500 feet in length. It is built of $\frac{3}{16}$″ steel plate, and is carried on steel columns at 15 ft. centres, and is provided with expansion joints every 60 feet. The only lining is placed opposite each downtake opening and covers a section about 12 feet square. Hoppers and doors for removing flue dust are placed every 6 feet; these discharge the dust into cars operated on a track running the length of the flue.

The ***stack*** is 210 feet in height and 15 feet inside diameter at the top. The base is 24 feet square, of granite masonry, with a circular lining of firebrick. The upper 150 feet of the stack is circular and is built of perforated radial stack brick. An independent steel stack, 12 feet in diameter at the base, 9 feet in diameter at the top, 125 feet in height, stands just outside the converter building. The hoods over the converter are connected with this stack by a steel flue.

At the *reverberatory* furnaces a *cross flue*, 6′ × 9′, which is covered by cramps, passes directly behind the furnaces. This flue is 70 feet in length and leads to the main flue or dust chamber. The main flue is a brick chamber without baffle walls, 15′ × 19′ and 177 feet in length, which connects with the *stack*. The stack is built of Custodis radial brick. It is 17′ 2″ in diameter at the bottom, 15′ 4″ in diameter at the top, and is 200 feet in height. Practically no dust collects in the flue.

Ore, Coke, Fluxes.—The ores smelted at this plant are derived almost entirely from the Company's own mines. Only very occasionally are small lots of custom ore received.

Connelsville coke is used for the blast furnaces, and Pennsylvania soft coal is used in the reverberatories. The latter is first pulverized in the coal crushing plant installed close to the reverberatory furnace building.

Quartz is obtained from the Company's own quarry at Dill, about 15 miles southeast of the smelter. Occasionally a small supply is received in the form of custom ores.

A small quantity of limestone is occasionally required. This is obtained from the Fiborn (Michigan) quarries of the Union Carbide Company, not far from Sault Ste. Marie, Mich.

Flue Dust. From time to time attempts were made to briquette or sinter the flue dust from the furnaces; these attempts were not successful, either through failure of the method, or because the high cost made them prohibitive. The flue dust was, therefore, allowed to accumulate in large dumps, to be utilized later in reverberatory furnaces. These furnaces were installed in 1911, and the accumulations of flue dust and fine ore from the mines (under ¼" diameter) are now being treated in the reverberatory plant.

Water System and Pumping Plant. The general water supply is obtained by gravity from two small lakes situated about 3,000 feet northwest of the smelter. A heavy concrete dam was constructed at their outlet, forming a reservoir of very considerable area. A 16" cast-iron main leads from this reservoir directly to the smelter. Other smaller mains supply the shops and the town of Copper Cliff.

At the furnaces the jacket water overflows into two continuous cast-iron launders, one on either side of the furnaces, sloping both ways from the middle furnace. It flows from these launders through 20" drains to an open cooling reservoir. As the water supply is limited, and as the furnaces alone require about 1,000 gallons per minute each, it is necessary to pump most of this water back to the furnaces from the cooling reservoirs. For this service three pumps are installed at the reservoir. Two of these are 8" pumps of 1,500 gallons capacity, and one is a 14" pump, of 5,000 gallons capacity. All are single stage turbine pumps, each direct connected to a constant speed induction motor. These pumps all discharge through an 18" flanged cast-iron pipe into a reinforced concrete tank, 25 feet in diameter, and 32 feet high, placed on the hill back of the smelter. Duplicate cast-iron mains, connected to this tank, run on either side of the furnaces just below the charge floor. The tank is also connected to the smelter supply main, the static head of the latter being just balanced in the tank. This adjustment gives a very steady pressure on the furnaces, the head being about 28 feet above the tops of the jackets.

For fire protection purposes a series of dry fire lines are laid around the smelter buildings; hydrants and hose houses are located at frequent intervals. A closed circuit electric fire alarm system with conveniently located signal stations is also installed.

The main pump for this system is located in the electric sub-station. It is a 6", 4-stage turbine fire pump, of 1,000 gallons capacity. It is direct connected to a 225 H. P. alternating current induction motor. In the steam power plant is located a Blake underwriter's fire pump, capable of delivering 1,000 gallons per minute.

Blast Furnaces.—There are six rectangular water-jacketed blast furnaces: five of these are 50″ × 204″, and one is 50″ × 240″ at the tuyères. The height from the hearth plate to the charging level is 19′, and the smaller size is rated at 400 tons per day each. The furnaces are placed in line at 61′-6″ centres, with their longer axes parallel to the length of the building. Each furnace is supported on a concrete pedestal rising 30″ above the solid concrete furnace floor. The four water-jacket hearth plates are supported on jacks resting on this pedestal. There are three tiers of water-jackets,

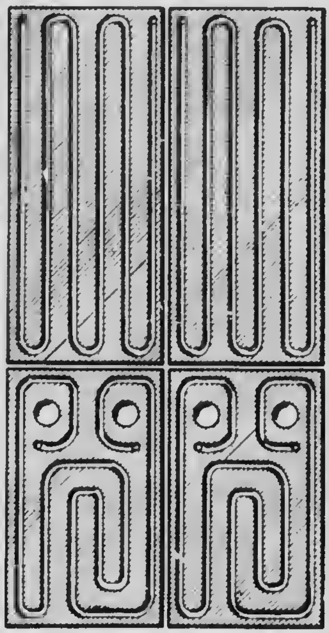


FIG. 5. Section showing arrangement of cooling pipes in cast iron furnace jackets as used by the Canadian Copper Co., Copper Cliff, Ont.

the lower or tuyère jackets being 4′-7″ in height, the middle jackets are 4 feet in height, and the upper jackets 6′-4″, the total height of the jackets being 14′-11″. These two lower tiers of jackets are special cast-iron jackets, made in the works, having 1·25″ water circulating pipes cast into an otherwise solid slab with stiffening flanges (Figure 5). The thickness of the jacket is 3·25″, the width at the flange is 8·25″, the flanges are cast about 1·25″ thick. The jacket is stayed by a cast-iron web running up the middle of the plate, and is also thickened at the corners. The side flanges are slotted for two bolts; tie-bolt lugs are also cast on the jackets. The outside legs of the pipe for conveying cooling water are centred about 3·5″ from the sides of the jacket and 4·5″ from the ends. In the tuyère jacket the tuyère opening is 6″ in diameter and is centred 9″ from the top of the jacket. The openings of the cooling water pipes in this jacket are placed 16·5″ below the top of the jacket. In the earlier furnaces the jackets in the lower tier were ordinary tuyère jackets, 8′-4″ in height and with four tuyères to a jacket. In the present furnaces each of these jackets has been replaced by a set of four cast-iron jackets. This type of jacket costs $35 and $30 each respectively for a tuyère section and a top section, or a total cost of $130 for a set of four sections. The cost is about half as much as for the single plate jacket originally used and the life of the jackets is four or five times as long. The upper jackets are of the ordinary plate type, and 50″ in width.

The supporting frame is of heavy steel construction, the charge deck of cast-iron plates. The hood above the furnaces is formed by building 18″ firebrick walls into a skeleton of very heavy structural steel. The end walls unite in a catenary arch to form a roof, the top of the arch being 33 feet above the charging level, making the total height of the furnace 58 feet above the tapping platform. The side walls are vertical and in one of them is the downtake opening, with its centre 27 feet above the charge floor. The down-take, as already noted, is 8 feet in diameter, is built of $\frac{3}{16}$″ boiler plate, and is lined with 4″ of firebrick for the first 20 feet. The charge doors are now operated by counter weights in place of air-lifts.

The principal data with reference to the construction of these furnaces are given in Table XV, chapter VIII, page 146.

The crucible bed is made of rammed chrome 'bats.' It is made about 13″ deep, but never retains that thickness as it is eaten out by the matte.

The side tap is notched out of one of the middle tuyère jackets on the crane side. It is filled with a water cooled cast-iron side tap jacket 10″ × 24″. The slag spout is a special cast-iron water cooled spout of local design. Both the spout and opening in the tap jacket are lined with chrome brick.

The settlers are placed immediately in front of the furnaces. They are oval in form 16′-0″ × 19′-6″ and 5′-6″in height, and are made of $\frac{3}{16}$″ boiler plate. They are lined with two rows of chrome brick laid end to end. The slag spout and the tap hole of each settler are diametrically opposite, the furnace spout discharging into the settler between them. The settlers are also fitted with cast-iron water cooled spouts lined with chrome brick.

The slag spouts of the settlers discharge into 25-ton slag pots carried on standard gauge trucks and running in the cut back of the furnaces. These pots are sectional, with four side pieces and a separate bottom piece. The pots are poured by means of a rack and worm gear carried on the truck. Small cast-iron catch pots, operated by hand winches, are used to receive the slag streams while the big slag pots are being shunted, in trains of six pots, to the slag dump.

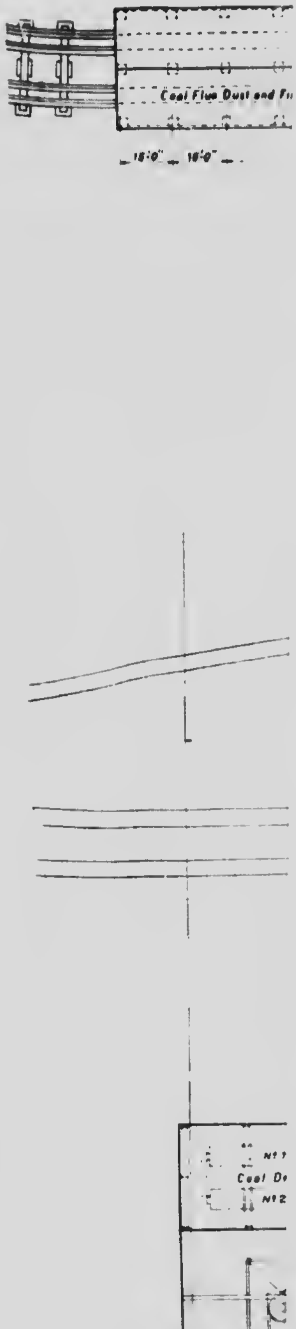


Fig.

35783—p. 48.

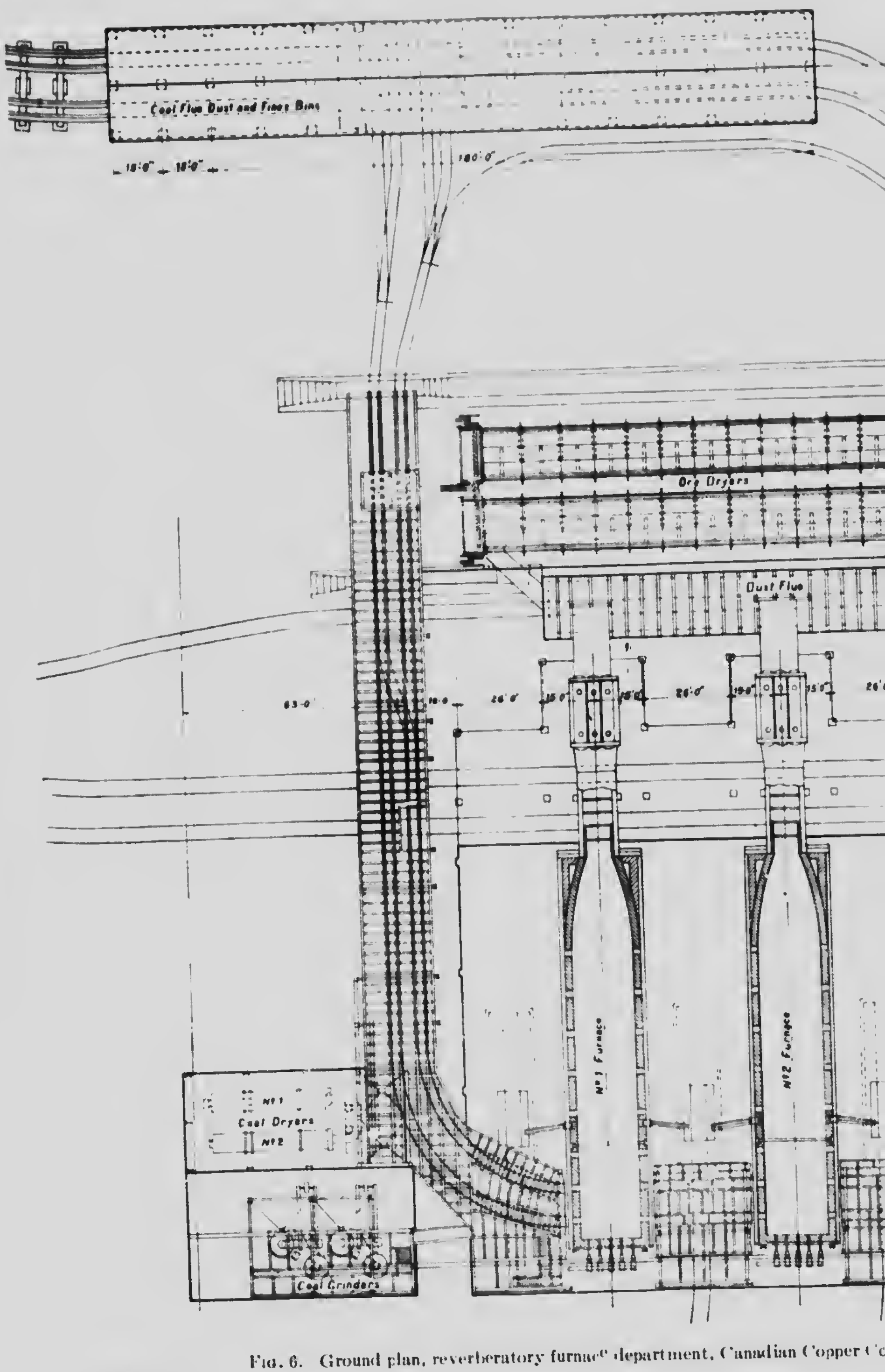
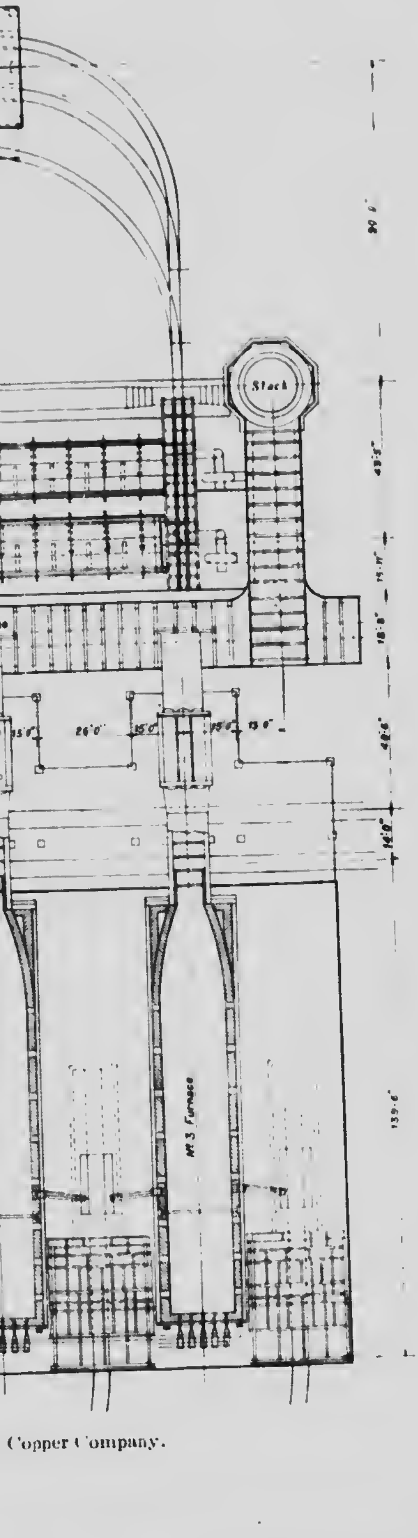


FIG. 6. Ground plan, reverberatory furnace department, Canadian Copper Co

35793—p. 18.



Copper Company.

Matte from the settlers is tapped into 10-ton clay-lined cast iron pots standing on the matte floor. These pots are placed by the travelling cranes; when full they are lifted upon low transfer trucks and hauled across the yard to the converter building by a small compressed air winch operating a small drum on which a haulage rope is wound.

Reverberatory Furnaces.—Two reverberatory furnaces designed to burn pulverized coal were installed during the year 1911. The first of these was blown in at the end of December, 1911, the second in March, 1912, The foundation for a third was laid in 1912, but the furnace has not been completed.

These furnaces are of the Steptoe type and each has a hearth area of 19 feet × 112 feet. As already noted in describing the reverberatory furnace building, the foundation for each furnace was made by pouring slag between concrete retaining walls, giving a solid block of slag about 10 feet in thickness. On this foundation the side walls of the furnace, 27″ in thickness, were built to a height of 10 feet. Slag was poured inside these walls to form a furnace bottom about 2 feet in thickness. The side wall is built of chrome and silica brick, to a thickness of 18″, the former kind being used near the coal dust burner. and the roof rests on this wall. Inside this wall, a flashwall 9″ thick is built of magnesite brick; this wall is brought up close to the roof, but it does not support it. The roof is 20″ thick for the first 35 feet near the coal burners, and 15″ thick for the rest of the way; it is built of fire-brick. The spring of the roof arch is 19″, or a 2″ rise to each foot of width. The extreme height inside is 6 feet. The hearth of the furnace was formed by evening up the poured slag bottom with concrete so as to provide an inverted arch with a spring of 12″. On this form one layer of firebrick, 2·5″ thick, was laid flat. Upon this 9″ of magnesite brick was laid to form the bottom of the hearth. This latter brick was laid in a mixture of ground magnesite and linseed oil. Expansion strips of wood were placed between every six courses; the expansion allowed was ¼″ to the foot.

The tap hole is placed at the side about 18 feet from the inlet end of the hearth; it is placed high enough to retain 12″ of matte in the hearth, so that the bottom will always be protected by a pool of matte.

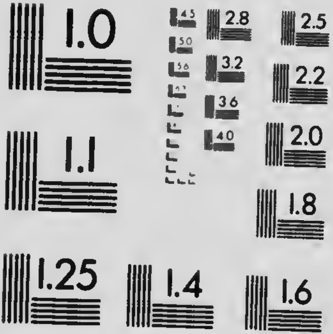
Slag is removed at either side of the furnace where the sidewalls commence to narrow in, about 11 feet from the front of the furnace.

The space at the front of the furnace, usually occupied by the slag door, slopes up gradually from the hearth to form a straight outlet for the products of combustion. The area of the throat is about 27 square feet. The gases meet no obstacles whatever, but pass straight into the cross-flue, 6′ × 9′, which is covered by cramps.

Two sets of charging bins are provided at the fire end of the furnace. Each bin has five hoppers discharging through the roof by slide gates. These bins are used to drop flue dust, ore fines, and other pulverized material

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Ma n Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phcne
(716) 288 - 5989 - Fax

FIG. 7. West elevation, reverberatory furnace department, Canadian Copper Co.

FIG. 8. Section on No. 1 furnace, reverberatory furnace department, Canadian Copper Co.

into the furnaces. Openings are provided along each side of the roof for fettling.

Hot converter slag is also charged into the furnace by a side door through a special chute on a carriage. This slag is brought from the converter building to the reverberatory furnace in 10-ton pots hauled by a locomotive which enters the tunnel between the furnaces. The reverberatory cranes pick up these slag pots through openings in the roof of the tunnel and discharge them into the furnace.

These reverberatory furnaces are fired by coal dust blast burners. Coal for this purpose is brought to the works in 50-ton cars and dropped into storage bins in the high line trestle. From these bins it passes through a special coal crusher, which breaks to 0·5″ size, to a conveyer belt. This belt discharges into a bin in the grinding room. A screw conveyer drives the coal from this bin into a Ruggles-Coles hot gas dryer, and thence into the boot of an elevator. The coal is elevated to bins on the floor above. From these bins it is fed into two Raymond impact pulverizers. These grind the coal to a very fine powder, most of which will pass a 200-mesh screen. This pulverized coal is sucked up by a fan into a separator at the top of the building. Here screw conveyers pass it into the reverberatory furnace building, dropping it into bins above the ends of the furnaces. In front of each furnace, five variable speed screw conveyers, each 4″ in diameter, deliver the coal into five corresponding burners, each conveyer dropping its coal dust in front of a nozzle which carries air from a fan. The air blast sends the coal into the furnace in the form of a cloud or spray of dust which burns just like fuel oil. Each burner can be run independently and the amounts of coal dust or air can be varied at will.

Mr. Browne states further that the system of firing is quite satisfactory and that, with the charge put in through the bins, it is expected that this method of firing will prove much cheaper than burning the coal on a grate. There is no loss of fuel efficiency, and all the carbon in the coal is consumed. The ash has offered no difficulty whatever, and the heat of the furnace is maintained uniform.

Converters. The old plant contained silica lined converters, 10 stands and 10 shells, 84″ × 126″. These were replaced in 1911 by the present equipment of basic lined converters.[1]

The new plant consists of five stands and shells of basic lined converters. Each of these shells is a cylindrical steel drum, 37′-2″ in length and 10 feet in diameter, outside measurement. The stack opening in the roof for the escape of gas is placed in the middle of the top of the cylinder, instead of at one end, as in the Peirce-Smith basic converters at the Garfield plant. There are two openings with spouts in the front wall opposite to but above

[1] Recent improvements and additions to the smelting plant of the Canadian Copper Company, by David H. Browne, Trans. Canadian Mining Institute, Vol. XV, 1912, p. 115. The description given is an abstract.

Interior of reverberatory furnace building, Canadian Copper Co., Copper Cliff, Ont.

35783—6

Old acid converter plant, Canadian Copper Co., Copper Cliff, Ont.

Basic copper converter Canadian Copper Co., Copper Cliff, Ont

the tuyère line from which slag or matte can be poured. There are 44 tuyères, each $1\frac{1}{4}''$ in diameter, and 7″ apart; no tuyères are placed directly under the stack for a distance of 5 feet.

The lining is special magnesite brick. The bottom lining is 24″ thick, the back or tuyère wall is 18″ thick, the front 15″ thick, and the roof is a 12″ arch of silica brick. The tuyère bricks are 24″ thick.

The shell is carried on four ring tracks, 12 feet in diameter, and placed one at each end and one on either side of the central stack. These tracks rest on roller bearings mounted on cast-iron bed plates beneath the converter. The shell is turned by means of two wire ropes each of which takes a one-half turn around it, one on either side of the stack. These ropes are led to a hydraulic piston working in a horizontal cylinder and having a stroke of 9 feet.

As ordinary hydraulic equipment would not be suitable in the climate of northern Ontario, oil is used for rotating the converter shells. This is moved in the cylinders by air pressure. Two oil tanks are provided, one for regular use and one for emergency. Each of these is made of $\frac{3}{4}''$ steel boiler plate and is 4 feet in diameter and 15 feet in height. A small amount of oil is pumped into these tanks and the space above the oil is filled with air at 75 pounds pressure. An electrically driven pressure pump now forces more oil into the cylinders, compressing the air to 300 pounds pressure, at which point the pump stops automatically. When it is desired to turn down a converter a controlling valve is opened on the converter platform; this allows the oil to pass from one side of the hydraulic cylinder to the other, moving the piston, and so, by means of the rope tackle, turning the converter as desired. In this operation the air in the tank above the oil expands and the pressure decreases; when it has fallen to 200 pounds the oil pump automatically starts pumping oil into the tank until the pressure again reaches 300 pounds.

As the entire plant is operated by electric power, it is evident that if the power went off the line for any reason the converter blower would stop blowing air into the tuyères. If the air stopped the matte would run back through the tuyères unless they were turned, the ordinary mechanism for turning them being also dependent on electric power. To avoid this danger, a spare tank is provided in which oil is kept under 300 pounds pressure. This spare tank is connected to an hydraulic cylinder by a valve which is kept closed by a solenoid brake. After the power goes off a blower engine will keep turning over and delivering air for perhaps 15 or 20 seconds owing to the momentum of the fly wheel; this affords time for the solenoid brake to operate. The brake is actuated by electric power, and the moment the power goes off the brake drops, opening the valve and admitting oil to the proper side of the cylinder to turn the converter down. This device is absolutely automatic and entirely separate from the turning device regularly used, and has proved quite satisfactory.

Metallurgical Practice. Roasting. The metallurgical treatment of the ores received from the Company's mines begins at the roast yards. These yards are located north of the smelter, on slightly higher ground. The site selected was a somewhat flat swampy area, which has been evened up and given a gentle slope from which drains rapidly remove surface water. The yard is served by a number of spur line tracks of standard gauge which traverse the length of the yard and divide it into a number of sections.

The ore is roasted for the purpose of oxidizing the iron and to remove as much of the sulphur as possible without involving undue losses in the furnace slag. If the oxidation of the iron is insufficient the matte made in the furnaces will contain so much iron that its retreatment is too costly; on the other hand, if too much sulphur is expelled with a too thorough oxidation, undue losses will occur in the furnace slags.

Open heap roasting as practised at Copper Cliff is an old, simple, cheap, and very effective method of treatment for the accomplishment of the purpose desired. The roast piles differ in size according to the rapidity of roast required; these sizes vary from 30′ × 40′ or 36′ × 40′ to 50′ × 100′. Small heaps will contain from 800 to 1,000 tons and can be roasted in about 90 days. Large heaps will contain as much as 3,000 tons and will require from 6 to 9 months to roast properly. The most satisfactory product is obtained by the long time roasts. The practice is to keep about six months stock of roasted ore in the yards ready for the smelter.

The wood used to form the base of a new roast heap is dry split wood, either hard or soft, spruce, pine, cedar, birch. The piles are made of the area desired and from 20″ 24″ in height. Around the ends and edges the sticks are piled crossed; the interior is covered with sticks laid parallel to each other and in a position similar to shingles on a roof, being inclined at an angle of about 30°. About one cord of wood is required for every 25 tons of ore in a heap.

The ore arrives at the yards in 50 ton cars, and it has already been crushed to pass a 4″ grizzly. Each car is run out to the place required and light planks are laid from the car to the heap. A shovel and barrow gang of about 10 men then transfers the ore to the pile. The coarse ore is piled above the wood to a depth of 5 6 feet, or more, according to the size of heap desired; this is topped with 8″–12″ of fines; the tops of the piles are built with a top slope of about 1 foot in 15 feet, presumably for drainage purposes.

When the pile is completed, it is fired and allowed to burn slowly, being carefully watched not only until it is fairly alight, but afterwards to make the roast as uniform as possible. When the roast is completed and the pile has cooled off sufficiently, the heaps are blasted to loosen the ore. The roasted ore is loaded by a Bucyrus steam shovel into 50 ton bottom-dump steel railway cars to be transferred to the smelter bins.

All ore entering the roast yards is weighed in at Clara Belle junction, north of the yards. All roasted ore is weighed out on a weigh scale at the foot of the yards and about one-third of a mile from the smelter.

Blast Furnace Practice. Four trains of 8 cars each are used on the charging floor. The cars are loaded at the bins: the load is weighed and adjusted at the most convenient scales and the train is then run to the furnaces. An ordinary charge consists of 500 2,000 pounds of quartz, 10,000 pounds of roast ore, 3,000 pounds of green ore from Crean hill, and 3,000 4,000 pounds of converter slag and scrap, a total of 16,500 19,000 pounds. The coke per cent of the charge varies between 10% and 12%. The charge varies somewhat inasmuch as the ore from the Creighton mine is deficient in silica. Occasionally a small quantity of lime is required to flux Crean Hill ores. On an average the furnaces are charged about three times per hour. The charge column in the furnace is maintained at about 13 feet: the blast pressure used is 30 35 ounces. The total quantity of blast required is about 1,313 tons of air per furnace, per 24 hours, the equivalent of about 22,600 cubic feet per minute.[1]

Slag flows from the furnace into the settlers in a continuous stream. The overflow slag from the settler passes out of the slag spout at one side of the settler and is led in a cast-iron trough to the back of the tap platform, where it discharges into waiting pots in the slag track. Slag trucks are hauled to the dump by a steam engine.

Matte is tapped from the settlers on the side opposite the slag spout. It is drawn off into matte ladles in 5-7 ton lots. The matte crane lifts the loaded pot upon a small lorry. The lorry is then hauled across the yard 60 feet to the converter building. Two tracks are provided for these matte transfer trucks.

Green ore from the Creighton mine, as it arrives at the roast yards, has the following composition: S, 23·75; Cu, 1·46; Ni, 4·35; FeS, 35·69; FeO, 4·40; SiO_2, 18·80; CaO, 2·00; MgO, 1·5; Al_2O_3, 4·5.

A typical roast will eliminate sulphur and oxidize the iron and the roasted ores will contain approximately 12%-16% of sulphur.

Reverberatory Furnaces.—The materials charged to the reverberatory furnaces consist, at present, of green fines, which have been accumulating for many years, flue dust, and hot converter slag. Reverberatory slag is removed in 25 ton pots on standard gauge tracks, laid in front of the furnaces and below the levels of the hearths. These pots are shunted to the slag dump by a steam engine.

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[1] At 32° F. and 29·92" bar.

Reverberatory furnace matte is drawn off into the same pots in which the converter slag was brought to the furnace. It is then hauled by the locomotive to the converter building and charged into the converter.

The composition of the reverberatory charge varies considerably owing to the nature of mixture used. After the four Wedge roasters, now being installed, are in operation there will be less variation. At present, the slags from these furnaces contain about 31% SiO_2, 45% FeO, and 0·6% Cu. Ni. The matte contains 25-27% copper-nickel.

Converters.—The converters receive matte both from the blast furnaces and from the reverberatory furnaces.

The efficiency of these basics for the service required may be judged from the data given below, which have been kindly supplied by Mr. Browne.

A converter installed in 1911 was operated from May 31 to September 17 without relining. During this period, 3,802 tons of bessemer matte, containing 80% copper-nickel, were produced. There was charged to the converter 11·147 tons of furnace matte, containing 28·79% copper-nickel, and 9,207,420 pounds of iron. To this was added 2,770 tons of quartz, 90% SiO_2, and 2,076 tons of rock. This rock was footwall rock from the Creighton mine, and contained 2% copper-nickel, 11·5% iron, 10% silica, 11% alumina, 7% calcium oxide, and 4% magnesium oxide. There were also 377 tons of scrap added to the charges. During this period the blast was on for 1,428 hours in an elapsed period of 2,618 hours, or for 54·55% of the operating time. The converter made 3,802 tons of bessemer matte and 11,642 tons of slag in that period.

The slag analysis showed the following composition: Cu, 0·65%; Ni, 1·65%; Fe, 49·05%; S, 1·30%; SiO_2, 28·80%; Al_2O_3, 1·35%; CaO, 1%; MgO, 1·3%.

The experience gained in the operation of these converters, since their installation in 1911, has resulted in a great increase in the output obtained before patching or relining becomes necessary. One converter, relined in the summer of 1912, lasted for 194 days, and treated 20,560 tons of matte which contained 9,500 tons of iron. During this period 5,122 tons of quartz, 3,568 tons of Creighton rock, and 676 tons of scrap were charged. The matte charged contained 23·55% of copper-nickel. The Creighton rock, charged during June, 1912, had the following analysis: Cu, 0·95%; Ni, 1·05%; Fe, 13·85%; S, 5·32%; SiO_2, 47·60%; Al_2O_3, 12·4%; CaO, 1·82%; MgO, 5·32%.

Near the end of September, 1912, there was one converter that was still in good condition which had a record output of over 6,000 tons of bessemer matte. It was expected that an output of over 7,000 tons would be obtained before repairs became necessary.

In contrast with the results obtained with these basic converters it may be noted that with the acid converters one lining would last for about eight hours blowing time on a 36% matte, and would produce 7 tons of

Pouring slag, Canadian Copper Co., Copper Cliff, Ont.

finished bessemer matte, containing 80% copper-nickel. On a 30% matte one lining was good for 5·3 tons of bessemer matte. Each shell consumed about 3,000 cubic feet of air per minute at 9-11 pounds pressure, practically a fixed amount. With a 36% furnace matte about 65 minutes blowing time was required to produce a ton of 80% bessemer matte, while with a 30% furnace matte 110 minutes were required. With the acid converters a large amount of scrap is thrown out around the stack, which has to be cleaned up and returned to the converter. This will amount to about the same quantity per blowing hour, regardless of the grade of matte. With lower grade mattes the blowing time increases and the production of the converter decreases.

The basic converters have been found to work very efficiently and make almost no scrap. The blowing time per ton of finished bessemer matte is greatly reduced, and the cost of lining per ton of matte produced is considerably less than when acid converters are used. The contrast between the two types of converters is further shown by the following table:—

Table V

Contrast Between Basic and Acid Converting on Copper-Nickel Mattes.

Converter type.	Tons flux per ton of iron removed	Tons furnace matte per ton Bessemer matte produced.	Tons Cu-Ni charged per ton B. matte produced.	Loss of Cu-Ni by slag and slop per ton of B. matte.*
Acid...............	1·31	4·66 27·38% CuNi	1·28	0·48 tons.
Basic...............	0·91	4·13 22·58% CuNi	0·93	0·13 tons.

* One ton Bessemer matte contains 0·8 tons of copper-nickel.

After the matte in the converters has been blown sufficiently to eliminate nearly all the iron it contains, it is poured into a pot, which is shifted by a locomotive to the casting moulds along one side of the converter building. Here it is poured into moulds, each about 25 feet in length, and 6 feet in width, forming a cake of these dimensions and about 4″ in thickness. After cooling, the slabs of matte are broken up and loaded into railway cars for shipment to the refinery.

Converter slag, under the present practice, is sent to the reverberatory furnace building and is charged into the furnaces.

HYDRO-ELECTRIC PLANT.

The plant which supplies electric power for operating all the mines and the smelter is located at High Falls on the Spanish river, about 4 miles north of Nairn station, on the Soo branch of the Canadian Pacific railway, and 23 miles west of Sudbury. It is connected with the main line by a spur line from Turbine station. The plant was built during the years 1904-5.

At the site selected the Spanish river flows in two channels around a high and rocky island, about 2,000 feet in length and 900 feet in width. The fall is about 65 feet; the island rises about 75 feet above the river level. A large forebay was cut out on one side of the island and two dams were erected in the channels, gaining a total effective head of 85 feet. These dams are of concrete construction and rest on solid rock. As much lumber is floated down this river, log slides and booms had also to be provided.

Water for the generators is conveyed from the bulkhead dam to the power house at the foot of the falls by three 9 ft. steel penstocks for the generators and one 3 ft. penstock for the exciters. Provision is made for the installation of a fourth 9 ft. penstock, when required.

The penstocks, bulkhead gates, and screens are housed. The formation of ice in the tubes in the winter is effectually prevented by the use of small amounts of current at critical points. No trouble has been caused by frazil ice, the nearest rapids being 6 miles upstream from the power house.

The power house is a brick structure resting on a concrete substructure. The roof trusses are steel, the roof covering is of 2″ × 4″ lumber, laid on edge, and sheeted with galvanized iron. The main building is 55 feet in width, and 106 feet in length; an extension along one side is 16 feet in width; at one end there is a wing, 33′ × 30′. The main building contains space for four generators, three of which are now installed. The 16 ft. extension contains the transformer rooms and the switch-tower; these are separated from the main room by fireproof brick walls and steel doors. The end annex contains a warehouse, workshop, and heating plant. The building is heated by hot air forced over steam coils by a Sturtevant fan.

Hydraulic Plant.—There are three turbines of the twin type,[1] to drive the generators, and two smaller ones to drive the exciters. Provision has been made for the installation of a fourth turbine, as soon as it is required.

The generator turbines are designed for a maximum speed of 375 r.p.m. under a head of 85 feet; water enters the turbines at a maximum speed of 7·2 feet per second. They are provided with two 34″ bronze runners in a single case. They are of 3,550 H.P. each.

[1] I. P. Morris Company, Philadelphia.

Canadian Copper Company's power plant, High Falls, on Spanish River.

Canadian Copper Co. generators at High Falls.

The exciter turbines are of the same design as the larger machines, but of smaller capacity. These small turbines are both served by the 3 ft. penstock.

There is also a 5", two stage, 500 gallon turbine pump, driven by a 50 H.P. direct current motor, operated from one of the exciters. The pump suction is connected to the penstocks.

Electric Equipment.—Each generator turbine is direct connected to a 2,000 K.W. Crocker-Wheeler generator. The current produced is 3 phase, 25 cycle, 2,400 volts.

The exciters are also each direct connected to an exciter turbine. Each machine is 200 K.W. (275 K.W.) capacity.

Transformer Plant.—There is one set of three transformers for each generator, three sets in all. Each of these is a 2,400-35,000 volt, 667 K.W. transformer.

Other Equipment.—The power house also contains a Westinghouse air compressor, which furnishes air for cleaning purposes and for handling oil by air pressure. A Whitney crane is installed in the building above the machinery. The Sturtevant blower belonging to the heating system is also placed here.

The operator's bench board occupies a central elevated position in front of the switch tower, giving a full view of the generator room and the switching operations in the tower. All switches are distantly controlled and are electrically operated, there being no current above 125 volts on the bench board.

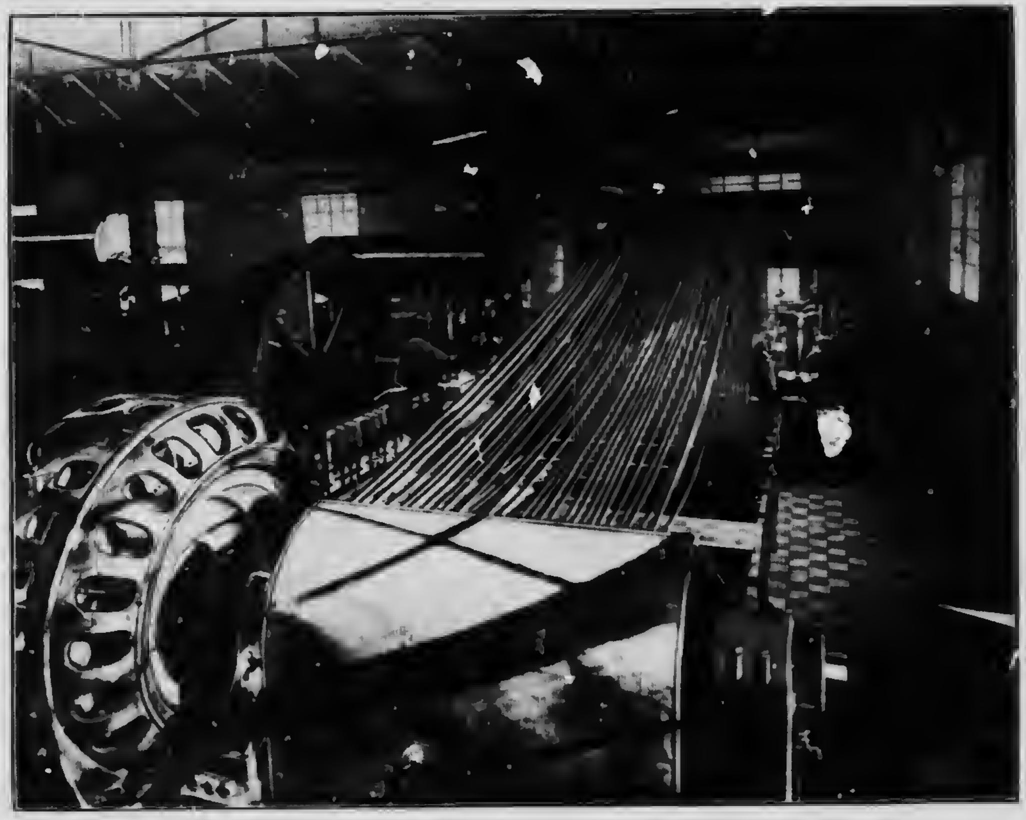
Transmission Line.—The main transmission line is about 30 miles in length. It runs from the power house at High Falls to the Copper Cliff sub-station, for the most part over its own right of way, which parallels the Canadian Pacific Railway line for about 29 miles; this right of way is cleared to its full width, 100 feet. The wires are carried on a double cedar pole line, the pairs of poles being placed at 8 ft. centres and bolted to a common cross arm; the poles are spaced 120 feet apart.

There are two independent 3-phase circuits strung with No. 1, hard drawn, bare, copper wire; the wires are hung 4 feet apart, and the nearest wires of adjacent circuits are also 4 feet apart. One circuit is transposed, the other is straight.

Lightning arresters of the horn type, Allis-Chalmers-Bullock construction, are provided outside the power house, and at the sub-stations at Copper Cliff, Creighton, Crean Hill, and Frood.

A telephone line is carried on a short cross-arm, 6 feet below the main cross-arm; the wires of this line are transposed every fifth pole. The line runs directly between the power house switchboards and the switchboards at the smelter sub-station; it gives perfect service. A second telephone line, carried for the most part on poles of the Canadian Pacific Railway's telegraph system, connects the terminal stations with the central telephone office at Copper Cliff, and with Crean Hill and Creighton mines, and other points between.

Sub-stations.—The principal sub-station is that already described, located in the smelter yard at Copper Cliff. There are other smaller sub-stations at the Crean Hill, Creighton, Number Two, and Frood mines.



Interior of substation at Copper Cliff, Ont.

CHAPTER III.

MOND NICKEL COMPANY, LIMITED.

INCORPORATION.—Incorporated September 20, 1900, under the laws of Great Britain. Operating in the Province of Ontario under license. Capital, £600,000, increased to £850,000 in 1908. Capital consists of 100,000 shares in cumulative 7% preference stock, in £5 shares = £500,000; 300,000 common stock in shares of £1 each = £300,000, and 50,000 shares deferred stock in shares of £1 each = £50,000. All the capital is issued.

Chairman, Sir Alfred Mond, M.P.; *General Manager*, Bernhard Mohr, London, England; *Secretary*, Robert Mathias, London, England; *Canadian Manager*, C. V. Corless, Coniston, Ontario; *Mines Superintendent*, Oliver Hall, Coniston, Ontario; *Smelter Superintendent*, John Roberson, Coniston, Ontario; *Head Office*, 39 Victoria St., London, S.W., England; *Mine and Smelter Office*, Coniston, Ontario.

Location.—The Company owns about 4,500 acres of mining lands, in fee simple, and controls about 2,500 acres under lease, a total of 7,000 acres in all, situated in the townships of Blezard, Denison, Snyder, and Garson, Sudbury district, Ontario; additional areas have also been acquired recently. The ores mined are deposits of nickeliferous pyrrhotites containing some chalcopyrite, and occurring in norite; they contain about 2·3% nickel and 1·75% of copper in addition to small amounts of gold, silver, platinum, and palladium. For many years the principal property was the Victoria mine, first opened about 1899. Two ore bodies, about 160 feet apart, occurred on this property. They lay with their longer horizontal axes almost on an east and west line, and had a uniform dip of about 75° towards the east. Development work was by diamond drilling, followed by shaft sinking and the running of levels. The main shaft is a 3-compartment shaft, 800 feet in depth, 4′ × 12′ inside the timbers; ten levels have been driven from this shaft to reach the ore body.

The other important mine which has supplied ore for a number of years is the Garson. There are two ore bodies at this mine, about 100 feet apart, and the development and mining have been through a 500 ft. shaft.

Extensive diamond drill work, based on the results of magnetic surveys, has shown the existence of a large body of ore on property belonging to this Company, adjacent to the Frood mine, lot 6, concession VI, township of McKim. Preparations are now being made to mine this ore body on a large scale.

The Company also owned and operated a smelter at Victoria Mines, Ontario, on the Soo branch of the Canadian Pacific railway, about 2 miles from the Victoria mine, and 22 miles west of Sudbury. This plant was working at the time of writing, but it is expected that operations will cease at this point about midsummer of 1913. The Company has been erecting a modern and fully equipped plant at Coniston, about 7 miles east of Sudbury, which is now nearly ready for operation. The new plant is more conveniently situated with respect to railway transportation and the future ore supply. Descriptions of both the old and the new works are included in the present report. These descriptions are based upon several published articles and upon data obtained by a personal visit to the two plants. The new plant was not completed at the date of the writer's last visit to the locality in September, 1912.

The ore supplied for the old plant was conveyed to the roast yards and thence to the smelter over a Bleichert aerial tram line, 11,000 feet in length. Ore from the Garson mine was brought about 31 miles in 50 ton bottom dump steel railway cars to Victoria Mines; from here a portion was sent to the roast yards over the tram line and the balance went directly to the furnaces.

Ore supplies for the new smelter will be derived chiefly from the Garson and the Frood mines, a portion of the ore body of the latter being on the property of this Company. The haulage distance to the new roast yards, about a mile and a quarter from the smelter, will be 10 and 12 miles respectively, chiefly over the Canadian Northern railway.

Power for the Victoria mine and smelter was furnished by a hydro-electric plant, owned by the Company, and located at Wabagishik falls on the Vermilion river, in Lorne township, and about 8 miles from Victoria Mines. Power for the Garson mine was procured from the lines of the Wahnapitae Power Company, whose two power plants are located on the Wanapitei river not far from Coniston. The new smelter is to be operated by Wanapitei power.

Historical. In the year 1899 the Company began operations in the Sudbury district by extensive stripping and other development work at the Victoria mine. This work included the building of roads, the preparation of a roast yard and other preliminary work. In 1900 the smelter was erected on its present site, under the supervision of Hiram W. Hixon. The Bleichert tram line, 11,000 feet in length, was installed by the Trenton Iron Company of New Jersey to connect the mine, roast yards, and smelter. The furnaces were first blown in early in 1901. The mine and smelter were closed down in December, 1902, and were not again in operation, except for a few months in the summer of 1903, until near the end of 1904. Since that date the plant has been in continuous operation, with only slight interruptions. The first furnaces were 44″ × 120″ at the tuyères; in 1908 the plant was remodelled and the size of the furnaces was increased to 44″ × 180″.

In 1911 the site for a new smelting plant was selected at a point about 2 miles from Romford Junction on the Canadian Pacific railway, conveniently located, both with respect to two transcontinental railway lines and to the principal mines owned by the Company. A new modern smelting plant has been erected on this site, and it is expected that it will be ready for operation in July, 1913. Two blast furnaces, 50″ × 240″, have been erected and space for a third is provided. Two Peirce-Smith basic converters 10′-0″ × 25′-10″ are also installed. All the auxiliary equipment necessary has been provided.

VICTORIA MINES PLANT.

This plant will cease operation before this report is in print. It has, however, served its purpose well and has been an important factor in the development of the copper-nickel industry of the Sudbury district. A brief description of the equipment and the method of operation is of interest and may also be of future value as a matter of record.

General Statement of Equipment. The plant as it now stands is equipped with two water-jacketed blast furnaces, 44″ × 180″, each capable of treating 400–450 tons of ore charge per day, under present practice. The converter building is equipped with two electric operated converter stands, and 6 shells, each 84″ × 126″, and a 30 ton, three-motor, Morgan travelling crane. Power is electric, supplied by the Company's plant at Wabagishik falls on the Vermilion river; a boiler plant is held in reserve at the smelter. The blower plant includes two Connersville blowers, and a Nordberg compressor for the converter air. The buildings include office and laboratory, engine house,[1] well equipped shops, club-house, boarding houses, and about 40 detached dwellings.

Bleichert Tram Line. This tram line is 11,000 feet in length and runs from the Victoria mine to the smelter. It is equipped with loading terminals at the mine, at the roast yards, and at the smelter, and with discharging stations at the roast yards and smelter. The buckets each hold about 700 pounds and travel the 2 miles from the mine to the smelter at such a rate as to deliver about 100 loads per hour. The roast yards are located between the mine and the smelter and about half a mile from the latter. Ore from the Garson mine is delivered into tram bins near the smelter by Canadian Pacific Railway ore cars; this ore is then raised by a small skip to charging bins on the tram line, whence it is conveyed to bins at the roast yard. The tram line also carries Victoria mine ore to the roast yards, roast ore to the smelter, and waste rock from the Victoria mine to the dump. The operation of this tram line is such that each bucket is idle for only a very short portion of the entire round trip from Victoria mine to smelter and return.

[1] The power plant at Victoria Mines was destroyed by fire on the day before it was to be closed down for removal to Coniston

The difference in elevation between the mine and smelter is only about 160 feet. Owing to the heavy duties required of the tram this fall is not sufficient to operate it, and additional driving power was furnished by 30 H.P. motor installed at the lower end.

Flue System and Stacks.—The downtakes of the blast furnaces lead to a steel dust flue with continuous V bottom. Slides are provided on either side at about 4 ft. centres, for the removal of flue dust. The main stack is of steel plate and is about 115 feet in height. The lower part of the stack, about 24 feet in height, is shaped as a truncated cone, the upper portion is cylindrical. The converter flues connect with the main stack.

Buildings.—The smelter building is a steel frame structure, covered with corrugated iron sheeting. The electrical sub-station, in which the power plant was also placed, was a wooden trussed brick building with concrete floors, 50′ × 90′; the roof was composite, being covered with corrugated steel on the outside and lined with matched pine. The various shops were housed in wooden structures.

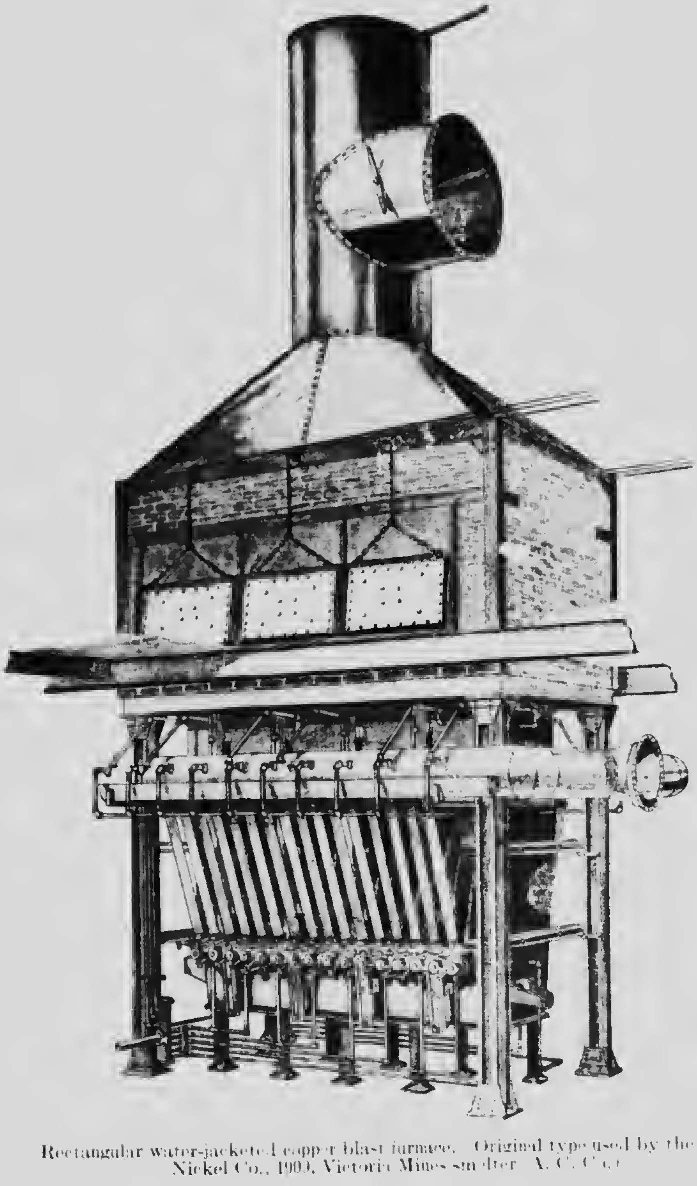
Coke, Fluxes, Silica.—The coke used in the furnaces comes from Pennsylvania. It is shipped by water to Algoma Mills, 73 miles west of Victoria Mines, where it is loaded into box cars, or coke cars, and hauled to the smelter by the Canadian Pacific railway. The freight charges amount to about $5.60 per ton on coke that costs $1.10 per ton at the ovens.

Limestone, which forms about 4% of the furnace charge, is obtained from the Fiborn quarries in Michigan.

For converter linings the siliceous ore from Bruce Mines, Ontario, is used. This ore consists largely of quartz carrying about 3% copper in the form of chalcopyrite; the ore is hauled 121 miles over the Canadian Pacific railway. When an additional supply of quartz is required, it is obtained from a local quarry not far from the smelter.

Blast Furnaces.—The two furnaces are each 44″ × 180″ at the tuyères. They are mounted on concrete foundations at an elevation of 6 feet above the converter floor. The superstructure is of structural steel above the charging floor; the hood, stack, and downtake leading to the flue are of steel plate (Plate XVIII). They are water-jacketed steel furnaces with brick tops, and cast-iron sole plate 2″ thick. Their capacity is 400-450 tons of ore charge per 24 hours for each furnace, under the present method of operation.

The furnaces as originally constructed each consisted of two tiers of water-jackets, three jackets on each side to each tier. The upper tier has now been replaced by brick; the inside brickwork is of firebrick, the outside of common brick. The furnaces are charged from the side, the charge doors being operated with a pneumatic lift. The charging floor is 14 feet above the tapping floor. The furnaces are provided with special water-cooled cast-iron spouts, each provided with only one set of water pipes. The spouts are lined with chrome brick and similar brick is also used at the



Rectangular water-jacketed copper blast furnace. Original type used by the Mond Nickel Co., 1900, Victoria Mines smelter. A. C. Co.

tap holes. The crucible is built within a plate steel box, and is carried by the sole plate. Chrome brick laid in magnesite cement is used for this; the magnesite cement is mixed with magnesium sulphate water.

The settlers are circular, each 12 feet in diameter and 4 feet in depth.

Converters.— There are two electrically operated converter stands and six Allis-Chalmers improved, 84″ × 126″ shells. The stands are operated from a pulpit by individual controllers and air valves. The converter shells and 5-ton cast steel matte ladles are handled by one 30-ton 3-motor Morgan travelling crane.

Lining for the converters is prepared by a 7″ × 10″ Blake crusher, and two 6 ft. Chilian mills direct connected to a 30 H.P. direct current motor.

Blower Plant.—Air for the blast furnaces is supplied by two Connersville blowers, each having a capacity of 15,340 cubic feet of air per minute at 40 ounces pressure, running at 130 r. p. m. Each of these is belt-connected to a 200 H.P. constant speed motor, taking current at 550 volts, and running at 580 r.p.m. The air pressure at the furnaces is about 38 ounces. Air from the blowers is delivered to a common receiver, and conducted to the bustle pipes of the furnaces. Bustle pipes run along each side of each furnace and across one end.

Air for the converters is supplied by a Nordberg duplex air-compressor, capacity 6,000 cubic feet of free air per minute, compressed to 12 pounds pressure, at 82 r.p.m. The low pressure cylinder is 34″ in diameter, the stroke 42″. The flywheel is 18 feet in diameter and is grooved for 18 ropes each 1·25″ in diameter. This machine is driven by a constant speed 315 H.P. induction motor running at 345 r.p.m., receiving current at 550 volts. This blowing engine is fitted with mechanical inlet Corliss valves and poppet discharge, and is regulated by the air pressure from the receiver through floating levers to the governor, this controlling the cut-off on the Corliss inlet-valves.

Flue Dust.—Flue dust is drawn from the flue through the slide doors into a barrow. It is wetted and fed to the furnace from hand barrows.

Smelting Practice. Roasting.—About two-thirds of the ore treated is first sent to the roast yards, about half a mile from the smelter and north of Victoria Mines station. Green ore is received at the tramway unloading station in the roast yards and dumped in a pile. Here it is shovelled into buckets and hoisted to the level of the staging that is built over the roast yards, and is loaded into end-dumping hand lorries, holding about 1,000 pounds each, which are pushed by hand to the roast piles. Each roast pile, when completed, contains about 3,000 tons of ore and covers an area of 40′ × 150′; the piles are built in a row, with the longer axes parallel, and about 10 feet between piles. To build a new pile a light pole staging is erected over the roast bed, and rails are laid in this staging to accommodate the lorries. A bed of dry wood, about 3 feet in depth, carefully and properly piled, is then laid as a base for the proposed roast pile.

Upon this wood ore is piled, to a depth of about 10 feet. A top dressing of 8″-10″ of fine ore is then spread over the top of the pile and down the sides and ends. The rails and stringers of the staging are then removed, the poles being left standing in the pile. The wood of the pile is then ignited; the whole pile will be alight in about four days. The pile is carefully watched, blow holes are stopped whenever they appear, and the roast continues for about 160 days, by which time about half the sulphur has been burned out, the green ore containing about 20% of sulphur, at the start.

After cooling, the roast heaps are loosened up by blasting. The roasted ore is shovelled by hand into cars and hauled by a horse to the aerial tramway. Here it is hoisted by a skip and dumped into the loading bins. Three men are required at the hoist in the roast yards; two men are required on each lorry; about 15 men in all are employed in these yards. The average output of the yards per day is, approximately, 475 tons of roasted ore, when the plant is operating at full capacity.

All ore from the Victoria mine is weighed into the roast yards at the mine; that from the Garson mine is weighed at the smelter before being sent to the yards. All roasted ore is weighed out of the yards.

Smelting.—At the smelter, ore, coke, and fluxes are all stored in bins placed with their discharge chutes above the level of the charging floor, so that the charge barrows can be run beneath them. The furnaces are charged by hand lorries holding about 800 pounds each. The ore charge consists of two parts roasted ore to one part of green ore; the coke makes up about 8% of the whole charge. A typical charge will consist of about 1,200 pounds of roasted ore, 600 pounds of green ore, 300 pounds of scrap and slag, including 75 pounds of limestone, and 250 pounds of coke.

The practice is to granulate the furnace slag, which is then flushed out to the edge of the dump.

Converting.—The furnace matte, containing about 33% copper and nickel, is collected in the settlers, which are tapped at intervals. From the settlers furnace matte is run into pots, which are lifted by the travelling crane and charged directly into the converters. Matte from No. 1 converter is blown up to about 60% copper-nickel. It is then skimmed and the slag is sent to the furnace settler while still hot and liquid. The matte from converter Number 1 is then charged to converter Number 2, and blown to about 80% copper-nickel. The slag from this converter also goes to the furnace settler, and the matte is run into a pot, from which it is poured on a matte bed to cool. There are four of these matte beds, each 4′ × 15′. It is customary to draw matte from the settlers at the same time as converter slag is being poured, thus preventing the overloading of the granulating streams.

The final Bessemer matte produced contains about 38% copper and 42% nickel, and about 15% iron, the balance being sulphur and other impurities. It is broken up on the beds, put into barrels, and shipped to the Mond Company's refining works at Swansea, Wales.

CONISTON PLANT.

The site for the new plant at Coniston was chosen only after very

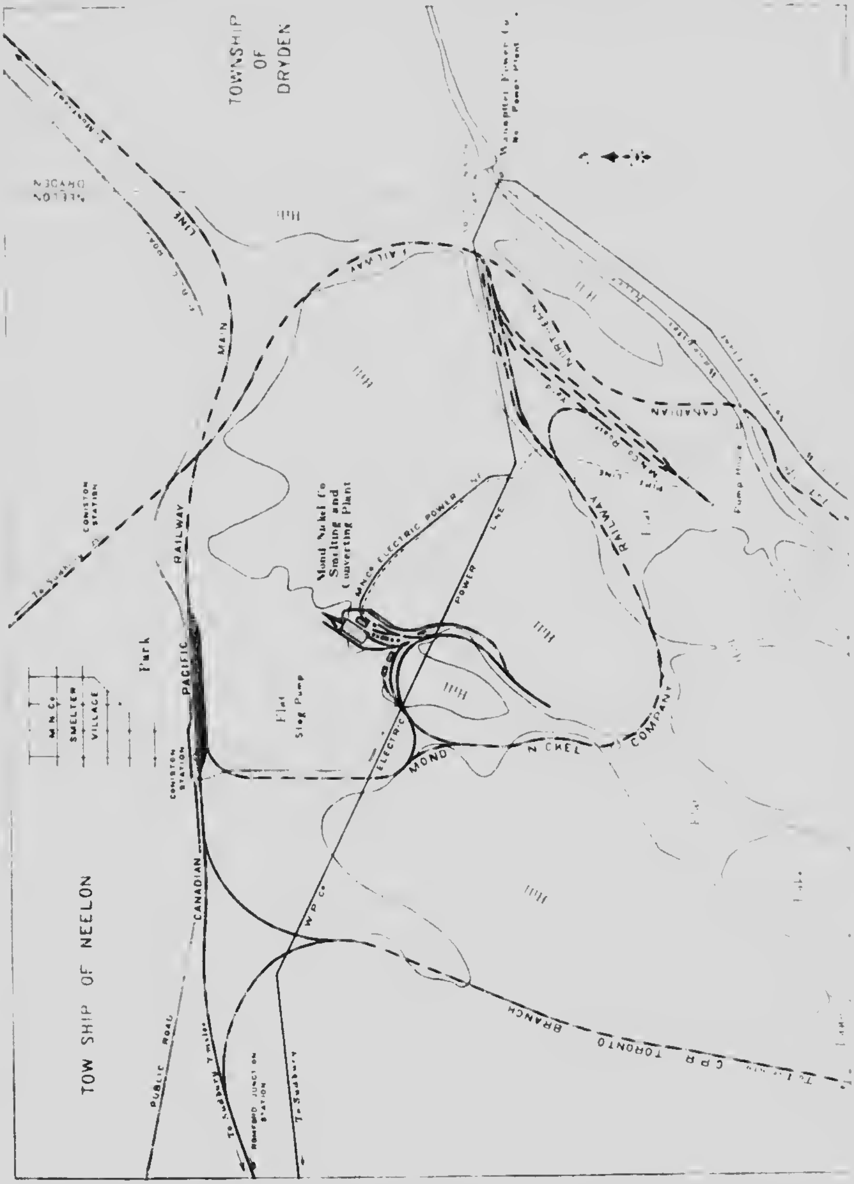


Fig. 9. Ground plan, Coniston plant, Mond Nickel Co.

careful surveys. The new smelter is located on a rocky hillside overlooking a large swampy flat which gives ample storage room for large slag piles.

The general layout of the plant and the railway approaches are shown on the accompanying plan (Figure 9).

The roast yards are located about three-fourths of a mile from the smelter, to the southeast, on the other side of the ridge at whose foot the smelter is placed. They are connected directly with the Canadian Northern railway and the Canadian Pacific railway, and are also connected with the smelter by a spur line belonging to the Company.

A new townsite has been selected and laid out, north of the Canadian Pacific line and about one mile from the smelter. Coniston will be a model town provided with every modern convenience.

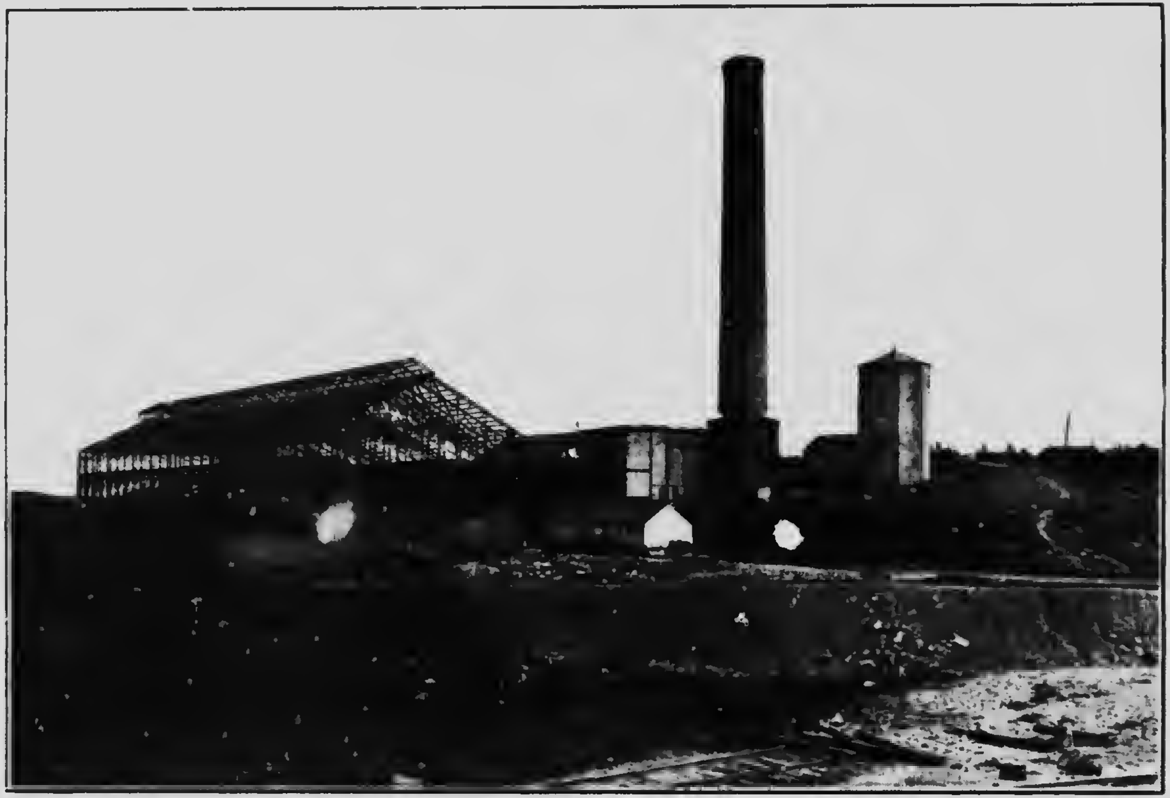
General Statement of Equipment.—The main smelter building has a concrete substructure resting on bed-rock, and a structural steel superstructure. In this building are placed two new modern water-jacketed blast furnaces, 50″ × 240″, and two Peirce-Smith basic converters, 10′-0″ × 25′-10″. Provision has been made for an additional blast furnace which will be added when required. The power building is located on the hill above the smelter. The ore bins are placed beyond this and a rock house stands southeast of the smelter and over the lower tracks. A semi-circular track leads from beneath the ore bins to the charging floor of the smelter building. It is carried over the slag tracks on steel trestles resting on concrete piers.

Receiving Ores.—As shown on the plan (Figure 9) spur lines have been built connecting both the Canadian Pacific and the Canadian Northern railways with the roast yards, the smelter yards, and the smelter ore bins. Ores from the mines to the north will come into the roast yards over the tracks of the Canadian Northern railway and can be delivered directly to the yards, or shunted over the Company's spur line to the smelter bins. Ores from the west will be diverted to the Mond Nickel Company's spur line at Coniston station, and can be run either to the smelter bins or to the roast yards. Ore from the roast yards can also be conveyed over the spur line to the smelter bins on the high line above the smelter.

Power.—Power to operate the plant is entirely electric and will be obtained from the power lines of the Wahnapitae Power Company. This corporation has two power stations on the Wanapitei river not far from Coniston.

Buildings.—The main smelter building is of steel construction with a concrete substructure, 90′ × 360′, resting upon solid rock; there is a monitor on the roof running the length of the building. A lean-to shed, 21′ × 240′, on the northwest side, houses the converter plant; a similar lean-to on the southeast, about 30′ × 210′, covers the slag track and the main flue (Plate XIX).

A slag cut on the southeast side is provided with a standard gauge track. The tapping floor is 14 feet higher, and the charging floor 24′-2·5″ above this. The furnace platform is 24 feet in width and 240 feet in



Coniston plant in course of erection. Mond Nickel Co., Coniston, Ont.

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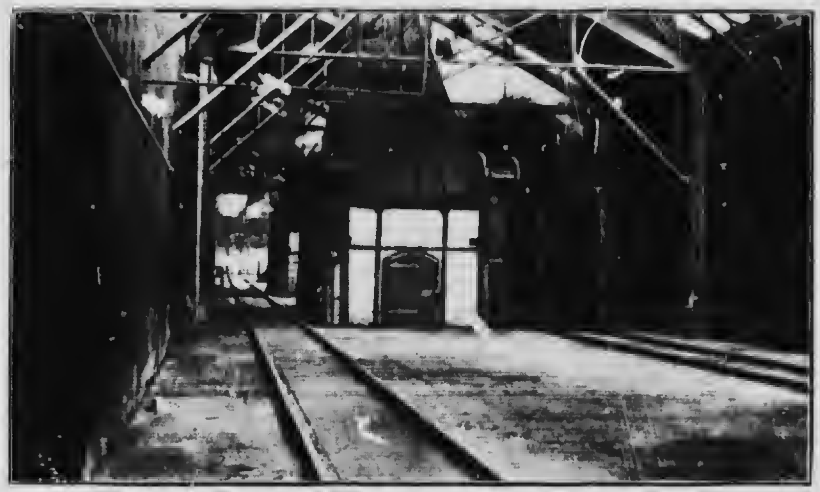
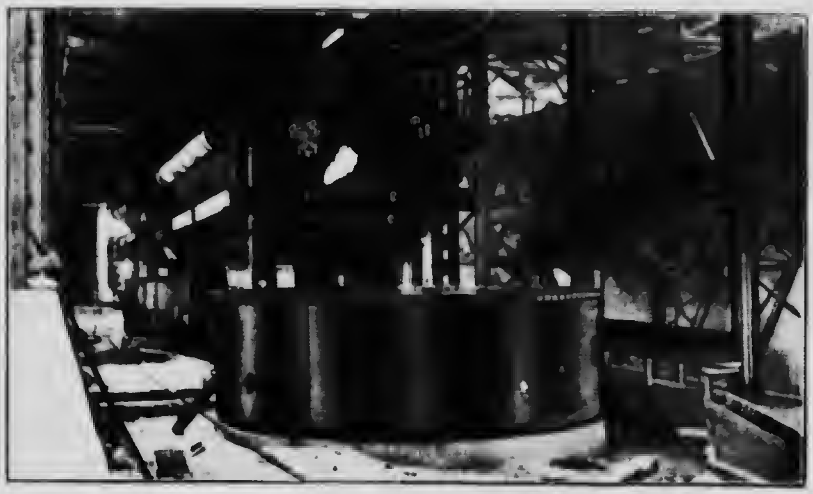
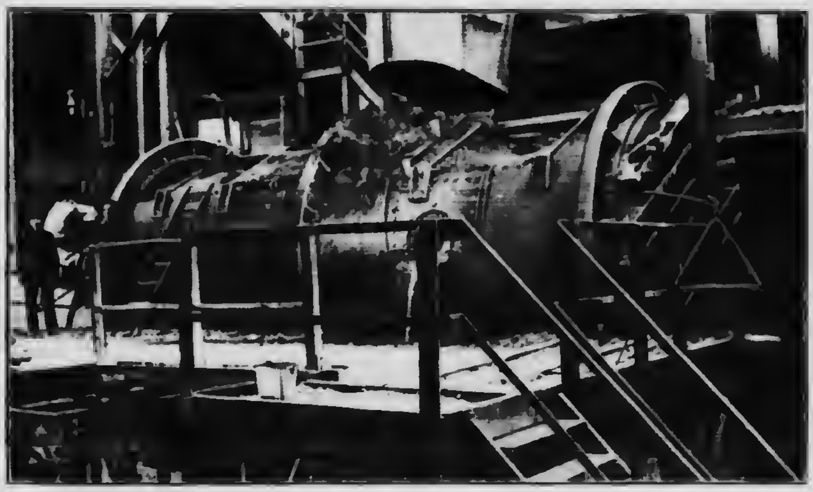
A. General view of the completed plant at Coniston. Note the curved line of trestles carrying the tracks that run under the ore bins and on the charging floor level.



B. Charging floor, showing top of a furnace.



A. Coniston plant, settler on furnace floor.



B. Converter in operation, Coniston plant.

length. The matte floor on the northwest side is 10 feet below the level of the furnace floor and about 56 feet in width.

The power house, built on the hill southeast of the smelter, is a brick and steel structure with concrete foundation and a tile roof.

Flue System and Stacks. The main flue is rectangular in cross-section 10′ × 15′, built of sheet steel. It leads to a dust chamber 30′ × 50′, built of stack brick, which connects with the base of the stack. The main stack rests on bed-rock; the lower 25 feet of the stack is square in section and is built of red brick, the upper cylindrical portion, about [illegible]6 feet in diameter, is built of Custodis stack brick. The height is about 175 feet.

The main flue is provided with 27 hoppers, placed at 7·5 ft. centres, in sets of two, between the main bents of the supporting structural steel work. There are also four large hoppers placed between the main flue and the brick dust chamber. The bottom of the dust chamber is fitted with 6 rows of steel hoppers, 9 to a row, the distance from centre to centre being 56″. Each hopper is provided with a circular discharge gate 13″ in diameter, closed by a lever operated slide. The hopper chutes beneath the dust chamber deliver to a common space so arranged that the flue dust can be run into a V-shaped auxiliary hopper of sheet steel hanging above a standard gauge track in the slag cut. Six chutes deliver from this hopper to a car placed beneath.

Blowing Equipment. In the power building foundations had been laid for three Connersville blowers and two Nordbergs. The blowers at the Victoria Mines plant were to be transferred to the new plant and one new Connersville and one Nordberg were to be added. Data with respect to the capacity of these blowers are given on page 65.

Blast Furnaces. There are two Allis-Chalmers rectangular water-jacketed copper blast furnaces, 50″ × 240″, each furnace being provided with a brick lined steel crucible and a brick top above the single tier of jackets. The height of the furnace is 32′-2·5″ to the base of the hood: the hood measures 12′-6″, giving a total height of 44′-8·5″. A goose neck, 7′-6″ in diameter, connects each furnace with the main flue, and a straight stack, closed by a damper, rises 15 feet above the hood.

Each furnace is carried on structural steel columns, the jackets being hung from I beams. The crucible rests on three rows of nine supporting columns each 5 feet in height. It consists of a rectangular steel frame about 6 feet in width, 21′-9″ in length, and 25″ in depth, made of I beams; the sole plate is of cast-iron in four sections. This crucible box is lined with chrome brick around the sides, ends, and bottom, reducing the internal width to 4′-2″.

Above the crucible there is a single tier of water-jackets, eight on each side, each 8′-2″ in height. The width of the furnace is 4′-2″ at the tuyères, at the top of the water-jackets it is 5′-9″.

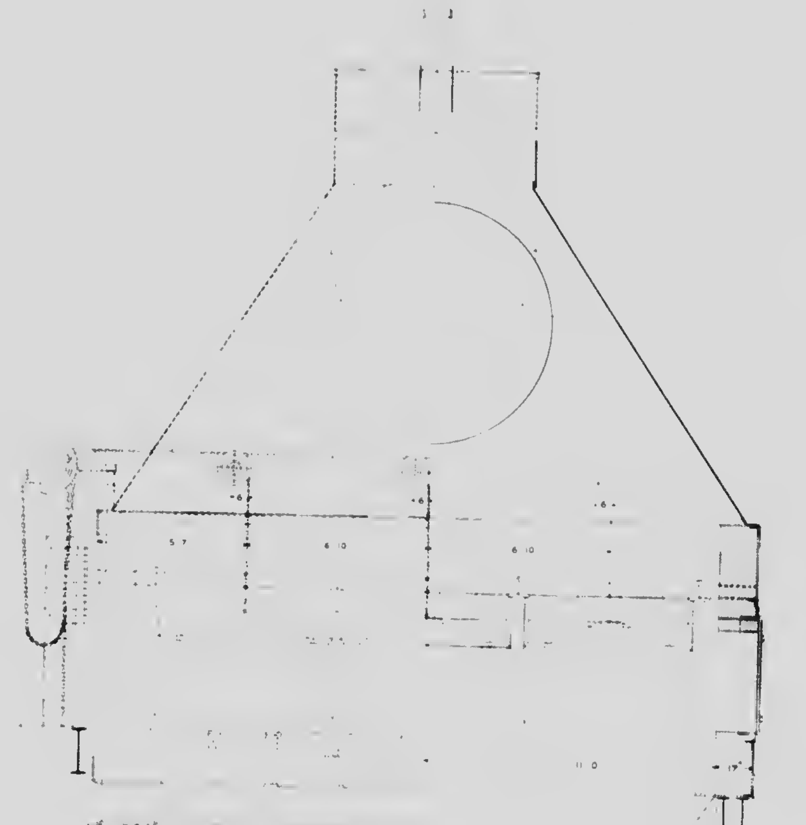


FIG. 10. Copper blast furnace, 1912, Mond Nickel Co. Vertical longitudinal section (A. C. Co.)

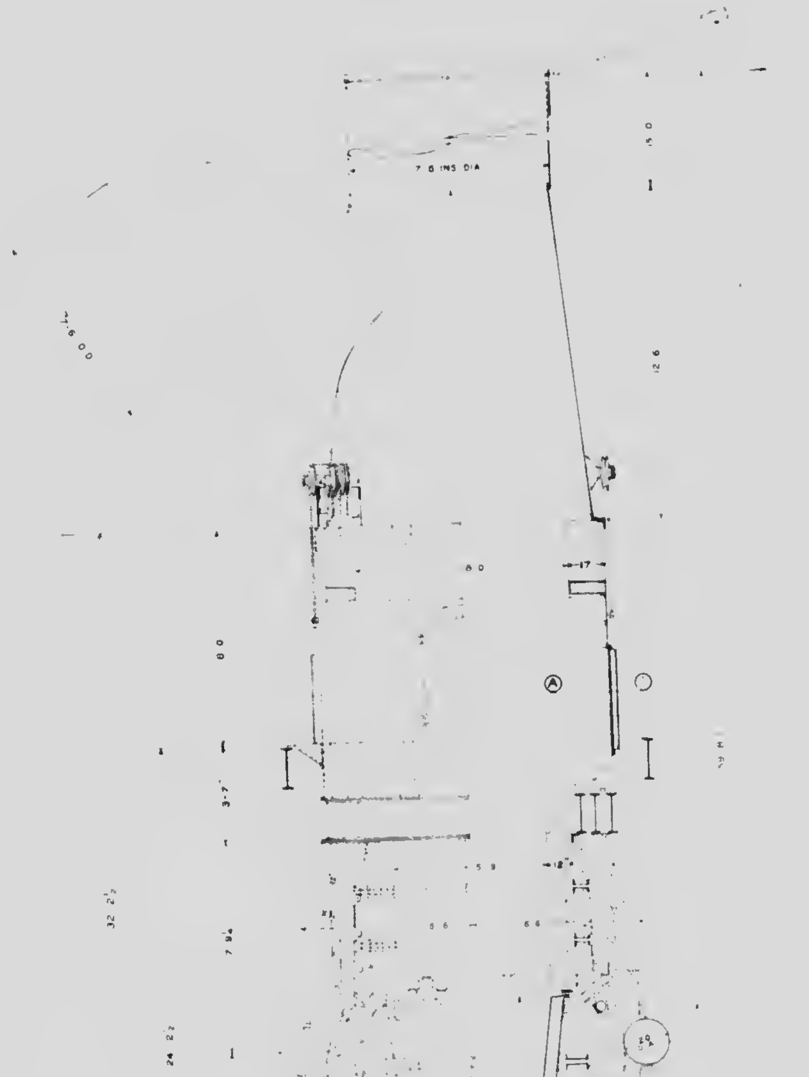


FIG. 11. Copper blast furnace, 1912, Mond Nickel Co. Vertical transverse section (A. C. Co.)

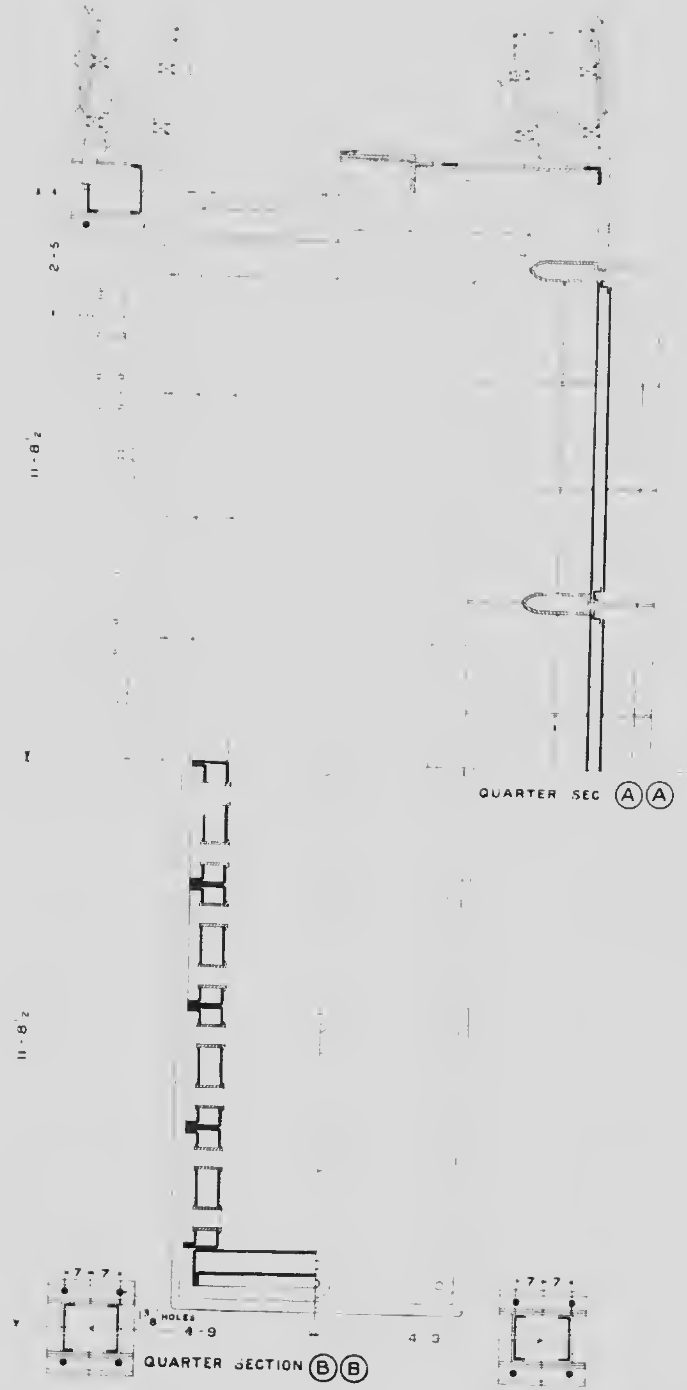
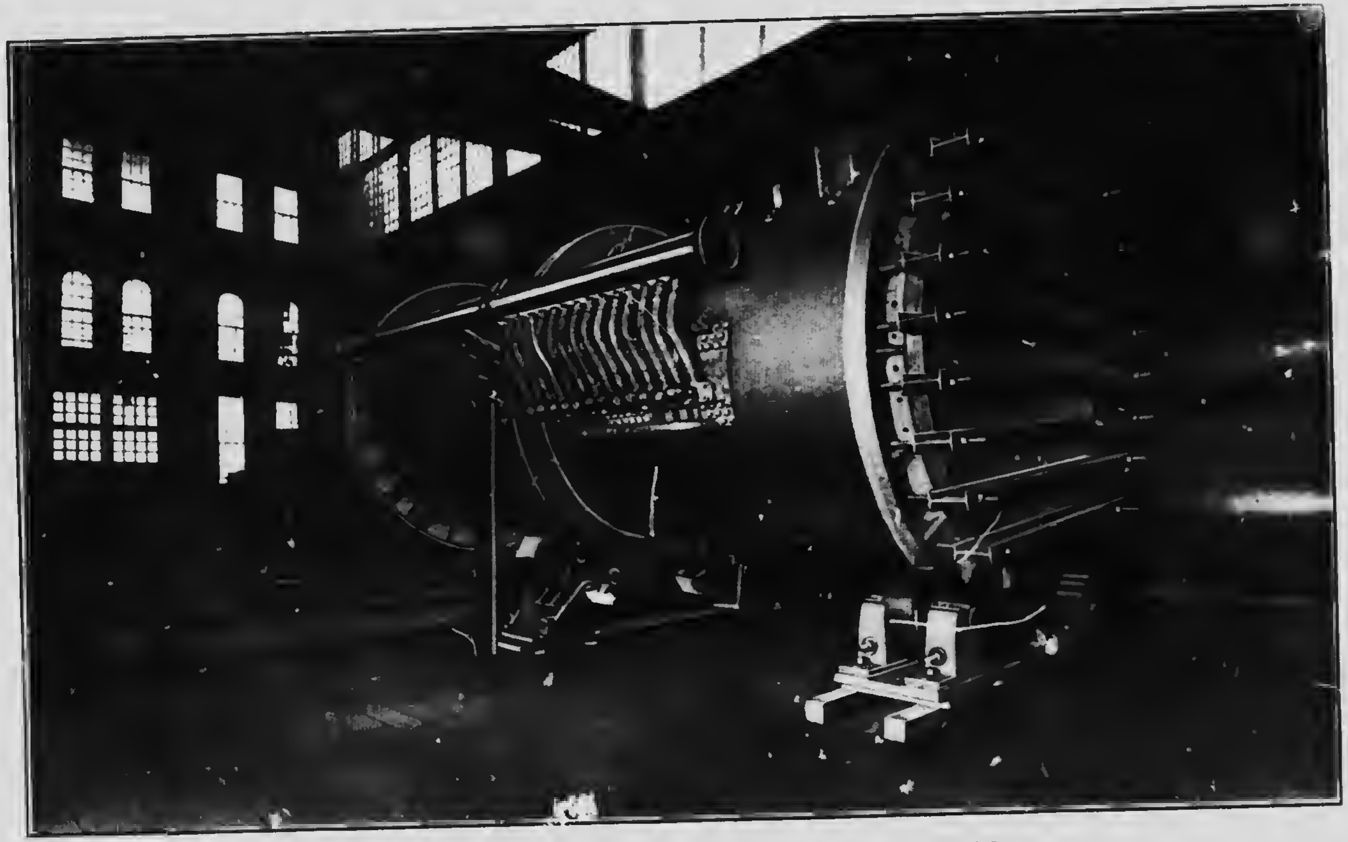


FIG. 12. Copper blast furnace, 1912. Mond Nickel Co. Horizontal transverse quarter sections. (A. C. Co.)



Peirce-Smith basic copper converter, Coniston plant, Mond Nickel Co.

The throat of the furnace above the water-jackets is built of ordinary brick and lined with firebrick, forming a jacket 12″ in thickness, the top being 3′-7″ below the charging floor. The space between the charging floor and the top of the brickwork is bridged by inclined apron plates.

At the ends of the furnace the brickwork is carried to the top of the furnace 8 feet above the charging floor. The charge doors along the sides of the furnace are operated by counter weights. Other data with respect to these furnaces are given in Table XV, chapter VIII. See also Figures 10, 11, and 12.[1]

The settlers are about 15 feet in diameter. They are placed beside the furnaces and discharge matte and slag from opposite sides.

The furnaces are placed parallel to the length of the building and may be charged from either side. Space has been provided for three, but only two are being installed at the present time.

Converters.—The converters installed in the new plant are of the Peirce-Smith type of basic converter with shells 10′-0″ in diameter and 25′-10″ in length. Two have been installed in the building (Figures 13-16, and Plate XXII).

The lining of each shell consists of 16″ silica brick and 9″ magnesite brick at the bottom, and 9″ magnesite brick at the top. At the tuyères special 18″ magnesite brick is employed.

Each shell is provided with 30 tuyères placed 14 on one side of the stack and 16 on the other, none coming directly below it.

The blowing stack is 3′-7″ in diameter, but the lining reduces the free space to 2′-9″. It is placed near the median riding track, its centre being 11′-2″ from the end of the shell opposite the bustle pipe. The pouring spout is placed 7′-7·5″ from the same end and about 77° of arc below the stack.

The ends of the shell serve as annular tracks upon which it may be rotated, and a third riding track placed 7·5″ to one side of the middle of the length of the shell has also been provided. The tracks rest on rollers carried on cast-iron bearing plates, bolted to a concrete foundation.

The shells are turned by steel ropes, pulled by a sliding gear operated by an electric motor and a worm screw, with an 8 ft. stroke.

The converter floor is served by two 50 ton Whiting cranes.

WABAGISHIK POWER PLANT.[2]

The hydro-electric plant belonging to the Company is located at Wabagishik falls, on the Vermilion river, about 8·5 miles from Victoria Mines station on the Canadian Pacific railway.

[1] From drawings supplied by the courtesy of the Allis-Chalmers Company, Chicago

[2] Based on a description by Grant B. Shipley, published in 'Industrial Progress, March, 1910.

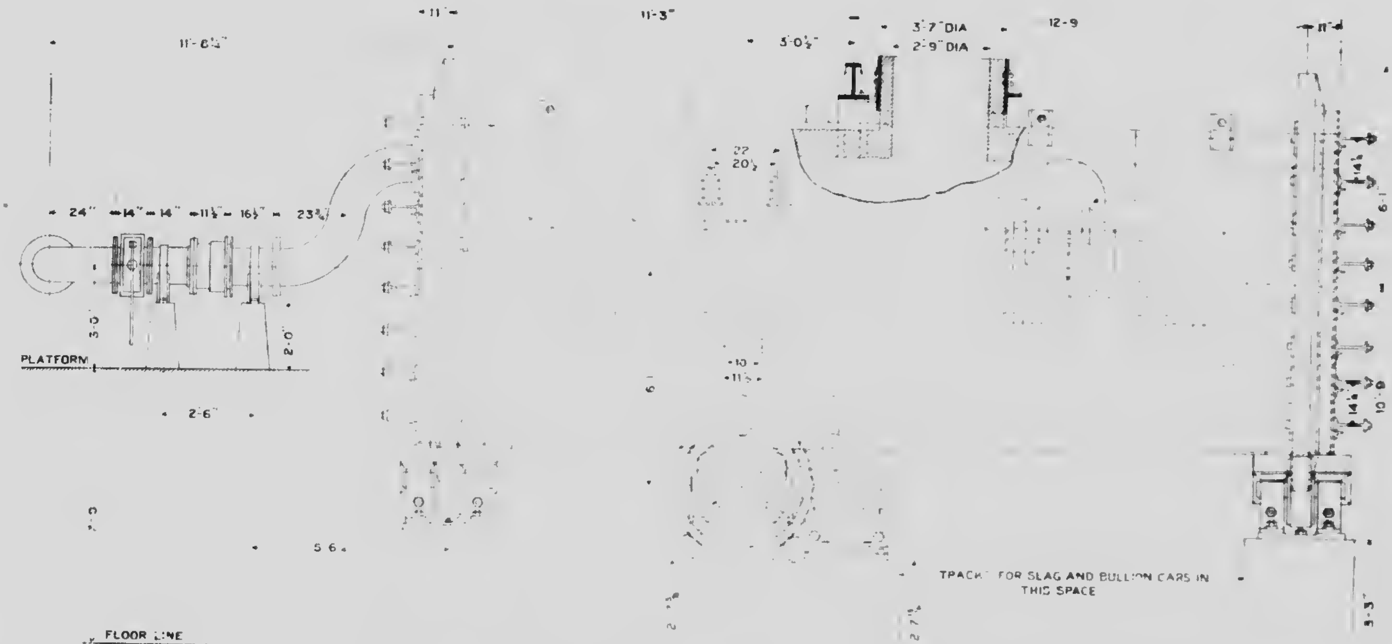
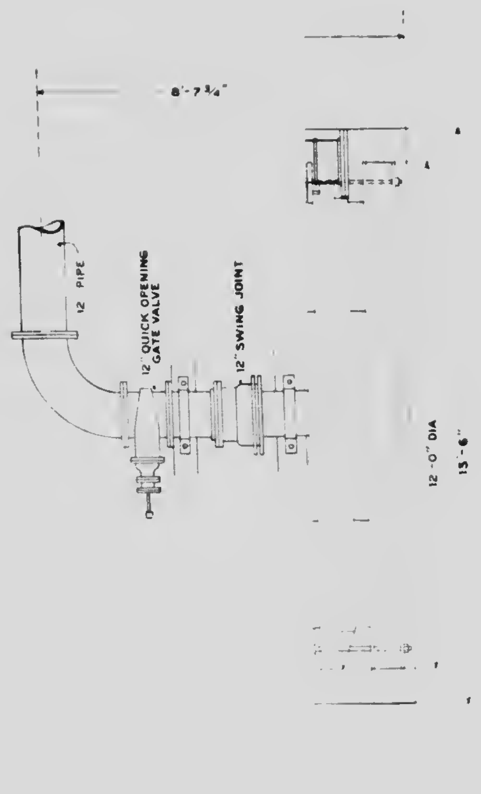


Fig. 13. Basic copper converter, Peirce-Smith type, Mond Nickel Co. Vertical longitudinal section (A. C. Co.)


8'-7 3/4"
12" PIPE
12" QUICK OPENING GATE VALVE
12" SWING JOINT
12'-0" DIA
15'-6"

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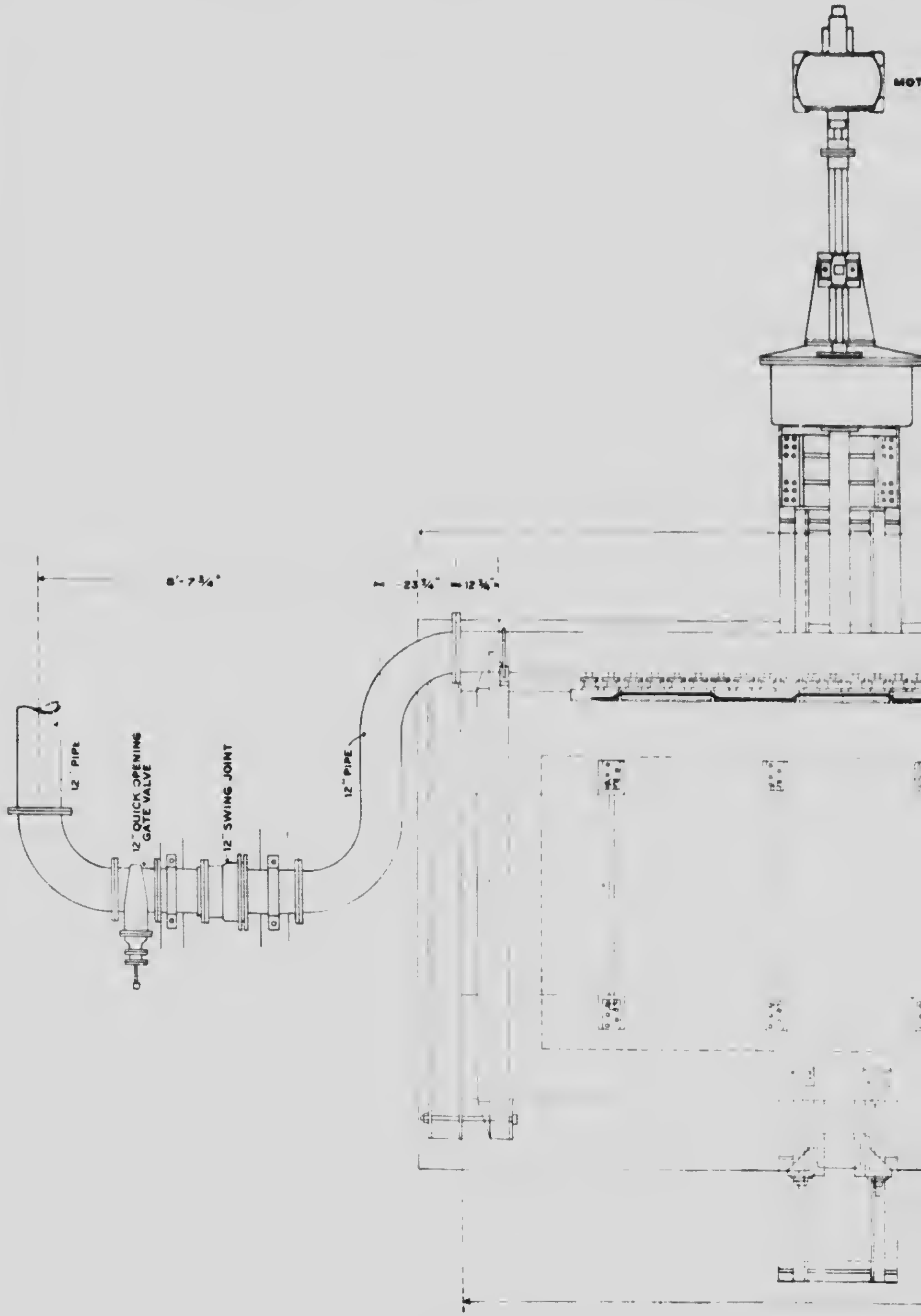
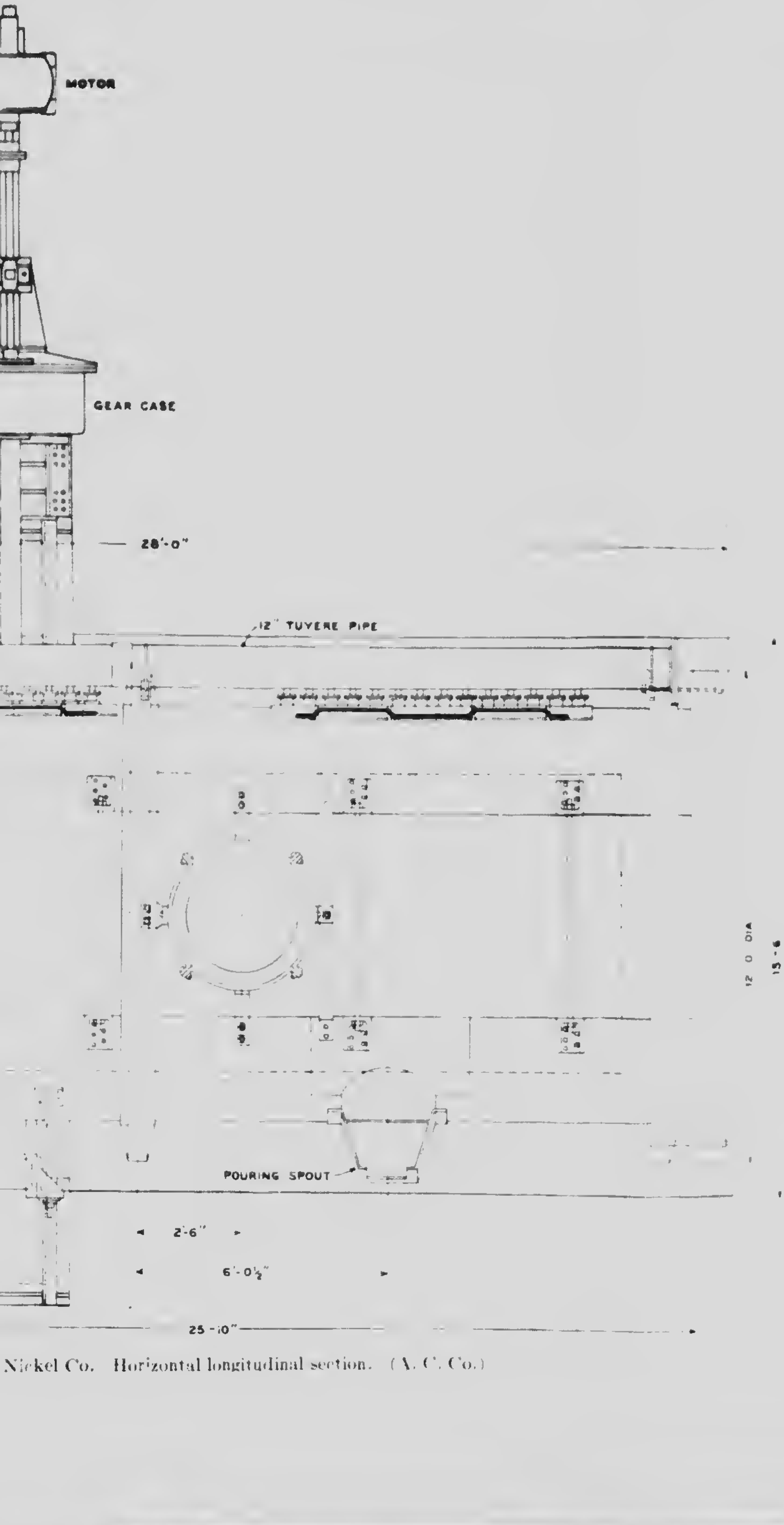


Fig. 14. Basic copper converter, Peirce-Smith type, Mond Nickel Co.



Nickel Co. Horizontal longitudinal section. (A. C. Co.)

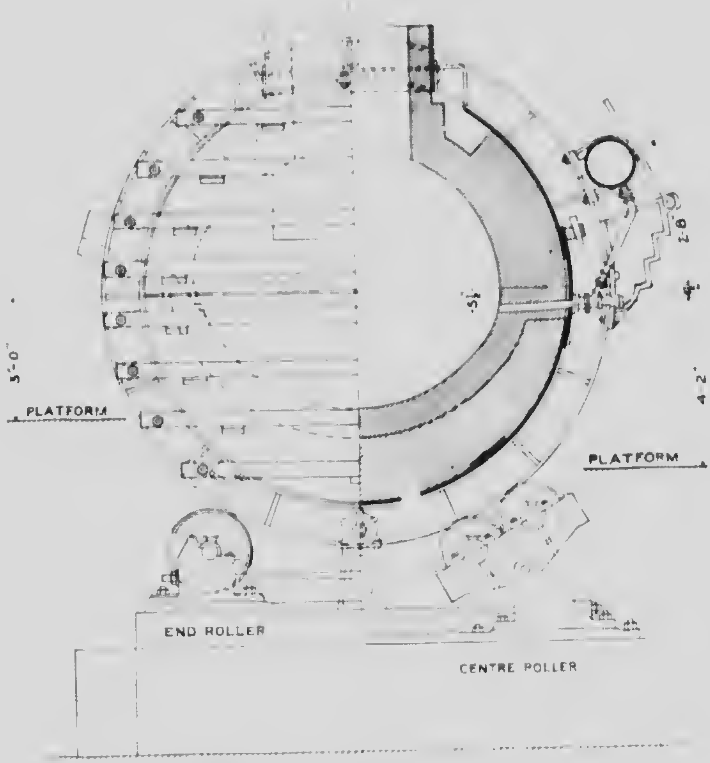
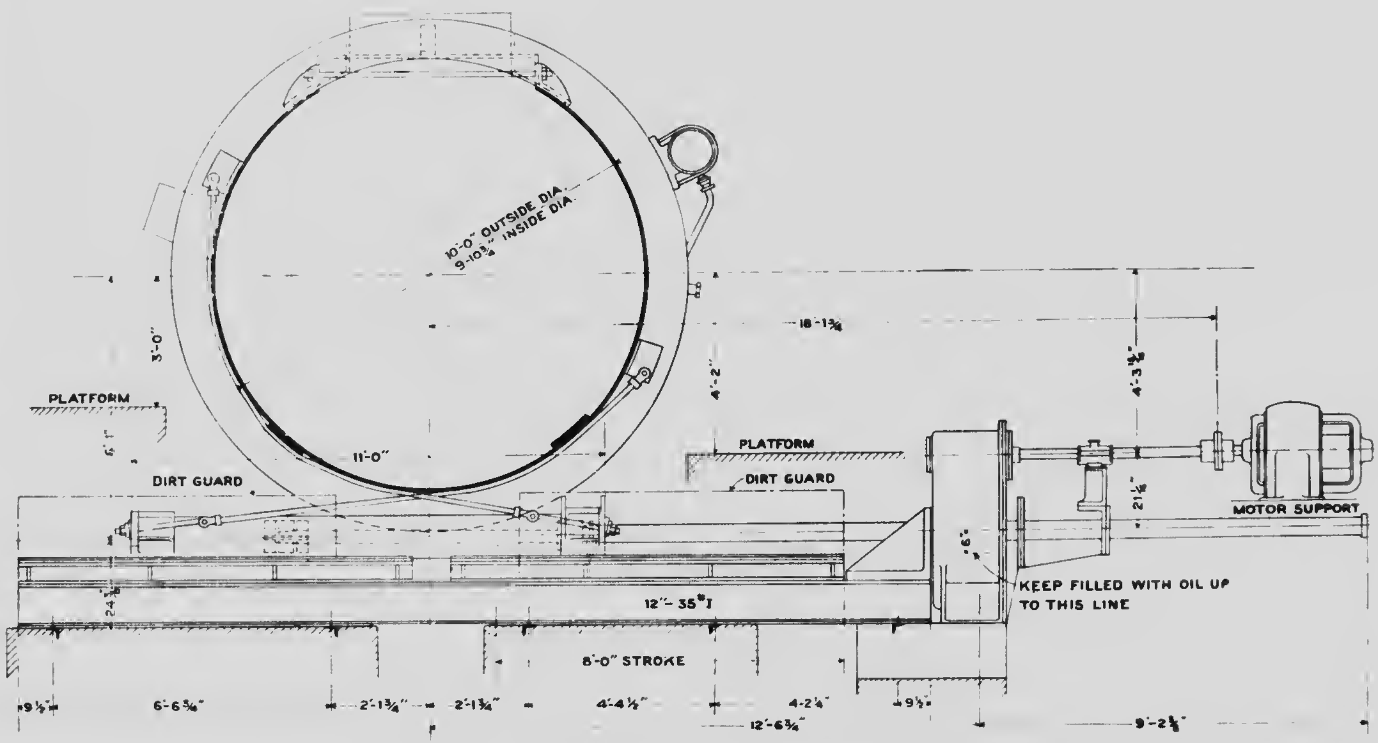


Fig. 45. Basic copper converter, Peirce Smith type, Mond Nickel Co. Transverse section through wind box and tuyère on ring nearest the tilting mechanism (A. C. Co.).



.16. Basic copper converter. Peirce Smith type. Mond Nickel Co. Transverse section showing attachment of tilting mechanism (A. C. Co.).

The power house is a concrete block structure, 46′ × 90′. It is equipped with an overhead travelling crane of sufficient capacity to lift the heaviest single piece of the turbine unit.

The steel pipe line leading from the dam to the power house is 450 feet in length, and 8 feet in diameter.

The main turbine is of the horizontal twin type, with a pair of cast-iron runners secured to the main shaft, all enclosed in a steel housing arranged so that the water enters parallel to the shaft, and discharges into a common draft chest. The top part of the housing is made in removable sections to facilitate quick inspection of all internal parts. The regulating gates consist of two sets of movable guide vanes, operated between two rings moved by short links and regulating rings that are connected to the regulating shafts by rods and levers.

The machine is governed by an hydraulic cylinder with piston connected by rods to the gates and operated by a geared pump and pressure cylinder. This pressure cylinder is provided with a fly ball governor, driven by belt from the main shaft, by which oil, under pressure, is admitted to either end of the oil cylinders, as required.

The turbine is designed to operate with 500 cubic feet of water per second under a 50 ft. head, when running 300 revolutions per minute at a power factor of 80%. It is direct connected to a 1,200 K.W. 60 cycle, 3 phase, 2,200 volt, alternating current generator. This machine, when running under load, generates from 800 to 1,300 K.W., the latter being the peak load when the mine hoist is suddenly thrown into action.

The exciter unit consists of one single horizontal shaft turbine, mounted in a cast-iron casing, with regulating gate made up of guide vanes pivoted on pins between two heads, and operated by means of a split regulating ring on the front head, connected by links to the governor. The generator is direct connected to the shaft, and is a 60 K.W., 120 volt machine. It is designed to operate on 27 cubic feet of water per second, at 50 ft. head, when running 875 r.p.m.

The switchboard apparatus at this power plant consists of one panel for control of the exciter, one panel for control of the generator, and one line panel provided with 16,500 volt lightning arrester and accessories.

The generator voltage is 2,200. This is stepped up to 16,500 volts for transmission over the power lines. The transformer equipment at the power house consists of one bank of transformers (three) of 800 K.W. capacity each. Power is transmitted over a line of No. 6 copper wire.

The smelter sub-station was equipped with three 350 K.W., oil insulated, water cooled transformers, which stepped the power down from 15,000 to 600 volts.

The Victoria mine sub-station is equipped with three 200 K.W. transformers, 15,000 to 600 volts.

CHAPTER IV.

THE CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA, LIMITED.

INCORPORATION.—Organized in 1905 as the Canadian Consolidated Mines, Limited. Name changed in 1906 to the present title. Authorized capital, $7,500,000, shares $100 par, issued $5,805,200. *President*, W. D. Matthews, Toronto; *Vice-President*, George Sumner, Montreal; *General Manager*, R. H. Stewart, Trail, B.C.; *Assistant General Manager*, S. G. Blaylock, Trail, B.C.; *Mining Engineer*, John M Turnbull, Trail, B.C.; *Superintendent Rossland Mines*, M. E. Purcell, Rossland, B.C.; *Superintendent Trail Smelter*, J. Buchanan, Trail, B.C.; *Metallurgist*, M. H. Sullivan. Fiscal year ends June 30. Annual meeting, Tuesday in September.

This corporation carries on the general business of mining, smelting, and refining gold, silver, copper, and lead ores; it also purchases the ores of these metals from other producers.

The subjoined article is descriptive of that portion of the works at Trail whose principal function is the smelting of ores containing copper, and the production of copper matte. In addition to the copper smelting department, the works at Trail include a complete lead smelting department and a lead refinery. There is also a roasting department whose chief function at present is to treat lead sulphide ores; ores which contain copper and which require roasting, and some copper mattes are occasionally treated in some of the roasters as circumstances require. Descriptions of the lead smelting and lead refining plant have not been included because they are not german to the subject in hand. The description given is based on personal visits to the plant and on published articles quoted in the text. The author is also indebted to the general manager, Mr. R. H. Stewart, to the assistant general manager, Mr. S. G. Blaylock; to the superintendent of the smelter, Mr. J. Buchanan, and to the metallurgist, Mr. M. H. Sullivan. The two latter gentlemen were kind enough to revise the first draft of the text and to supply many details. Reference should also be made to an article by Mr. J. M. Turnbull, published in 'Mines and Minerals,' September, 1910, pp. 121-125, entitled 'Trail Smelter and Lead Refinery,' and to an article by Mr. Buchanan, read before the Western Branch of the Canadian Mining Institute on September 18, 1912, entitled 'Copper Smelting Department of the Trail Smelter,' a copy of which, in manuscript form, was kindly placed at the disposal of the writer by its author.

COPPER SMELTING PLANT AT TRAIL.

Location.—The Trail smelter and refineries are located at Trail in the West Kootenay district, British Columbia. A branch line of the Canadian Pacific railway affords rail connexion with the principal mining

Birdseye view of the Trail plant, Consolidated Mining and Smelting Co., Trail, B.C.

camps of southern British Columbia, and with the Crowsnest Pass coal field. The smelter is located on the corner of a river bench in the Columbia River valley, at the mouth of Trail creek. The side and frontal slopes of this bench are steep and its top stands about 200 feet above the Columbia river. The location makes it advantageous to handle ore and slag by gravity, and comparatively little mechanical elevating is required.

The lead refinery is located on the same bench farther up stream; beyond this, and overlooking the Columbia river, are the houses of a number of the Company's officials.

The town of Trail is built below the smelter on the flood-plain of Trail creek beside the Columbia river.

Historical.—The site was first selected by Mr. F. A. Heinze of the Montana Ore Purchasing Company, and a small smelting plant to treat the Le Roi and other Rossland ores was established here in 1896. Reverberatory furnaces were first erected, but, these proving unsatisfactory, they were replaced by blast furnaces, the total capacity being about 200 tons per day. The plant was purchased by the Canadian Pacific railway in 1898; it was transferred to the present owners in 1906. Lead furnaces were installed in 1899, and the lead refinery, using the Betts patent electrolytic process, was erected in 1902. Changes and enlargements have been almost continuous and have resulted in some inherited disadvantages of arrangement. Some recent changes have been made, resulting in an increase in efficiency and economy, and the plant as a whole is both modern and efficient.

The general appearance of the plant is pictured in Plate XXIII. In the centre foreground is seen the Canadian Pacific Railway station at Smelter Junction, and the tracks leading to the ore bins and yards. The brick building to the right of this is the assay office. Farther to the right are the several shops; still farther over on the edge of the bench is the blast furnace building with the slag dumps lying below the bench. The flue rising from this building is connected with the lead furnaces. The tall flue behind the shops belongs to the copper blast furnaces and to the roasting plant. In front of this flue is the old sample mill, while the roasting furnaces and the Huntington-Heberlein plant are located in the buildings back of it. To the right of the sample mill is the blower room followed by the matte plant adjacent to the end of the blast furnace building. Ore bins and storage piles of coke lie to the left of the roaster buildings. The lead refinery is seen at the extreme left of the plate, and the residences of some of the principal officials of the Company lie back of this along the edge of the bench overlooking the Columbia river.

The panorama view shown in Plate III, made from a picture by Carpenter,[1] in 1906, gives a better view of the site upon which the works

[1] 303 Hastings St., Vancouver.

are located. While there have been many changes in the internal arrangements of the plant since the picture was taken, the essential features, so far as external appearances are concerned, are still the same; the slag piles seen on the left of the works and reaching towards the town of Trail are, however, very much larger. The lower of the two stacks belongs to the lead furnaces; the downcombers of the copper furnaces show clearly behind this stack; the main stack occupies almost the middle of the picture of the works; the long building in the foreground contains the roasting department; and coke storage piles are seen to the right of this. The lead refinery is shown near the right hand edge of the plate.

General Statement of Equipment.—The general equipment of the plant includes railway yards with 3 miles of sidings, railway scales, ore bunkers, storage yards with a capacity of 30,000 tons, two sampling mills, five large copper blast furnaces, two lead blast furnaces, with seven rotary blowers, two O'Hara furnaces, two Dwight-Lloyd roasters, seven Huntington-Heberlein furnaces, and 36 converters, an electrolytic lead refinery, briquetting plant, assay office, machine, carpenter, and boiler shops, together with a large amount of smaller machinery and equipment, including an extensive installation of pumps, hydrants, and hose for fire protection.

Electric Power.—Electric power is used throughout the works. It is received from the power plants of the West Kootenay Power and Light Company at Bonnington Falls. It is transmitted over the same 3-phase 60 cycle, 20,000 volt lines that run to Rossland, being stepped down at Trail to 550 volts. The Trail sub-station is owned by the Consolidated Mining and Smelting Company of Canada, Limited. The equipment of this station consists of two banks (six) of transformers, 150 K.W. each, 16,500/575 volts, oil insulated, natural cooled, manufactured by the Wagner Electric Company; and one bank (three) of transformers, 1,250 K.W. each, 16,500/575 volts, oil insulated, water cooled, manufactured by the Westinghouse Company. All switchboard apparatus, including lightning arresters, are by the Canadian General Electric Company.

The smelter proper has motors installed, having a combined capacity of 1,800 H.P.; the electrolytic lead refinery requires about 1,100 H.P. The total horse-power requirements of the plant are thus about 2,900 H.P.

Receiving Ores.— Ore is received in railway cars. These are weighed over a 100 ton Fairbanks recording scale, thence run over the proper bins and dumped. Ore is drawn from the bins to the proper sampling mill, of which there are two. The bulk of the copper and low grade ores is handled in the large mill; the other mill handles lead and dry ores and concentrates.

Sample Mill Equipment, for Copper Ores. The receiving bins have a capacity of 1,700 tons; three of them deliver directly to a No. 8 McCully gyratory crusher, 150 tons capacity per hour; the remainder deliver to the same crusher over a 36″ pan conveyer driven by a 20 H.P. motor. The crusher delivers into the boot of a 33″ manganese steel link belt bucket elevator, which lifts the ore to the top of the mill, where it is discharged over a 76″ Vezin sampler which cuts out 10% of the whole. The reject passes to the mill bins, and the sample passes through a No. 4 McCully crusher which breaks to 4″ size. A 48″ Vezin cuts out 20%, which passes to a 7″ × 10″ Blake crusher (to 2″) discharging into a 9″ bucket elevator. The sample is again elevated to a 36″ Vezin cutting 25%, which passes to a 14″ × 30″ rolls (to 1″), and thence to a second 36″ Vezin which sends 10% to 14″ × 24″ rolls (to ½″) and thence to the quartering floor. One two-thousandths of the original sample is thus delivered to the quartering floor where it is put through a 9″ × 20″ sample grinder and quartered down by hand or in Jones riffles; it is then sent to the bucking room. Part of the final sample goes to the assay office, and part is kept as a check until settlement is made for the shipment. All rejects are deviated to bins, whence the ore is conveyed by electric haulage to its destination—either to the charge bins for copper furnaces, or to the beds for roasters, or to the lead furnaces. It is hauled to its destination in trains by a Jeffrey electric trolley locomotive (Figure 17).

The mill is designed so that all sampling can be done on one shift with resultant economy, and more efficient supervision. It is now being arranged to handle lead and dry ores as well as copper and low grade ores.

The number 8 McCully crusher is driven by a 100 H.P. motor, and the balance of the mill by a 50 H.P. motor.

Haulage and Distributing System.—A high-line trestle, carrying 18″ gauge tracks, runs through the sample mills, and branch trestles from this line run to the storage yards, lead beds, etc.

The second haulage line is located 20 feet below this. It runs below all the sample mill bins and into a tunnel under the coke and storage yards. The ore and coke are drawn through chutes directly into cars, and run over the furnace charge bins, which have a capacity of 4,000 tons. These haulage lines are connected by a pair of balanced elevators.

The third line, 25 feet lower, is on the level of the feed-floor of the copper blast furnaces. It runs under all the furnace charge bins and has branches connecting it with the ground floor of the roasting and briquet plants. Each copper furnace has a track on either side on which the charge trains are run alternately.

Jeffrey electric trolley locomotives are used throughout the works for haulage purposes. Twelve are in service, seven of which are of 1,000 pounds draw-bar pull, and five 1,600 pounds. Two additional 10 ton motors have recently been added, chiefly for hauling anode cars from the lead smelter to the refinery.

The charge cars are of the swivel side dump type, are built of sheet steel, and have a capacity of 1,000 pounds.

The direct current required for the trolley lines is generated by two motor-driven, 100 K.W. generators. The current is supplied at 550 volts. An auxiliary or reserve set of 85 K.W. is also installed to prevent the serious complications which would follow a break in the haulage service.

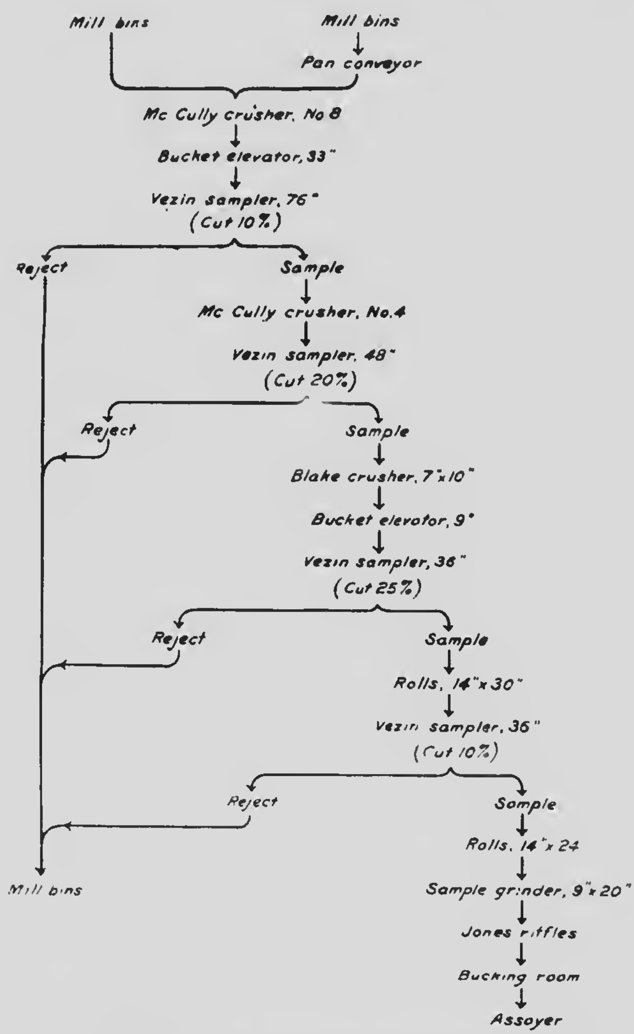


FIG. 17. Sample mill flow sheet, Consolidated Mining and Smelting Co., Trail, B.C.

A railway spur, on a trestle 12 feet above the high line, delivers coke to the storage yard. Usually about 6,000 tons of coke are kept on hand to provide against contingencies at the coal mines. This trestle extends over the bins which deliver ore from their chutes directly into the mouth of the large sample mill crusher.

Buildings.—All furnaces and machinery are housed in steel frame, galvanized iron sheeted structures. The blast furnace building is 225 feet in length, 70 feet in width, and 70 feet in height. The shops and the assay office are of stone and brick; the office building is of wooden construction. The trestle work and all bins are of wood.

Flue System and Stacks.—An extensive system of brick and metal flues is installed connecting with two brick stacks, one for the copper and one for the lead furnaces. The copper furnace stack is 185 feet in height, and has an internal area of 144 square feet.

Shops.—The property is provided with machine, boiler, blacksmith, and carpenter shops, all sufficiently equipped to handle all ordinary repair and construction work connected with the works.

Ores, Coke, and Fluxes.—The ore supply for this plant is drawn from the East and West Kootenay and the Boundary districts of British Columbia, with some siliceous gold ores from the State of Washington.

Rossland camp, 11 miles distant by rail, supplies about 4,000 tons of ore per week, averaging about 1% copper, $9-$12 per ton in gold, with 45% silica and 7-8% sulphur chiefly in the form of pyrrhotite. Most of this ore comes from the Centre Star-LeRoi group of mines in Rossland. At present only a small quantity of ore is received from the Boundary district. Formerly (1910) from 2,000-4,000 tons per week of self fluxing ore, running about 1·3% copper and $1.50 in gold and silver, were obtained from the Snowshoe mine near Phoenix, which this Company was operating under lease. Under favourable conditions of the copper market it is probable that the Company will mine and ship ore from its own properties—the Phoenix-Amalgamated group—in this camp, according to the demands of the smelter. The haulage distance is 110 miles.

The largest and steadiest supply of lead ore comes from the Sullivan mine in East Kootenay, controlled by the Consolidated Company. Ore comes from the Standard and Monarch mines and some ore is still obtained from the St. Eugene.

The balance of the ores received at the smelter comes from a large and variable number of smaller shippers and includes high and low grade copper ores, galena ores and concentrates, gold quartz ores, and gold mill concentrates, with some dry silver and gold ores.

Coke comes from the Hosmer Mines, Limited, near Fernie, B.C., a distance of 249 miles. The plants require about 225 tons per day.

Limestone for fluxing purposes is obtained from the Company's quarry at Fife, 68 miles by rail from Trail. About 225 tons per day are required and the costs are $1 per ton. In addition to being used for flux, a small quantity is burned and used as a briquet binder. No other barren flux is used except a small quantity of scrap iron as occasion may require.

Assay Office.—The building[1] is of stone and brick, 68′-10″ × 35′ 10″, the main floor being occupied by a furnace room, 30′ × 21′; two balance rooms 12′ × 15′; parting room 12′ × 9′; laboratory 15′ × 24′; bucking room 20′ × 21′; office 10′ × 12′, and a small store room. The basement is used as a store, and here is also placed a 5 H.P. induction motor for driving the mills, etc., in the bucking room, and a generator supplying current for electrolytic work.

The furnace room, which is the main department, occupies a space adjacent to, and near the centre of the south wall, and is covered by a gable roof to give extra height, set at right angles to the main building. This gable is extended 15 feet beyond the main wall of the building, providing a space 15 by 30 feet, for the stoking room. The furnace room is walled in with brick, plastered, open to the roof and well ventilated, light being obtained through windows set in the walls and i · the roof.

The muffle furnaces, four in number, are set behind the south wall of the room, the front of the furnaces being flush with the wall. The furnaces are built for the combustion of long flame coal, and the muffles used measure 24″ × 15″ × 7½″, and are capable of accommodating forty 15 gm. crucibles.

The draught is supplied by a stack 5 feet square at the base, and 40 feet high, to which are also connected the various hoods throughout the building.

In front of the furnaces a concrete floor is laid, half the width of the room, and running its entire length, and on this rests the pouring table, the top of which consists of an iron plate, 12′ × 2′ in area, and is 1″ thick. Under this are placed the buckets for used crucibles, scorifiers, etc.

Running parallel to the pouring table, with an intervening space of 4 feet, is a work bench 14′ × 5′. This is covered with ¼″ sheet lead, and a space in the centre 2′ × 10′ is occupied by the flux bins, provided with well fitting lids, to prevent salting from dust.

At one end of the room, the slagging, or breaking down table is placed, in the centre of which is a trough, which communicates with a suitable bin by means of a chute, for the removal of waste. At the other end are cupboards, for the storing of crucibles, etc.

The stoking room behind the furnaces is also open to the roof and ventilated, the brick floor being covered by ¼″ sheet iron plates. The coal bins are placed outside, and are accessible by means of three openings in the stoke room wall, on the floor level.

With the exception of the four walls of the furnace room, the partitions throughout the entire building are of glass, giving a maximum amount of light.

The furnace room communicates with the two balance rooms, the parting room on the north side, and the bucking room on the east, by

[1]Description supplied by J. Buchanan to 1907 Edition Mining and Metallurgical Industries of Canada.

means of glass panelled doors; and access is gained to a small store room, for beakers, chemicals, etc., through a door on the west side.

The tables in the balance rooms are set on concrete piers, free from walls and floor, and are topped with plate glass, backed with black paint. There are four balances, a Keller and an Ainsworth for gold, another Ainsworth for silver assays, and a Becker for analytical work. In this room is placed the electrolytic plating cabinet, the bus bars, and all connexions—which are of aluminium—the current for deposition being supplied by a group of storage batteries, which are in turn charged by the generator in the basement.

The office adjoins this room on the east, and is equipped with a writing table, desk, chairs, and a bookcase containing a valuable reference library.

The other balance room contains three analytical balances, and is provided with a large cabinet, the bottom half being fitted with drawers, etc., for storing the pulp samples of the different mine shipments. These samples have to be kept six months before going to the waste bins. The top half is fitted with a glass front, and is used as a cupboard for glass apparatus of various descriptions.

Adjoining this room is the laboratory, which though a little too small, for the amount of work accomplished, is thoroughly equipped for all kinds of wet determinations; besides complete apparatus for gas and coal analysis. The work bench runs around three sides of the room, and is covered with $\frac{1}{4}''$ sheet lead, the hood occupying the major part of the other side. The centre of the room is occupied by a beaker stand and two sinks.

The hood is of brick, with concrete hearth and glass front, and is connected with the furnace stack, which provides a first rate draught and keeps the room very free from fumes of all kinds. It is divided into two compartments, one being used exclusively for sulphuretted hydrogen, the heat being supplied by four electric plates (three heat) in each department. These plates are connected to the 110 volt circuit.

In the winter the distilled water used is condensed from the steam used for heating the building; an electric still serving the purpose in the summer. This water is stored in tanks above the work tables, heated by an electric coil, and conveyed to the benches by means of small rubber hose, fitted on the end with a small nozzle and pinchcock, serving the purpose of the old time wash bottle. A series of filter pumps are installed for the rapid filtration of gelatinous silica, etc.

The more staple of the standard solutions used in volumetric work are stored upstairs in carboys, and conducted by means of glass tubing and three-way cocks to burettes on the titrating table. This room is well lighted by eight windows 6 and 7 feet in height by 2·5 feet in width.

The parting room is situated between the two balance rooms, and is provided with electric heating plates, enclosed in a suitable hood for carrying off the fumes. The storage batteries are also placed in a cupboard in this room, together with a sink and glass topped table, on which the acid bottles are kept.

Not the least important of the different departments is the bucking room, where all the various samples [illegible] are prepared for the chemist and assayer. The equipment include[illegible] combined jaws and rolls, two grinding mills, a set of rolls, and one Braun's disc pulverizer, which reduces the actual bucking to a minimum. [illegible] are all driven by the 5 H. P. motor located in the basement.

The room is also fitted with two [illegible] drying ovens, heated by electric radiators, and in the centre are placed four bucking tables.

Being connected with a smelter h[illegible] both lead and copper ores, and producing refined lead, silver, gol[illegible] imony, the variety of the work is manifestly large, and is han[illegible] of five chemists and two sample buckers.

Copper Blast Furnaces. The pla[illegible] with five copper blast furnaces of the following sizes and c[illegible]

No. 1.	Tuyére dimensions,	210[illegible]	[illegible]	[illegible]50 tons daily.
No. 2.	"	" 42[illegible]	[illegible]	[illegible]
No. 3.	"	" 36[illegible]	[illegible]	[illegible]
No. 4.	"	" 42[illegible]	[illegible]	"
No. 5.	"	" 264″ × 42″	[illegible]	"

These furnaces are of the modern Americ[illegible] water-jacketed type—the jackets extending from the bottom plate to the feed floor. The principal features of their construction are given in the table of furnace data, No. XV, Chapter VIII, p. 146.[1]

These furnaces are provided with wrought iron, water-cooled, trap spouts. The nose of each spout is further protected by a water-cooled copper pipe which runs around its edge. These copper nozzles are made of copper plate ¾″ and ⅜″ thick respectively, on the lower and upper sides.

Two water-jacketed forehearths are used for each furnace, the second catching only from 0·25 to 0·50 per cent of the matte.

When in operation each furnace requires a motorman, a feeder, and a loader on the feed floor; on the settler floor a furnace man and a pot puller are required, while a third man attends to the spouts on two furnaces.

At the present time furnace Number 1 is used for the pyritic smelting of matte. Furnaces Numbers 1 and 5 are provided with two heavy rails which run down the middle of the furnace on the charge floor level. Bottom dumping charge cars can be run into the furnace to dump into the centre; the feed of these two furnaces is thus either from either side or from the centre, as the operator chooses.

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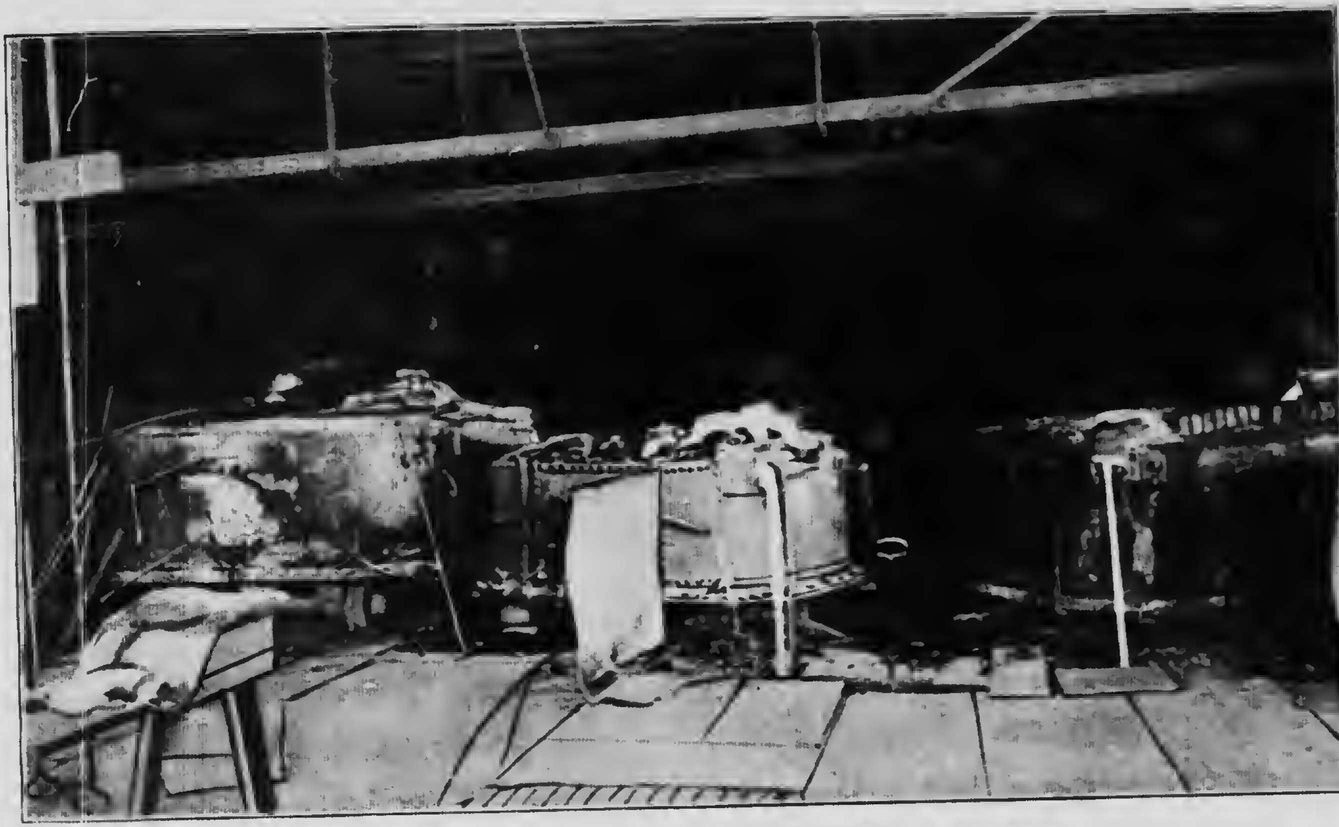
[1]Number 1 furnace was altered in February, 1912, to 120″ × 42″, to be used for making high grade matte; it was later extended to its present length of 210″. Number 4 furnace is being extended from 300″ to 420″, and widened to 50″. Other changes are also in progress.



Settlers at the copper blast furnaces, Trail plant, Consolidated Mining and Smelting Co.

Number 2 furnace, which has been extended to 35 feet in length and rebuilt, is also provided with a car track down the middle. This track is protected by two 5″ water pipes which run beneath the rails for their entire length, and is supported by four water pipes, 4″ in diameter, which run across the furnace.[1] The hood is a brick arch. The feed is by bottom dump cars which are run down the centre. Eventually it is intended to place side rails in the furnace similar to those used in the Granby plant, and to provide the cars with small side wheels from which they will be suspended while in the furnace. Number 4 furnace is being rebuilt. It will be similar to Number 2, but the jackets will only be half the width of those in the other furnaces.

Roasting Plant.—The roasting department contains the following equipment: two Allen-O'Hara roasters used for roasting Sullivan ore, formerly used also for roasting low grade mattes; two Dwight-Lloyd roasters used on lead ores, and for sintering copper concentrates; thirty-six circular Huntington-Heberlein roasting furnaces used on lead ores; thirty-six lead converters, used on lead sulphides.

Allen-O'Hara Roasters.—There are two furnaces of this type in operation at the works. The dimensions of the hearths are respectively 9′ × 95′ and 12′ × 97′.

The Allen-O'Hara roasting furnace consists of two hearths, built one above the other, over which rabbles are drawn by a pair of endless chains. The chains run, one on either side of the hearth proper, in a longitudinal channel provided for this purpose and do not come in actual contact with the roasting ore. At fixed points on the chains are fastened rabble bars which stretch across the hearth between the chains, there being six such bars to each hearth. The rabble blades are shaped somewhat like small ploughshares, and are set on the rabble bars, the vanes on each half of any given bar being turned in opposite directions to equalize the tendency of the ploughs to work towards the sides of the hearth.

The rabble chains are carried on sprocket wheels located in pairs at opposite ends of the furnace, one set of wheels acting as the drivers. The weight of the rabble bars and ploughs is carried on small carriages which run on rails laid in the longitudinal channels before-mentioned as lying beside the hearths for their entire length. To allow the rabbles to pass from one hearth to the other, the latter are closed at their ends by hinged doors of sheet iron, so arranged that they operate automatically, opening when a rabble is leaving or entering a hearth, and closing after it has passed. The chain is supported at mid-intervals between the rabble carriages, by small auxiliary carriages which also run on the rails. The guide rails on which the carriages run are carried some distance beyond the end of the furnace to permit the chains and rabbles to partially cool off each

[1] A new type of water-cooled rail, made in the works by shaping a 6″ water pipe under the steam hammer, is being tried in this furnace (September).

time after passing through the hearths. Each rabble bar completes a revolution in about 3·75 minutes.

The ploughs on adjacent bars are so arranged that the ore on the hearths is alternately turned towards the centre and towards the sides, and at the same time it is moved along the hearth a short distance in the direction in which the rabbles are travelling. Ore is fed to the upper hearth from above; through hoppers, it advances along this hearth to its distant end, where it drops through an opening and is then moved along the lower hearth in the opposite direction to the discharge point.

Along the sides of the furnace are built six fire boxes, 2 + 1 for the upper hearth, and 1 + 2 for the lower hearth. The fuel used in these fire boxes is coal.

Air is admitted to the hearths through dampers in special doors provided for this purpose along the sides of the furnace.

Dwight-Lloyd Roasters.—Two Dwight-Lloyd blast-roasting machines of the straight line type are installed for roasting certain lead ores. They have also been used for sintering flue dust and for treating copper matte and while not at present used for either of these purposes, it has been thought advisable to include a description of the installation.[1]

The Dwight-Lloyd sintering machine of the straight line type (Figure 18) consists of "a structural steel frame supporting a feeding hopper, an igniting-furnace, a suction-box, and a pair of endless track circuits to accommodate a train of small truck-like elements called pallets, which in combination, form practically an endless conveyer, with the continuity broken at one place in the circuit. Each pallet is provided with four wheels which engage with the tracks or guides at all parts of the circuit, except when the pallet slides on its planed bottom over the planed top of the suction-box, thus making an air-tight joint. A pair of cast-steel sprocket-wheels, turning inside of concentric guide-rails, lift the train of pallets from the lower to the upper track by engaging their teeth with the roller-wheels, and launch each pallet in a horizontal path under the feed-hopper and igniting-furnace and over the suction-box. In a train of pallets in action all the joints are kept closed and air-tight by the pallets being pushed from behind. At the beginning and the end of the track formed by the planed top of the suction-box, there is a planed 'dead-plate' over which the pallets must glide; it serves to prevent any leakage of air. After a pallet passes over the suction-box and terminal dead plate, its wheels engage the ends of the circular discharge-guides. These are adjusted with the view of raising

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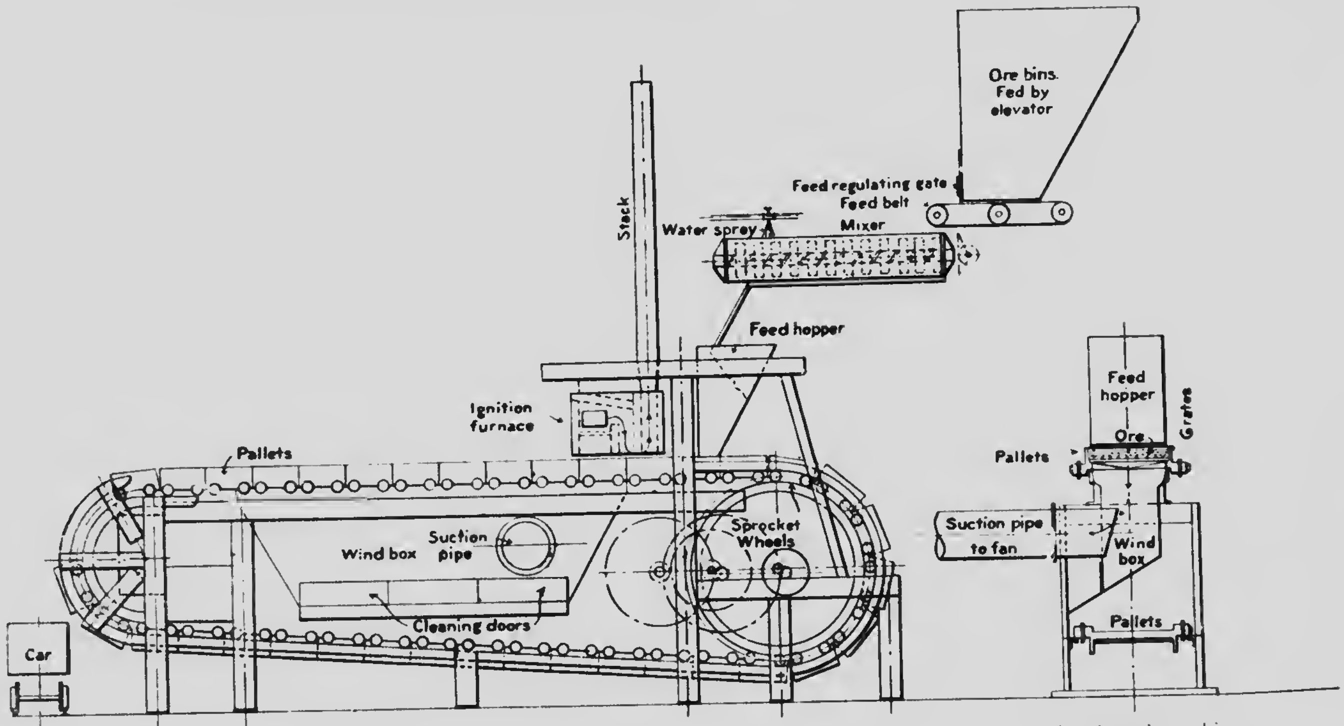
[1] See 'Recent Progress in Blast-Roasting,' H. O. Hofman, Trans. A.I.M.E., Vol. XLI, pp. 755-763 (1910).

'The Sintering of Fine Iron-Bearing Materials,' James Gayley, Bull. A.I.M.E. No. 56, Aug., 1911, pp. 631-641.

The description given here is largely adapted from Prof. Hofman's article mentioned above.



Side elevation.

Section through machine.

FIG. 18. Straight-line Dwight-Lloyd blast roasting machine (after Hofman.)

Note. The machines at Trail are provided with gas burners instead of the ignition furnace, and one machine has an additional hopper behind the one shown in the diagram.

the pallet about 0·5″ vertically and thus automatically prying up the cake of sinter and freeing it from the grate-slots. A "breaking-roller" prevents the prying action from extending too far back, and tends to form a line of fracture. This roller, however, is not essential in all cases. On reaching the curve of the guides the pallets one by one drop into the guides, each strikes the pallet which has preceded it and, at the same time, discharges its load of sinter-cake, and shakes free the slots of the grates. The force of the blow can be regulated by the gap left in the train of pallets at this point. The weight of the train keeps the pallets fed down to the lower teeth of the sprocket-wheels.

The igniter used with the Trail machines uses gasoline for fuel and it is placed 2″ above the bed of ore to be roasted.[1] The original igniter was a small coal-burning furnace built of tiles, having a grate area of 10″ × 42″, and burning about 650 pounds of coal in 24 hours. The flame, after passing over the fire-bridge, was deflected downward upon the ore by a brick curtain which could be raised and lowered, and was then drawn upward by the natural draft of a small stack or bleeder. The feed of this coal burner gave a good deal of trouble because of the down draft due to the suction fan, and the back feed. For this reason gasoline has been substituted with more satisfactory results. At present on Sullivan lead ore, about one gallon of gasoline is required per ton of ore roasted.

Each of the machines at Trail is supplied with two suction boxes on top, each 11 feet in length and 42″ in width, which gives for the grates, an effective hearth area of 77 square feet; this is the true measure of the capacity of the machines.

The pallets measure 42″ in width and 24″ in length.

The power delivered to the machine has its speed-factor reduced by passing through a train of gear-wheels, the last of which engages the internal gear-teeth cast in the large sprocket-wheels, and actuates the train of pallets. The drive is by two cone pulleys by means of which the speed may be varied to suit the mixture being roasted.

The complete cycle of operations is as follows:—

A pallet, being pushed onward tangentially from the top of the sprocket-wheels, passes under the feed-hopper, where it takes its load in the form of a continuous even layer of charge, say 4″ thick, passes next under the ignition-furnace, where the top surface is kindled, and at the same time comes within the influence of the downward-moving currents of air, induced by the suction-draft; these carry the sintering action progressively downward until it reaches the grates. The roast-sintering operation is complete, the cake is discharged by dropping into the discharge-guides, the pallet crowds its way back to the sprocket-wheels, is slowly raised to the upper tracks, and begins a new cycle.

[1]A burner using producer gas has since been substituted, and is operating satisfactorily.

The suction blowers employed for the Trail machines are Sirocco blowers, Number 110, built by the American Blower Company, driven by a 50 H.P. Canadian General Electric motor, running at 850 r.p.m. A 20 H.P. motor is required to drive each machine, including the elevator, feed belts, conveyer belts, mixer, and gasoline pump.

The furnaces as installed at Trail have proved to be poor roasters and of low capacity. To obtain good results the maximum size of particle should be about ¼″. Changes in the method of firing have already been introduced with increased efficiency. At the time of the writer's last visit to the plant, an additional feed hopper was being placed back of the old hopper, so that this machine would have two.[1] The rear hopper was to be used for feeding coarser ore low in sulphur, to a thickness of about half an inch, in an attempt to keep the grates clean, trouble having been experienced with their clogging. A new type of grate, with movable interlocking bars, has also been designed. These bars are intended to overcome the clogging of the grates, as experienced in the old herringbone type of pallet grate, on the original machines.

The machines at Trail are classed as Type E, 42″ × 264″. The rate of travel of the pallets can be varied; with the Sullivan ores it was 2 feet in 5 minutes. The largest size of particle permissible for good work has been found to be ¼″; the tonnage obtained with each machine was only 15, while between 75 and 100 is said to be the rating for machines of this type. The sintered material contained 5% of sulphur against 23% in the unroasted ore. One gallon of gasoline was required for each ton of ore roasted. About 18 H.P. was required to drive the machine and 50 H.P. to operate the suction fan; two men per shift attended each machine.

Blower Plant.—The blower plant consists of eight rotary blowers operated by individual motors. The three older are Connersville blowers, while [illegible] others are of the Root type. The largest blower delivers 33,000 cubic feet of free air per minute at a pressure of 36 ounces and consumes 350 H.P.; a new Root blower, size No. 10, recently installed, delivers 200 cubic feet of free air per minute running at 570 r.p.m. and requires two 150 H.P. motors to operate. The total power required for the blower plant is 1,500 horse-power. All blowers deliver to a common receiver for distribution to the blast furnaces (including the lead furnaces). Usually only the four larger blowers are in use.

The air at the blast furnaces is used at a pressure of 32–34 ounces.

Matte Plant.—The matte crushing plant is located next the blast furnace building at the north end. It is provided with a 10″ × 21″ Blake jaw crusher and a pan conveyer that discharges into three upright steel storage bins.

[1] This hopper is now in place, but at present (September) is not being used.

Briquetting Plant.—The flue dust is collected in a brick flue 10′ × 20′ in section, and 750 feet in length and delivered to a pugmill where it is mixed with 5% burned lime as a binder. The mixture is then briquetted in a Chisholm Boyd and White disc briquetting machine, the briquets being collected in a car and sent to a furnace bin and thence recharged into the low grade furnaces.

Smelting Practice.—The present practice is to smelt the raw gold-copper ores to a low grade first matte, which carries a variable amount of copper—about 10%.

Rossland ores, which form the bulk of the supply, are charged directly. They require about 30% of good limestone as flux, and about 16% of Crowsnest coke per ton of ore charged. The ore column in these furnaces is maintained at 8 feet above the tuyères.

In the low grade furnaces the charge is varied according to the ore, giving a slag of the following proximate analysis: silica (SiO_2) 40–45%; ferrous oxide (FeO) 14–18%; calcium oxide (CaO) 18–22·0%; magnesium oxide (MgO) 1·5–30%; aluminium oxide (Al_2O_3) 14·0–16·5%; sulphur a trace; copper 0·15%, with trifling amounts of gold and silver. The slag is granulated and sluiced to the dump, an ample supply of water for this purpose, under a 140 ft. head, being obtained from several mountain creeks.

The first matte, running about 10% copper, 27% sulphur, and 50% iron, is cooled and crushed and is subsequently treated in Number 1 furnace by pyritic smelting methods. The former practice was to granulate the matte and then to roast it in the O'Hara furnaces and subsequently in lead converters to about 1–3% sulphur. This roasted matte was then smelted in the high-grade furnace with a self-fluxing ore and an ore low in sulphur, producing a matte running about 42% copper.

The present method of treating high grade matte was adopted after considerable experimentation, the furnace used for the purpose, No. 1, having been modified first by reducing its size to one-half, and later by removing the ends of the hood and providing heavy rails along the middle of the furnace, whereby it can be charged along the centre with bottom dump cars. This method of charging appears to be necessary to prevent the rather fine siliceous ore used from crusting along the sides of the furnace.

In operating this furnace, two charge cars are used and the charge, which is divided equally between the two, consists of 4,200 pounds of matte, 2,900 pounds of siliceous ore, 13·5% limestone. Four per cent of coke is also fed to the furnace by shovelling. The charge, other than the coke, is weighed into the cars, matte first, then ore with the limestone on top. If the furnace shows signs of crusting, the matte is weighed on top of the ore for a time, thereby throwing more matte along the sides, which invariably has the desired effect of cutting out the crust.

Stock piles, Consolidated Mining and Smelting Co., Trail, B.C.

The matte is concentrated twice in this furnace, the first product running from 15%-20% copper, equivalent to a concentration of 2·5 to 3 into 1. This matte is returned to the furnace and smelted with enough low grade matte to produce a 40%-42% copper matte in the second concentration.

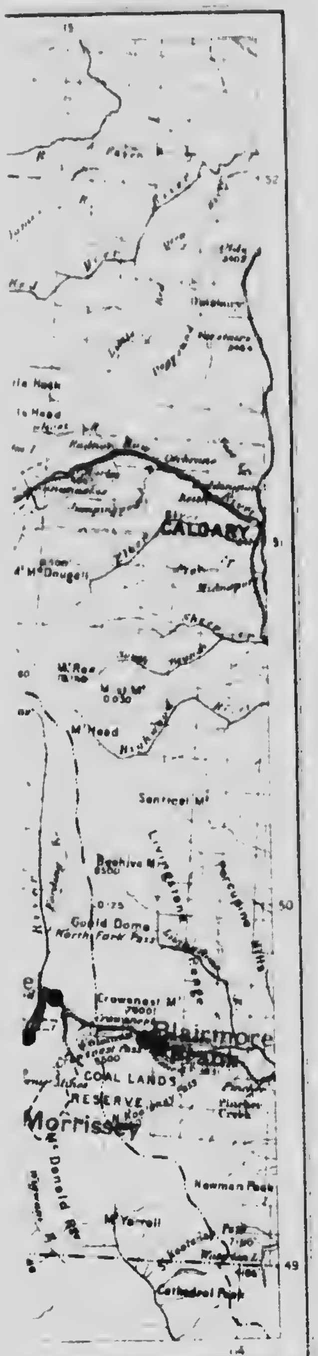
The high grade matte is tapped into 1·5 ton Kilker matte cars, cooled and hauled by electric trolley locomotive to the crushing plant. The pans of the matte car dump directly into a 10″×21″ Blake crusher which delivers to a pan conveyer that discharges into three steel bins. From these bins the matte is drawn into 'V' shaped cars, running on a 36″ gauge track, and hauled to the charge bins or shipped to Tacoma according to grade.

The high grade slag from the pyritic furnace runs about 38-42% silica (SiO_2); 40-44% ferrous iron (FeO); 10-13% calcium oxide (CaO); and 3-4% aluminium trioxide (Al_2O_3), with 0·35% copper and 0·04 ounce of gold. This slag is added to each charge of the lead blast furnaces to keep the charge open, and a portion of the gold is recovered in the lead refinery.

Fire Protection.—Water for fire protection purposes is carried a distance of 12 miles through a 20″ wooden stave pipe from Stony, Rock, and Murphy creeks. An auxiliary supply of water, which is impure and hence to be used only in cases of emergency, can be obtained from Trail creek through a flume three-fourths of a mile in length. Both these lines lead to a reservoir 24′ × 15′ × 10′. From the reservoir two steel mains respectively 22″ and 16″ in diameter, are laid to the smelter; an 8″ pipe line is laid throughout the plant, and a branch line runs to the refinery. The natural pressure is about 40 pounds per square inch, but a centrifugal pump driven by a 150 H.P. motor, direct connected, in connexion with the main system, is kept always ready for emergencies. This pump is capable of giving a pressure of 140 pounds and can supply five lines of 2½″ hose at this pressure. A similar pump is installed at the refinery. A three stage McDougall turbine pump has also been installed on an incline platform, which can be kept at the level of the Columbia river. This pump is driven by an Allis-Chalmers Bullock 300 H.P. motor, 1,130 r.p.m., taking current at 550 volts. The system includes 20 hydrants, 15 alarm boxes, with bells and secondary circuit in series, with relays; 8 bells are placed at prominent places and are tested every morning. The alarm system on the main circuit is run by 24 gravity batteries. A fire alarm sets the fire pumps in action automatically.

Labour Conditions.—About 550 men are employed in the smelter and refinery, and in the shops and yards. Data are not available to the writer as to the number employed only on the copper smelting portion of the business. Eight hour shifts are worked by the furnace crews, smelter yardmen, roasters, and refinery employees. Nine hour shifts are worked by the mechanics and labourers.

Markets.—High grade copper matte is sent to the smelter at Tacoma, Washington, to be refined. Fine silver is sold to the Canadian and United States mints and fine gold is sold to the United States Assay Office at Seattle. Much of the fine silver is shipped to the Orient. Lead is largely sold in Canada.



MAP No. 211

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DEPARTMENT O

MINES BRAN

H.E.BAINE, Chief Draughtsman
Base Map Dept. of Interior

RELATIVE POSITION OF COPPE

IN SOUTHERN BRIT

Scale, 35 Miles

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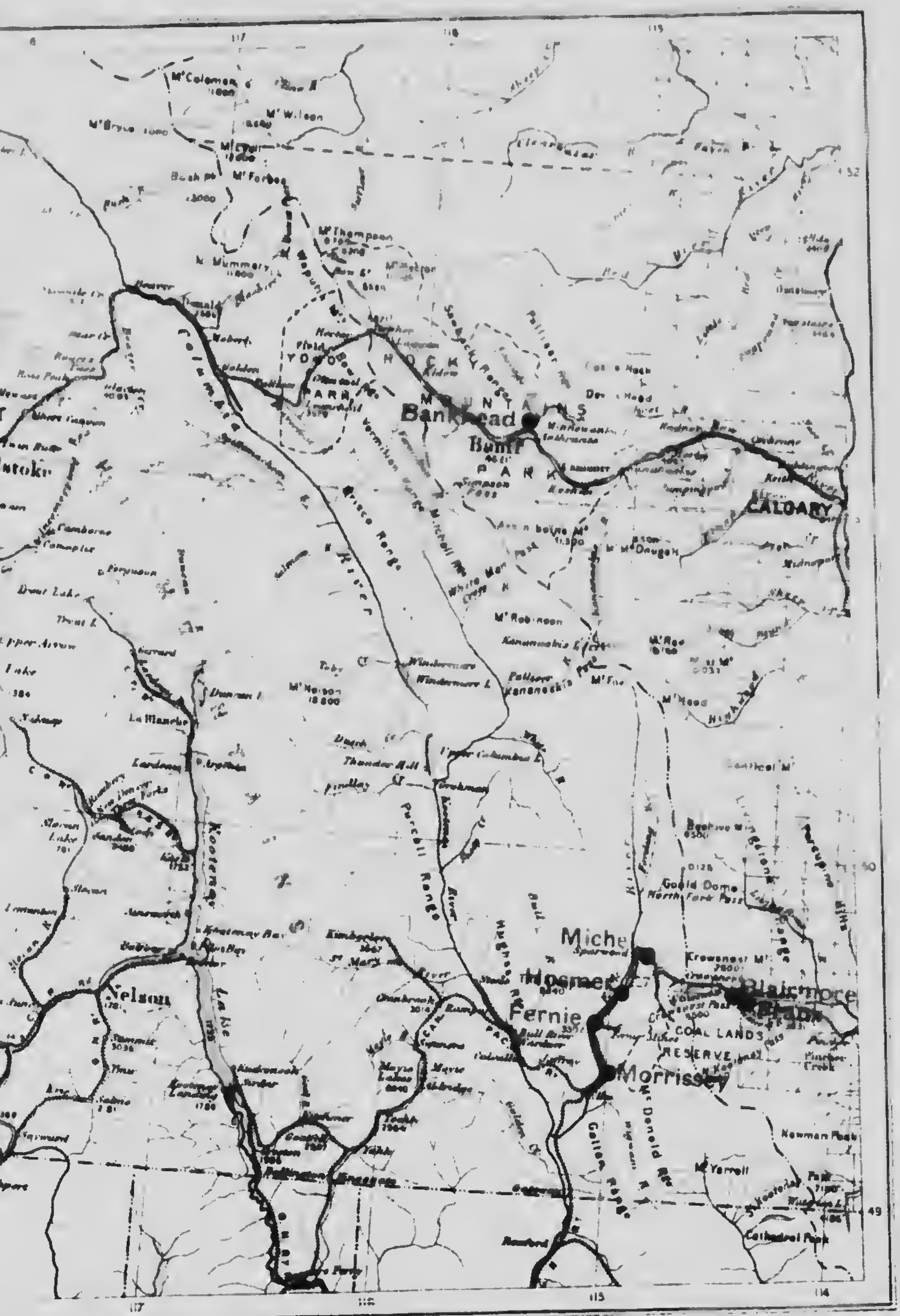

MAP No. 211

COPPER SMELTERS AND MINES

N BRITISH COLUMBIA

, 35 Miles to 1 Inch

25 50 75 miles

● Copper Smelters
♀ Copper Mines
● Coal Centres

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CHAPTER V.

THE GRANBY CONSOLIDATED MINING, SMELTING, AND POWER COMPANY, LIMITED.

INCORPORATION. Incorporated March 29, 1901, by special Act of the Parliament of British Columbia. Authorized capital, 1,500,000 shares of $10, changed in 1906 to 150,000 of $100 each. Issued 149,985·15 shares=$11,998,515. *President*, William H. Nichols, New York; *Vice-President and General Manager*, Jay P Graves, Spokane, Washington; *Assistant General Manager*, F. M. Sylvester, Spokane, Washington; *Treasurer*, George W. Wooster, Grand Forks, B.C.; *Secretary*, Northrup Fowler, 52 Broadway, New York; *Mines Superintendent*, O. B. Smith, Jr., Phoenix, B.C.; *Smelter Superintendent*, Wakely A. Williams, Grand Forks, B.C.; *Assistant Mine Superintendent*, C. M. Campbell, Phoenix, B.C.; *Assistant Mine Superintendent at Hidden Creek*, H. J. C. Macdonald. *Head Office*, Grand Forks, B.C.; *Branch Office*, 733-52 Broadway, New York; *Mine Office*, Phoenix, B.C. Fiscal year closes June 30; annual meeting, first Tuesday in October.

The Granby Consolidated own 1,100 acres of mineral lands in the Phoenix camp of the Yale mining division, and 61 acres of land, containing a limestone quarry near Grand Forks, all being in British Columbia. Their property ownership includes one hundred town lots in Phoenix and Grand Forks. They also own a large smelter site about a mile from Grand Forks. The ownership of all the capital stock of the Hidden Creek Mining Company gives the Granby Company virtual ownership of considerable areas of mineral lands, a smelter site, and the townsite of Anyox at Granby bay, on Observatory inlet, about 110 miles from Prince Rupert. They also own about 5,000 shares of Crow's Nest Pass Coal Company's stock.

The following description relates chiefly to the smelting plant at Grand Forks. Plans for a new smelter of 2,000 tons daily capacity, to be erected at Anyox, the new townsite on Granby bay, Observatory inlet, are completed and the plant is in course of erection. It is expected that the works will be in a condition to operate in November or December of this year (1913). Through the courtesy of the Traylor Engineering and Manufacturing Company, it has been possible to include a brief description of the new furnaces and converters that are being built for the Anyox plant. The mining properties and mining methods are to be described in the separate report on the copper mining industry of Canada.

GRANBY SMELTER, GRAND FORKS, BRITISH COLUMBIA.[1]

Location.—This smeltery is located about three-fourths of a mile from the town of Grand Forks, Grand Forks mining division, British

[1] General Report on the Smelter of the Granby Consolidated Mining, Smelting and Power Company, Limited, August 1, 1910, by W. A. Williams, published in the Annual Report of this corporation for the year ending June 30, 1910. (*See footnote next page.*)

Columbia. It is situated in the valley of the North Fork of the Kettle river on a bench standing about 100 feet above the river level. This location is about 24 miles from the mines at Phoenix, the chief source of the ore supply, and about 3,000 feet below it. The works are served by both the Canadian Pacific and Great Northern railways.

Historical.—The plant was built primarily to reduce the ores from the Company's own mines at Phoenix. The original plant, consisting of two furnaces, 44″ × 160″ at the tuyères, with water power and dam, was built in the years 1899 and 1900 and blown in August 21, 1900. These furnaces were hand charged from a car extending their whole length and feeding from the side. The capacity was 700 tons per day. The slag was granulated, and the matte containing 50%–60% copper was shipped to the refineries of the Nichols Chemical Company near New York. The operation of this plant was so successful that plans for two similar furnaces and a converter plant were prepared. These furnaces, Numbers 3 and 4, and three converter stands, 72″ × 100″, were installed and in operation in 1902. At this time additional power was obtained under contract from the Cascade Power Company, operating on the main branch of the Kettle river, 10 miles below Cascade, B.C. Blister copper 99% pure was consigned to New York; converter slag was returned to the blast furnaces.

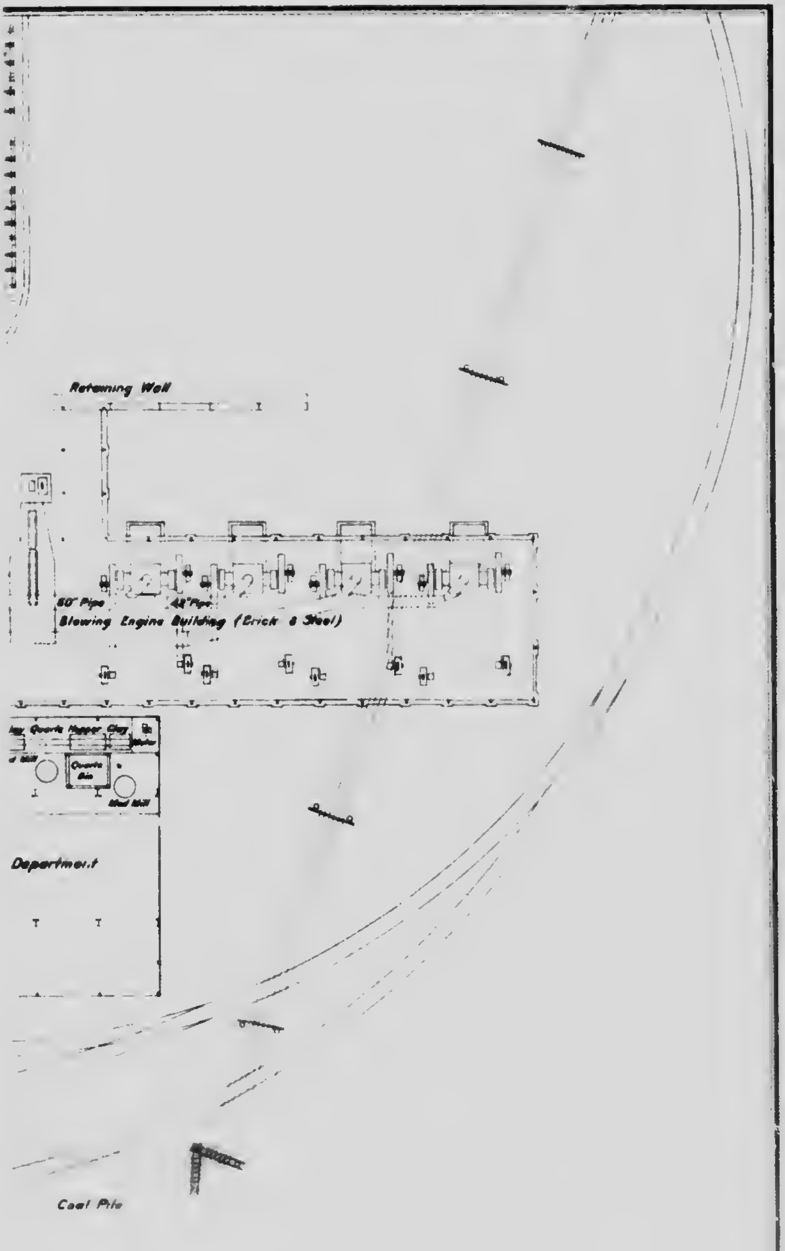
In the year 1904 furnaces Numbers 5 and 6, similar to the others, were added. At this time the system of end charging, designed by Mr. A. W. Hodges, the then local manager, was introduced, changing from hand feed to mechanical feed.

In 1905 furnaces Numbers 7 and 8, 48″ × 213″ at the tuyères, were erected. These furnaces were designed to make a higher grade matte than was ordinarily obtained in the earlier furnaces. The bosh was increased and carried directly to the bottom of the furnace, the width at the tuyères was increased and the tuyères of the new furnaces were 3·5″ in diameter, set at $8\text{-}\frac{21}{32}$″ centres, instead of 5″ tuyères set at 17·75″ centres, as on the old furnaces. By the end of 1906 all the furnaces were enlarged to this size. At this time the capacity of the plant was 3,000–3,500 tons of Granby ore per day. Additional power was obtained from the Bonnington Falls power plant. In this year the Great Northern railway was built into both mines and smelter. No further enlargements took place until 1909.

'Recent Developments at the Granby Smelter,' by Frank E. Lathe, Journal of the Canadian Mining Institute, Vol. XIII, 1910, pp 273-287.

'Handling Three Thousand Tons of Ore per day at the Granby Mines and Smelter, Phoenix and Grand Forks, B.C.' by A. B. W. Hodges, Journal of the Canadian Mining Institute, Vol. XI, 1908, pp. 407–414.

The author is indebted to Mr. George W. Wooster for personal assistance in revising the manuscript of this report, and to Messrs. W. A. Williams, W. B. Bishop, and Frank E. Lathe for many courtesies during his visits to the works at Grand Forks.



Retaining Wall
60" Pipe
48" Pipe
Blowing Engine Building (Brick & Steel)
Quartz Hopper Clay
Quartz Bin
Department
Coal Pile

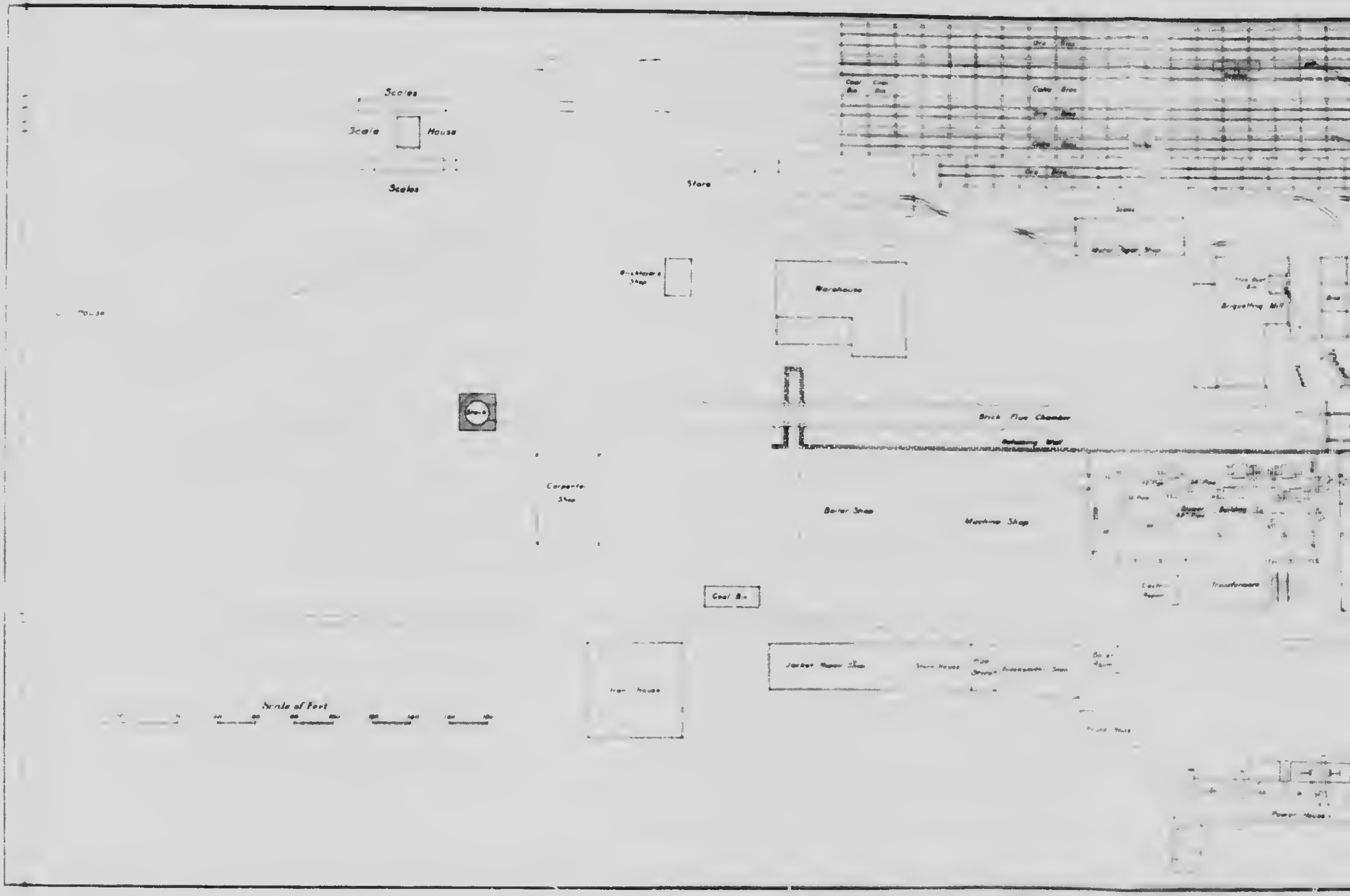


Fig. 19. Ground Plan of the Grand Forks Plant, C

Plant, Granby Consolidated Mining and Smelting Company.

Birdseye view of the Granby smelter, Granby Mining and Smelting Co., Grand Forks, B.C.

In 1909 six of the furnaces were enlarged to 260", and Numbers 7 and 8 to 266·5" in length, and were all made 4 feet deeper, increasing the ore column from 9 feet to 13 feet. Two of the old converter stands were also taken out and three 81" × 126" electrically operated converters installed in their place. These new furnaces have a capacity of 4,000-4,500 tons of Granby ore per day with cleaner slag and less fuel. The actual tonnage treated averages less than 4,000 tons per day. The converter capacity is 100,000 pounds of copper per day.

During the period of expansion of the blast furnace and converter departments of the work, the other departments tributary to these were correspondingly enlarged by the addition of new equipment. The storage bin capacity was increased from 1,000 tons in 1900 to 9,000 tons of ore and 7,000 tons of coke in 1907; new rotary blowers and blowing engines were added; a new steel flue dust chamber with mechanical dust conveyer in part replaced the old brick chamber; the slag dump had become so large that it became necessary to substitute a haulage system; the early wooden buildings were replaced by steel, or steel and brick structures; additional power was procured from the Bonnington Falls plants.

A general view of the works, as they appeared in 1912, is shown in Plate XXVI. The slag dumps are prominent in the foreground. On the left of the picture is seen the stack erected in 1905, and in front of this the newly-erected slag distributing plant. This latter has been somewhat modified since the picture was taken, and another inclined unit has been built leading towards the right. A little to the left of the centre of the picture the downcombers of the eight blast furnaces are readily distinguishable. The panorama view (Plate IV) taken in 1906[1] gives a better idea of the general appearance of the works from the exterior. On the left of the centre the tops of the stacks of the furnaces are visible above the ridge of the furnace building; the building to the right of this is the converter building; several of the shops are seen to the left in front of the base of the 1905 stack. The appearance of the immediate foreground has changed considerably since the picture was taken, the slag dumps having become larger, and the new distributer being erected upon the old slag piles. On the right of the picture a portion of the transformer house is visible towards the rear, and in front of this, facing the camera, is the assay office.

The general layout of the works is shown in plan in Figure 19.

General Statement of Equipment.—The plant, as it now stands, consists of 8 blast furnaces, six 48" × 260", and two 44" × 266·5", and a converter equipment of three electrically operated converter stands, 81" × 126" with 10 shells. The blower department is fully equipped to supply both blast furnaces and converters. Ample storage capacity for ore and coke

[1] Carpenter, Vancouver.

is provided; an efficient haulage system and a new plant for distributing and disposing the slag have been installed. The works are served by shops fully provided with tools for making all necessary repairs and for executing designs of new equipment. There is a small power plant, a pumping and fire protection system, a sample mill, and an assay laboratory. The plant as a whole is capable of handling 4,000 4,500 tons of Granby ore per day, and of producing 50 tons of copper. It is well laid out, is easily operated, and on the whole is provided with good machinery and good buildings.

Power. The power used in operating the works is wholly electric. The Company's own power plant on the North Fork of the Kettle river is capable of generating about 400 H.P., the balance of the power needed is obtained from the lines of the West Kootenay Power and Light Company.

The Company's power dam is located about a mile above the smelter. This is a rock filled crib dam, 12″ × 12″ timber; it is 65 feet in length, 127 feet in width, and 26 feet in height. It backs the water to form a lake of 600 acres. The 9′ × 11′ flume leading to the power house is 5,600 feet in length, and has a fall of 0·03 feet per 100 feet. It delivers water to the wheels under a 45 ft. head.

The power house is a wooden structure, 22′ × 168′ placed about 100 feet lower than the smelter and 1,000 feet away. The installation includes three 180 K.W. alternating current generators, each direct connected to two 16″ American turbine wheels, generating current at 440 volts; one 180 K.W. alternating current generator, similarly connected, generating current at 2,200 volts for transmission to Grand Forks; and one 22·5 K.W. direct current generator, direct connected to a 10″ turbine wheel, generating current at 125 volts for excitation and lighting. There is also a 13″ turbine wheel driving two 40 H.P. triplex pumps. All the switchboards and meters necessary for this plant are also placed here.

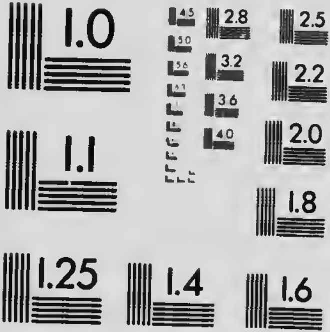
Power from the Number 2 plant of the West Kootenay Power and Light Company reaches the transformer station at Grand Forks over two 3-phase, 60 cycle, 60,000 volt lines. At this station it is stepped down to 440 volts, the voltage for which all the motors in the works are designed. The transformer station for these lines is equipped with two banks (four transformers) 1,250 K.W. each, 60,000 440 volts, oil insulated, water cooled transformers, manufactured by the Canadian Westinghouse Company. All switchboard apparatus, motor operated oil break switches, lightning arresters, etc., are manufactured by the Canadian General Electric Company. When this installation is complete there will be two banks (six transformers) 1,250 K.W. each, 60,000 440 volt, oil insulated water-cooled transformers.

The Number 3 power plant is connected with two 3-phase 60 cycle, 22,000 volt lines to the Grand Forks sub-station. The equipment at this

Interior of No. 1 blower building, Granby smelter, Grand Forks, B.C.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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Interior of the blast furnace building, Granby smelter, Grand Forks, B.C.

sub-station consists of one bank (three transformers) 312·5 K.W. each, 20,000 500 volt transformers, oil insulated, natural cooled, together with its switchboard apparatus, Westinghouse manufacture.

Power for use in the works may be taken from either plant.

Receiving Ores.—Ores are received over the lines of the Canadian Pacific and Great Northern railways. Each has its own yard, but the yards are connected by cross-overs. A switch engine is maintained jointly by both roads to handle all ore, coke, and freight passing through either yard.

A scale house between the yards and the ore and coke bins is so placed that the scales are easily accessible to both yards and bins. This house covers one 36 ft. and one 50 ft. 80-ton track scales. All cars are weighed in and empties are weighed out. These scales are inspected by a Dominion Government inspector every three months.

The ore bins are located on a terrace east of the main works and at a higher elevation. The ore cars are run from the yards to track over the bins. There are five sets of storage bins, built of wood, parallel to each other and 756 feet in length; they are built high enough for the charge cars to pass beneath to be loaded by gravity. The dimensions and capacity of these bins are given in the following table:—

TABLE VI.

Ore Bins at Granby Smelter.

No. 1 Ore	bins	20 feet high,	17 feet wide,	bottom	slope 45°
No. 2 Coke	"	25 feet "	17 feet	"	"	flat
No. 3 Ore	"	25 feet "	20 feet	"	"	slope 45°
No. 4 Coke	"	25 feet "	20 feet	"	"	flat
No. 5 Ore	"	25 feet "	20 feet	"	"	slope 45°

The bottoms of the bins are made of two thicknesses of 2″ plank. It will be noted that the coke bins are arranged alternately with the ore bins; the loading chutes from parallel sets of ore and coke bins open to the same line of track greatly facilitating the loading of the charge cars. The capacity of the ore bins is 12,000 tons; in addition there are bins holding 5,300 tons at the sample mill, giving a ' ore storage capacity of 17,300 tons. The coke bins are of 7,000 tons capacity; yard storage of an additional 12,000 tons of coke is also provided.

Sample Mill.—The metal content of the ore is very uniform and very careful sampling is not required. The practice is to send about one car in ten to the sample mill bins; this is recrushed and sampled automatically in 1,000 ton lots. There are two Snyder Automatic sampling mills, built of wood, placed 35 feet from the receiving ore bunkers. Number 1 mill, 64′ × 50′, has a bunker capacity of 500 tons and samples only Granby ore and the less siliceous ores. Two additional sets of storage bins, used chiefly for storing custom ores, are also provided near the mill. The flow sheet of the mill sampling custom ores is shown in Figure 20. The equipment of the other mill is similar.

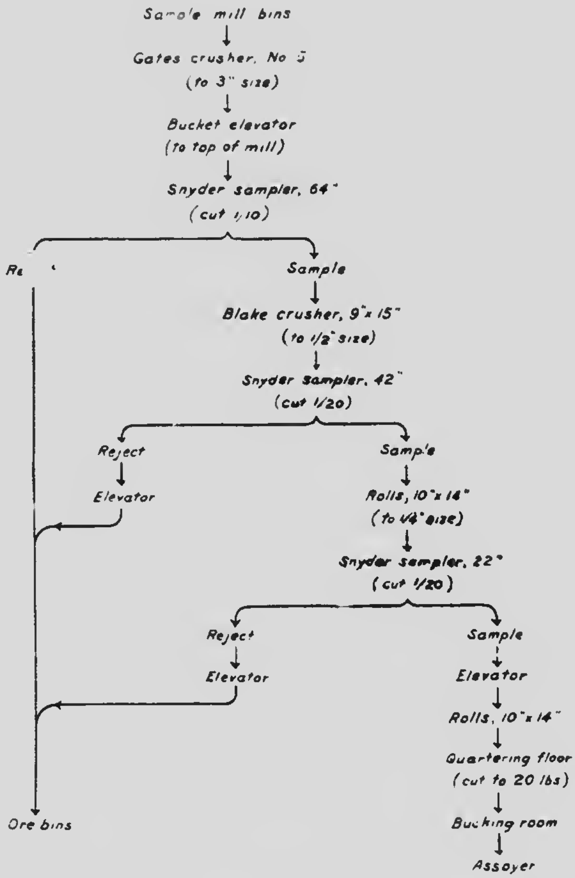

FIG. 20. Flow sheet of sample mill No. 1, Granby Consolidated Mining and Smelting Co.

Granby ores being very uniform are left as coarse as is consistent with accurate sampling; siliceous ores, some of which are required for converter linings, are crushed to less than half inch size. In both mills the first crusher is a Gates gyratory crusher reducing the ore to 3″ size; it is then elevated to the top of its respective mill. From this point the treatment is different except that Snyder samples cutting one-twentieth are used in both mills.

Granby ore is cut at the top of the mill, the discards and all subsequent discards pass to storage bins and thence directly into charge cars; the sample passes to a Blake crusher which reduces to 0·5″ size. The sample then successively passes a Snyder sampler, rolls set at 0·125″, a third Snyder, and thence to the quartering floor, from which a 20 pound sample is sent to the bucking room.

In the siliceous ore mill where the ore requires to be finely crushed, two separate operations take place. The sample first cut passes to a storage bin that receives the whole initial sample from a shipment. The discards pass over a half-inch grizzly to a crusher and 2 sets of rolls, reducing to half inch size, all the crushed ore being then elevated to receiving bins, the samplers being idle meanwhile.[1]

When the first discards have been treated and stored the chute of the sample bin is opened and the sample undergoes a similar treatment and is cut after each reduction in size; the sample from the last roll is split on a 1″ riffle and then quartered by hand. The mill has a capacity of 40 tons per hour.

Haulage and Distributing System.—A system of tram car tracks, 20″ gauge and 30 pound rails with cross over switches, is laid on the charging floor level; these tracks run beneath the bins, the chutes of which are placed 6 feet above this level, and lead to the furnaces.

The charging cars are designed specially for feeding the furnaces from the end. The form and construction of these cars can be seen by a reference to the accompanying figures (Plate XXIX and Fig. 21). As shown in end view these cars are divided longitudinally into wedge-shaped sections, each closed by a side door which is hinged at the top; the wedge-shaped ridge which covers the truck of the car serves to spread the charge in the proper place along each side of the furnace. A transverse partition further divides the car into four compartments. The cars are provided with two sets of wheels. The lower or truck set are for ordinary locomotion over the charging floor tracks; the upper set, one wheel being placed near the corner of each car, engage in pairs with heavy rails set in the inside of the furnaces in the walls, and carry the load while the cars are in the furnace. The rails on the charging floor end at the mouth of the furnace, but as a car leaves the floor rails the hanger wheels engage with the sloping ends of the furnace rails and so the car passes into the furnace. When the cars are completely inside of the furnace the feeder by means of a long hook, inserted at *a* (Fig. 21 C) pulls the release arm *b*. This in turn raises rod *c* and lifts gate arm *d* over centre unlocking the side doors, and the weight of the load then opens the doors, permitting the charge to drop into the furnace. The gate arms are shown closed in Figure 21 B and open in

[1] Since the adoption of basic linings for the acid shells of the converter plant, it is probable that some changes have been made in the crushing. Data as to the practice are not available at going to press.

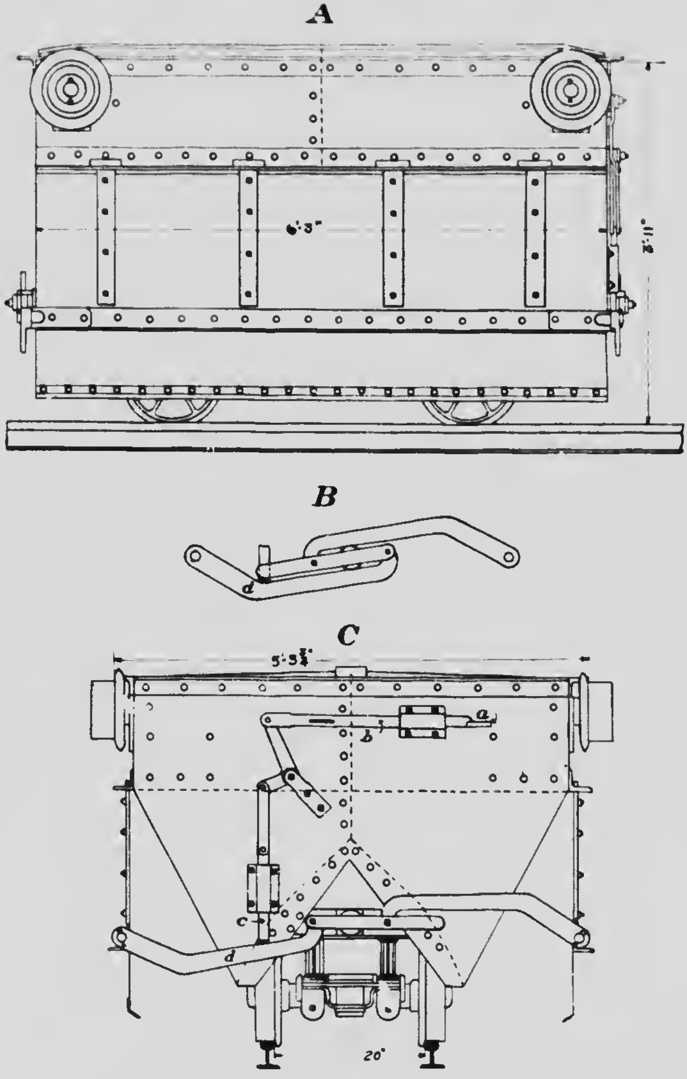

FIG. 21. Charge car, Granby Consolidated Mining and Smelting Co.

Charging cars, Granby smelter, Grand Forks, B.C.

Old slag pot, Granby smelter, Grand Forks, B.C.

Slag elevator at Granby smelter, Grand Forks, B.C.

Figure 21 C at *d*. To facilitate discharging, the locks of the cars are chained together so that they will dump simultaneously. A train can be backed into a furnace, discharged, and pulled in 10-20 seconds. The hoppers are closed after the train of cars is withdrawn from the furnace.

A charging train consists of three charge cars (whose combined length is just equal to the length of a furnace) and a 30 H.P. Westinghouse electric locomotive for hauling; one train serves two furnaces.

A slag haulage system was installed at the plant and was in use for a number of years. Each furnace was served by six slag cars (Plate XXX) 44 cubic feet capacity each, three being used on each side of the small settler. These cars were handled by 14-ton Davenport steam locomotives, cylinders 9″ × 14″, one engine handling slag cars from two furnaces six cars at a trip. Six engines and 52 slag cars were required for this service. This system was discontinued in 1911, when a special equipment for distributing granulated slag was installed (Plate XXXI). This system was subsequently modified by discontinuing the use of the transverse distributing belt carried on the high trestles, shown in the plate, and a new type of distributor was designed. A second unit with the incline rising to the opposite direction to that shown in the plate has recently been installed.

Granulated slag is now delivered to special drainage bins; the hoppers of these bins discharge to a belt 30″ in width, running under the bins and extending for 40 feet beyond them on each side. This belt can be driven in either direction to feed the belt on either incline. The conveyer to the north, the one shown in the plate, lifts the slag up an 18° incline to a height of 120 feet above the older dumps, where it delivers to a distributing car described below. The new conveyer to the south has an inclination of 18° 26′, and runs over 36″ pulleys set 317 feet centre to centre; the top is only 60 feet above the old dumps. Special distributor cars receive the slag at the tops of the respective inclines, and deposit it where required within a limited radius. The car on the older incline is 40 feet in length, and carries a 24″ belt. The car can be made to extend forward 20 feet in front of the rails. It is pushed forward, as required, by a jack having a maximum extension of 3 feet; it is held in place when discharging by being clamped at the heel to the 56 pound rails on which it runs; the car may also be swung from side to side as required. The belt is longer than the car and extends below it to a tightener. As the car is projected forward new sections will be built in at the rear. The newer car on the south incline is similar to that on the north, except that it carries a 30″ belt.

By distributing the slag in this way the granulated slag will be spread over the present dumps to a depth of over 100 feet. The capacity of the north incline is about 5,000 tons of slag per day, or about 3 tons per minute. The capacity of the south incline is somewhat larger.

Flue System, Stacks.—The eight furnaces are each provided with uptakes 6 feet in diameter, with dampers, which can be raised if needed; these are seldom used. They are also provided with 6 ft. downtakes leading to an overhead steel flue-dust chamber paralleling the furnace building. This flue is 12 feet above the feed floor, it is 13 feet wide, 15 feet high, 313′-7″ long; it is built of $\frac{3}{16}$″ and $\frac{5}{16}$″ steel plate. It has 28 hoppers in the bottom in which the flue dust collects. The dust is discharged through 9″ openings into a trough kept clean by a wire rope drag conveyer. One end of the steel chamber connects to a brick flue 10′ × 15′ × 448′ leading to a brick stack 13 feet in diameter and 153 feet high. The other end also connects with a brick dust chamber, 10′ × 10′ × 340′, leading to a square brick stack, 11′ × 11′ × 153′. The converters are connected by downtakes with this latter flue. A partition in the main steel flue prevents an undue amount of furnace gases passing to either stack. The brick flues or chambers are provided on either side with hand doors at 6 ft. centres, through which the flue dust can be raked out.

Buildings.—The principal buildings on the property are of fireproof construction, steel, or brick and steel. The ore bins, the sample mill, and the various shops of the mechanical department are of wood. The furnace building is of steel, with roof and sides of corrugated iron, 71 feet wide, 289 feet in length, and provided with a leanto 9·5 feet wide and 12 feet in height. It contains eight rectangular water-jacketed blast furnaces, each placed with its longer horizontal axis at right angles to the longer axis of the building. The average distance, centre to centre, of the furnaces is 36 feet; the height from furnace floor to feed floor is 18 feet.

The converter building lies end to end with the furnace building; it is of steel construction with corrugated iron roof and sides. The main building is 42 feet wide and 240 feet in length; the east leanto is 23 feet wide, and the west leanto 32 feet in width.

There are two buildings for housing the blowers. Number 1 lies north of the furnace building; it is a steel building with brick walls, a concrete floor, and corrugated iron roof, 57′-0″ × 128′-9″. The main blowing engine building is placed back of the converter building. It is of steel, with brick walls, concrete floor, and corrugated iron roof. The main building is 55′-4″ × 212′-9″; it is provided with an L 41′-2″ × 73′-0″.

Shops.—The mechanical department of the plant includes the following buildings: machine shop, boiler shop, blacksmith shop, engine roundhouse, store room, and electrician's workshop. All are of wooden construction; on the whole they have been found too small for the needs of the plant.

The machine shop is 27′ × 97′. It contains a planer, 30″ × 32″, with a 9 ft. table; one lathe 16″ swing, 5 ft. centres; one lathe 32″ swing, 12 ft. centres; one McCabe double spindle lathe, 26″ and 48″ swing, 12 ft. centres; one milling machine capable of milling 14″ gears; one Bickford radial drill press 5 ft. swing arm, 24 speeds, Universal table; one No. 4 drill press; Curtis and Curtis pipe cutter cuts pipe from 215″ to 12″; one bolt cutter; one small pipe machine; two power hack saws; one hydraulic wheel press 40 tons pressure.

The boiler shop is $40' \times 50'$. It contains a Whiting punch, No. 6, $\frac{13}{16}''$ hole through $\frac{3}{4}''$ steel plate; air tools such as rippers and hammers; one power shears for cutting steel plates; one set 5 ft. rolls; one set pneumatic clamps.

The blacksmith shop, $28' \times 45'$, contains one 1100 pound Bement-Niles steam hammer and all the necessary tools and forges.

The roundhouse, $28' \times 36'$, holds two engines at a time and has repair pits under each track.

The electrician's workshop, $15' \times 24'$, has a lathe for rewinding armatures, and other necessary equipment.

There are also several storage houses including an iron house, $50' \times 50'$, and a jacket, pipe, and store room, $24' \times 120'$.

The warehouse stands isolated from the other buildings, its dimensions are $50' \times 70'$.

The carpenter shop, $34' \times 47'$, is equipped with planers, stickers, handsaw, a wood lathe, and other necessary machinery and tools.

Ore and Coke.—As already indicated, the chief source of the ores treated at this smelter is the Phoenix camp of the Boundary district, 24 miles from the smelter.

A small quantity of siliceous custom ores is also purchased. Much of this comes from the Snowstorm mine in Washington.

Coke is received from Fernie and Michel in the Crowsnest Pass coal-fields. It comes partly in box cars having four long slots in the bottom, for dumping; most of the supply comes in 40 ton steel coke-racks which dump outwards.

Clay for use in lining converters is received from Hendrix Cut, Washington. It is dumped into the end bins near the converters. The clay bins have a capacity of 500 tons, and the discharge at the end.

Blower Plant.—Blower engine room Number 1, north of the furnace building, is equipped with the following Connersville blowers:—

One.....No. 10, 30,000 cubic feet of free air per minute.
Four.... " 8, 52,000 " "
Three... " 7, 37,500 " "

In the main blower engine room, in the L there are four more Number 10 Connersville blowers, 30,000 cubic feet capacity each. The total capacity of the blowing engines is 239,500 cubic feet of free air per minute. All the blowers deliver to a common receiver, consisting of two $60''$ pipes at the back of the furnaces. Connexion with the tuyères at each furnace is made by bustle pipes. All blowers are belt driven from Westinghouse alternating current motors. The No. 10 blowers are each driven by two 150 H.P. Canadian Westinghouse, 580 r.p.m., motors, belt connected at each end, running the blower at 100 r.p.m. and supplying 300 cubic feet of air per revolution. The No. 8 blowers are driven by one 100 H.P. motor for each blower, running the blower at 130 r.p.m. and delivering 100 cubic feet of air per revolution. The No. 7 blowers are also driven by individual 100 H.P. motors running the blower at 155 r.p.m. and delivering 80 cubic feet of air per revolution (Plate XXVII).

The building also contains one 12″ × 18″ Rand, Class E compressor, supplying air at 80 pounds pressure for pneumatic tools in the shops.

A brick and steel room within blower building Number 1 contains the 22,000 volt transformers and switchboards which are connected with the Cascade power plant for use in emergency. They include an air-cooled set of 1000 H.P. and an oil-cooled set of 800 H.P.

Blower engine building Number 2 contains the following equipment in addition to the four Connersville blowers located in the L:—

One 36″ × 36″ Nordberg blowing engine, capacity 3700 cubic feet of free air per minute; one 34″ × 34″ × 36″ Allis-Chalmers duplex engine supplying 6,000 cubic feet per minute, when running 81 r.p.m.; one 40″ × 40″ × 42″ Nordberg duplex engine, 10,000 cubic feet per minute, giving a total capacity of 19,700 cubic feet per minute. All are belt driven from Westinghouse alternating current motors, of 200, 300, and 500 H.P. each respectively. This plant is of ample capacity to operate all three converter stands simultaneously using air at 12 pounds pressure.

Air for the tampers, when silica linings were used, was supplied at 80 pounds pressure, by one 12″ × 18″ Rand Class E compressor.

A motor generator set is installed to operate the cranes, tilt the converters, and run the charge system. The motor is a 200 H.P., alternating current motor, running at 850 r.p.m.; it is direct connected to two 85 K.W. generators, running at 750 r.p.m. and supplying current at 220 volts.

An hydraulic triplex plunger pump, 6″ × 10″, driven by a Westinghouse 30 H.P. running at 850 r.p.m., supplying water at 250 pounds pressure, is also located in this building. This plant is used for operating the slag casting machine and the wheel press in the shops when the high pressure line is in trouble.

Copper Blast Furnaces.—The plant is equipped with six furnaces, 44″ × 260″ having 4·5″ tuyères, 18″ centres, and 12″ bosh, and two furnaces 48″ × 266½″, 3·5″ tuyères, 8″ centres, 12″ bosh. These furnaces are served by two 12″ water mains and two 60″ blast mains, directly behind and running the entire length of the building in front of the furnaces. There are two 10 ton Morgan Engineering Company's cranes installed, one being kept in reserve. Each crane has three direct current motors, and is used for handling all heavy material and to deliver matte to the converters. (See Plates XXVIII and XXXII; both views facing north, and Figure 22.)

The furnaces are numbered in order beginning at the north end. Furnaces Numbers 1 and 8 are three jackets high, the others two; furnaces

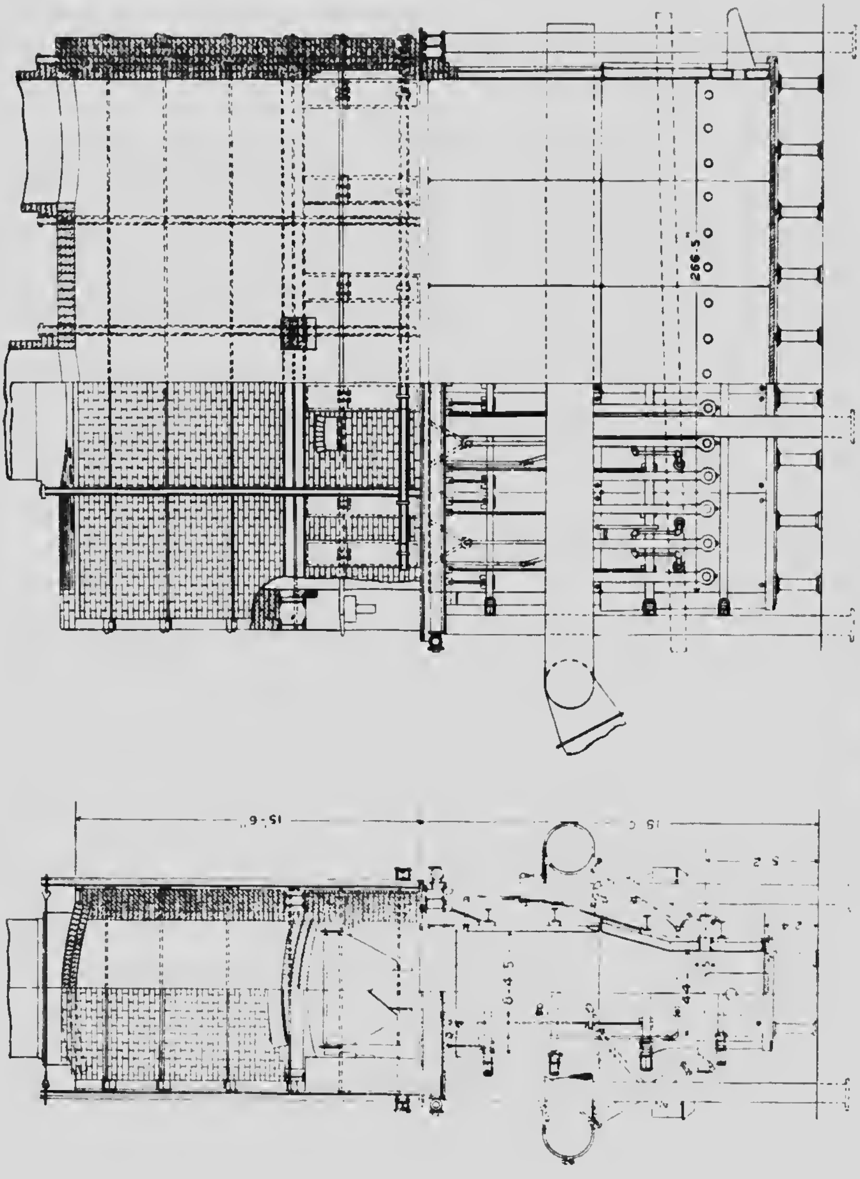

FIG. 22. Copper blast furnace, Granby Consolidated Mining and Smelting Co. Grand Forks plant. (After Lathe.)

Numbers 5 and 6 have 60 small tuyères, while the others have 30 tuyères of the larger size. On furnaces 5 and 6 the upper jackets are placed vertical, while the lower jackets, which are straight, are set at an angle from the vertical; the upper jackets on the other furnaces are also vertical, but the lower jackets are boshed.

The portions of these furnaces above the water-jackets are built of brick, ordinary red brick being used outside, and firebrick inside for those parts which are exposed to greater heat. The brickwork is bound with 56 pound rails, I beams and buckstays are used to hold the jackets in position.

The jackets are of riveted steel, fire plates $\frac{5}{16}''$, air plates $\frac{3}{8}''$. The circulating water enters the upper jackets and flows thence to the lower jackets; all the jackets have deflectors to throw the cold water to the bottom. About 2,000 gallons per minute are required by the eight furnaces, which is equivalent to 3 gallons per minute per square foot of hearth area. Water enters at a temperature of 35°–50° F. and issues at 140° F.

Each furnace is provided with a water cooled trap spout; the trap is 5″–5·5″.

There are two settlers for each furnace (Plate XXVIII). The one next the furnace, which receives the continuous flow of matte and slag, is rectangular in section, 72″ × 90″ with rounded corners, and 36″ deep. It is surrounded by a continuous 2″ water-jacket, the inner plate $\frac{3}{8}''$, the outer $\frac{1}{4}''$ steel. The removable bed plate is of cast-iron 2″ in thickness. To prepare a settler for use a course of firebrick is laid in the bottom; then both bottom and sides are lined with the quartz-clay cement material used for lining the converters.[1] The life of a settler depends upon the rate at which it fills with metallics; when the bottom becomes high enough to materially decrease the capacity of a settler it is replaced by one newly lined. The metallics are then removed from the former and broken up with a heavy ball weight.

The second settler is similar to the first, but smaller, 48″ × 60″ and receives the slag overflow from the latter. The slag overflow from this settler discharges into granulating water and is washed to the draining bins, whence it passes to the slag elevator. A third small settler is sometimes introduced between this second settler and the granulating stream. Recently some experiments have been made in introducing as many as six settlers in a string. The additional saving has barely paid the cost of the operations.

Converter Plant.—The converter equipment consists of 3 converter stands, electrically operated by 25 H.P. motors, and 10 shells, 84″ × 126″, by the Power and Mining Machinery Company. There are also trucks carrying moulds for metallic copper, and a slag-casting machine and conveyer (Plate XXXII).

[1] A lining of one course of red brick and one course of firebrick is also used.

Interior of the converter building, Granby smelter, Grand Forks, B.C.

During the summer of 1912 experiments were made in lining the acid shells with a basic lining and the relining plant was not in use. The relining equipment, which was still in place, included three Allis-Chalmers self discharge mortar mills, two 7 ft. pans, and one 6·5 ft. pan. The shells were tamped with air rammers. All machinery was driven by a 75 H.P. motor. When acid lined converters were used the practice was to line with chrome brick placing some magnesite brick around the tuyères: inside this was placed a 2 ft. layer of siliceous ore cemented with clay and well tamped; silica brick was used on the caps.

The converter building is supplied with a 40 ton four motor Morgan Engineering Company crane, 42 ft. span, which runs the entire length of the building, and is used for shifting converter shells, handling matte, charging converters, etc.

Briquetting Plant.—The greater part of the flue dust is collected in the steel dust chamber, whence it is discharged through 9″ openings into a trough kept clean by a rope drag conveyer. The attendance of one man for part of a day is needed to control the flow of dust from the hoppers; all other movements are automatic. Dust from the brick chambers at either end of the flue is drawn out by hand through the side openings into barrows, and conveyed to the briquetting mill. At this mill all the dust is dumped into a receiving bin from which it is drawn by an automatic feeder to a mixer. It is moistened thoroughly, no binder being necessary, and then passes to a Number 2 White briquetting machine which has a capacity of about 50 tons per 24 hours, or 4,000 briquets per hour. The machine delivers the briquets to a belt conveyer which transfers them to charge cars; they are recharged without drying.

Smelting Practice.—Coke and ore are charged separately into the furnaces. A train of three cars is run under the bins by the electric locomotive, and receives a charge of $1\frac{1}{4}$ tons of coke; after weighing this is charged into the furnaces by backing the train through the end door of the furnace and dumping the cars when the entire train is within the furnace. The train then returns to the bins for the ore charge; the cars are filled to their capacity, 10 tons per train, and are then weighed, run into the furnace, and dumped as before. The former custom was to load the coke into the bottom of the car with the ore on top and to dump the two simultaneously; practice has shown, however, that a more even distribution of both constituents of the charge is obtained when they are charged separately. Ore is charged at intervals of 20–30 minutes.

As already noted Phoenix ores are of very uniform composition, carrying 1·2–1·6% of copper. An average analysis would show approximately the following composition, SiO_2, 35%; FeO, 13%; CaO, 17%; Al_2O_3, 8%; MgO, 3%. The iron is present as a silicate chiefly, uncombined with oxides and sulphides, while nearly all the lime and magnesia occur as carbonates. Chalcopyrite is the copper-bearing mineral, and it also carries gold and silver. About 65% of the sulphur in the ore is burned off—the concentration being approximately 32·1. A typical slag would show the following analysis: SiO_2, 45%; FeO, 15%; CaO, 22%; MgO, 3·8%; Al_2O_3, 7%; copper 0·22%. The matte will average about 35% copper, 10-15 ounces of silver, and 1·6-2·6 ounces of gold per ton.

There is a constant flow of matte and slag from each furnace to the settlers; these being arranged either two or three in a string, one large and one or two small. The furnace slag from the last settler is discharged into granulating water, which sweeps it down into the drainage bins, whence it passes to a belt leading to the distributor. The matte is tapped at intervals into 5 ton pots in which it is conveyed to the converter building.

Matte pots are received by the 40 ton crane in the converter building and charged into the converters. There is no definite quantity of matte per charge as the converters are seldom run to their capacity. The blast is used at about 12 pounds per square inch. Converter copper carries 99·5-99·6% copper, 25-37 ounces of silver, 4-6·5 ounces of gold per ton. The impurities shown by an average analysis were as follows: Fe, 0·17%; S, 0·11%; As, 0·014%; Sb, 0·008%; Se and Te, 0·012%; Ni and Co, 0·123%; Zn, 0·004%; Pb and Bi, none.

Converter copper is run into moulds carried on a truck. These trucks are 16 feet in length and run on 44″ gauge tracks, and there are 3 trucks to a stand; each truck carries 8 moulds 33″ × 24″ outside dimensions, forming a continuous row from car to car. When a converter is ready to pour, a train of these cars is drawn underneath this converter by a wire rope operated by a motor driven drum. The converter is turned over and the pouring begins when the last mould is under the lip; the copper is poured in a continuous stream, the train being pulled forward as the moulds are filled. A bar of cast copper from one of these moulds weighs about 220 pounds. The bars are cobbled, removed, trimmed, and loaded directly into cars for shipment.

The converter slag is poured into pots holding about 3 tons. These are picked up by the crane and set in a tilting frame above the slag conveyer. The frame is then tilted by hydraulic power and the slag pours into the moulds of a conveyer that carries it up an inclined plane under water sprays, which cool it. The conveyer dumps into a bin from which the slag can be drawn into steel railway cars. The converter slag is transferred to the charging bins and thence to the blast furnaces as part of the charge. This conveyer is driven by a 5 H.P. motor at a speed of 20 feet per minute. It handles about 100 tons of converter slag per 24 hours. This slag contains up to 40% SiO_2, and varying amounts of copper, the balance is principally iron oxide.

Pumping Plant and Water System.—The pumps at the power house are located 1,000 feet from the smelter and 100 feet below it. The equipment consists of six Smith-Vaile 8″ × 10″ triplex plunger pumps, 550 gallons per minute each against 200 ft. head. Two of these are belt driven by 13″ water wheels, the other four are belt driven from four 100 H.P. motors. Their combined capacity is 4,740,000 gallons per 24 hours. From the header at the pumps four mains, 12″, 10″, 8″, and 7″, lead to the smelter and to pressure tanks on the hills above the works; mains through the yards are 8″ and 4″. The tanks are three in number, one of steel holds 77,000 gallons, one of wood holds 90,000 gallons; the third is a small wooden tank receiving water from a small creek above the works; this water is used for drinking and domestic purposes; the overflow goes to the large steel tank. The pressure at the pumps is 100 pounds, and at the works about 45 pounds. Water mains on the furnace floor and feed floor are 4″; 17 hydrants are so placed that three streams of water can be placed on any building. At each hydrant is placed a small hose house having 150 feet of hose and a nozzle. Hose houses and hydrants are inspected weekly.

Labour.—The men employed are both union and non-union, and nearly every nationality of the white races is represented. The furnace and converter departments have a general foreman with shift bosses under him; each of the other departments has its own foreman. Shifts are eight hours each; wages vary from $2.50 per day for labourers to $5.30 per day for shift bosses.

COMPARATIVE STATEMENTS.

TABLE VII.

Granby Ore Tonnage, Metal Recovery.

Period.	Dry tons shipped.	Metals recovered per ton.			Cost per ton exclusive of marketing. Blister Cu.
		Cu. lb.	Ag. oz.	Au. oz.	
Aug. 20, 1900—June 30, 1901	172,258	31·49	0·4106	0·1003	1·77
Year ending June 30, 1902	296,162	27·23	0·2952	0·0803	1·08
" " 1903	290,133	24·58	0·2772	0·0717	3·75
" " 1904	514,387	22·87	0·2619	0·0608	3·35
" " 1905	551,304	24·68	0·2688	0·0599	3·14
" " 1906	796,528	21·30	0·3107	0·0513	2·87
" " 1907	614,549	21·43	0·3038	0·0503	3·28
" " 1908	865,030	23·42	0·2865	0·0454	3·11
" " 1909	963,510	21·90	0·2730	0·0435	2·85
" " 1910	1,178,853	18·70	0·2281	0·0370	2·50
" " 1911	957,200	17·73	0·2150	0·0340	2·50
" " 1912	723,024	18·01	0·2100	0·0352	2.47
Total tons	7,952,938				

TABLE VIII.

All Material Smelted to Date at Granby Smelter.

Period.	Granby ore.	Foreign ore.	Foreign matte.	Total.
	Tons.	Tons.	Tons.	Tons
To June 30, 1901	169,087	7,832	.....	176,919
Year ending June 30, 1902	293,645	4,451	3,001	301,100
" " 1903	289,583	7·691	6,223	303,497
" " 1904	516,059	36,182	4,290	556,531
" " 1905	550,738	39,382	..	590,120
" " 1906	796,188	36,158	...	832,346
" " 1907	649,022	16,893	.....	665,915
" " 1908	858,432	24,179	.....	882,611
" " 1909	964,789	19,944	....	984,733
" " 1910	1,175,548	21,829	....	1,197,377
" " 1911	959,563	21,783	....	981,346
" " 1912	721,729	17,800	....	739,519
Totals to June 30, 1912	7,944,383	257,127	13,514	8,215,014

TABLE IX.

All Metals Produced to Date at Granby Smelter.

Period.	Au. oz	Ag. oz.	Cu. lbs.
To June 30, 1901	8,871	34,990	5,435,955
Year ending June 30, 1902	30,786	274,511	10,836,851
" " 1903	35,121	277,574	12,551,758
" " 1904	54,493	275,935	16,020,986
" " 1905	45,980	215,449	14,224,692
" " 1906	50,020	316,947	19,939,004
" " 1907	32,738	201,337	16,410,576
" " 1908	40,068	300,204	21,092,288
" " 1909	45,760	335,520	21,901,528
" " 1910	48,752	356,746	22,754,899
" " 1911	41,797	343,178	17,858,860
" " 1912	33,932	225,305	13,237,121
Totals to June 30, 1912	468,218	3,157,696	192,264,518

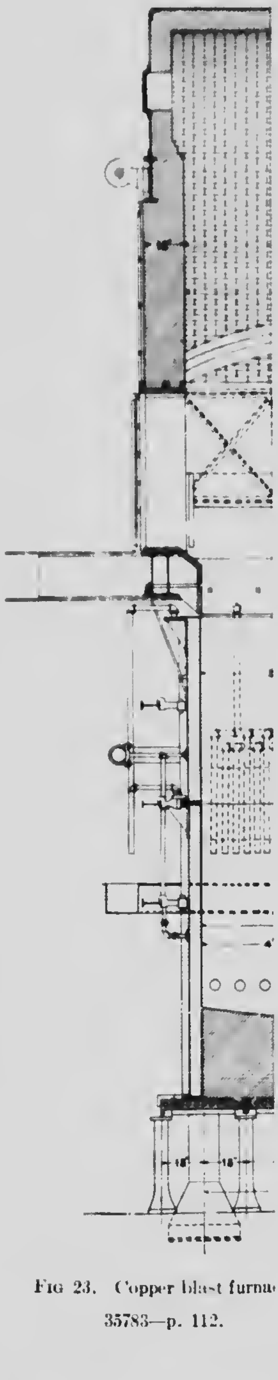

FIG 23. Copper blast furna

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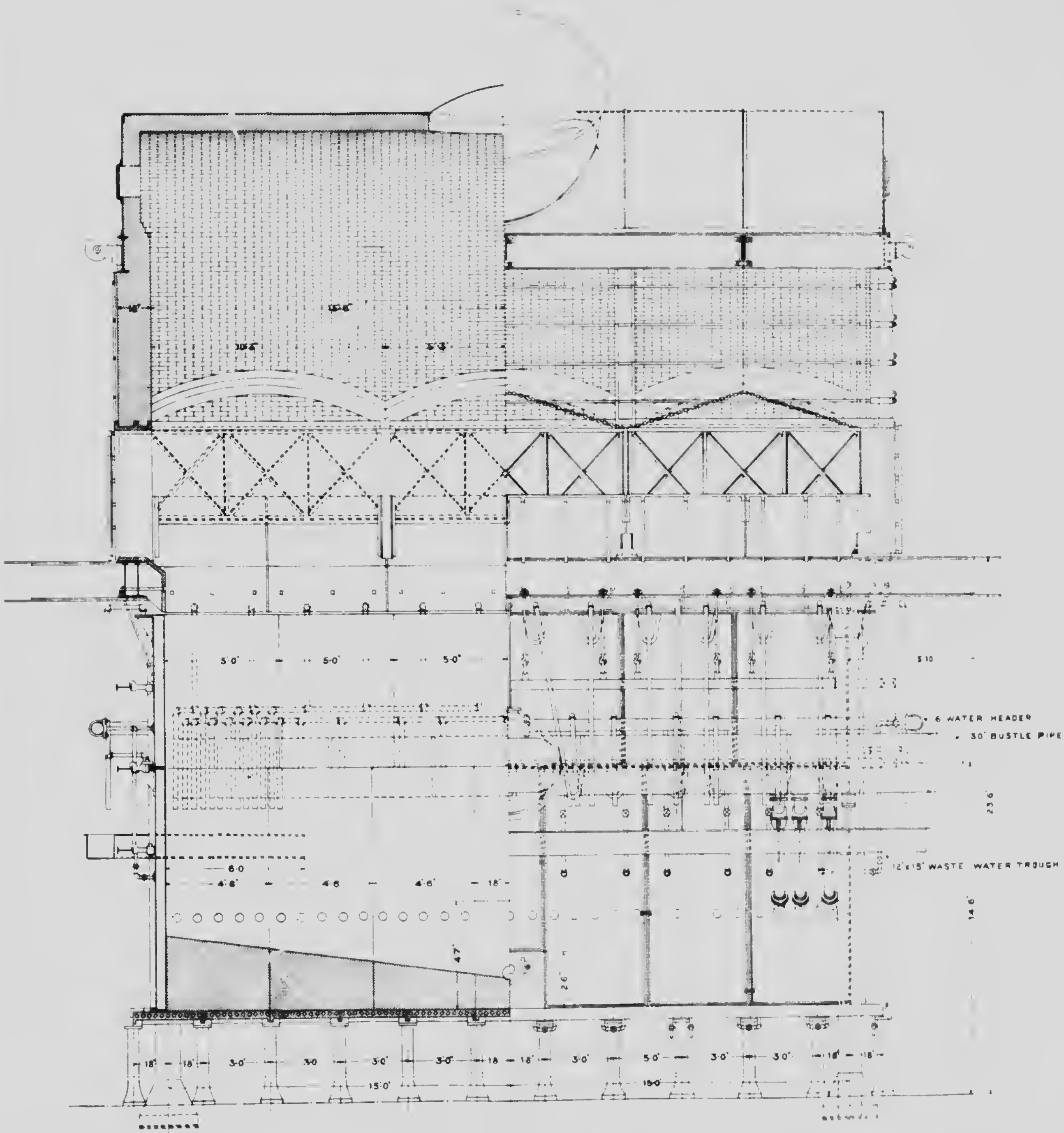

FIG. 23. Copper blast furnace, Anyox plant, Granby Consolidated Mining and Smelting Company (T. E. M. Co.). Vertical longitudinal section.

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ANYOX PLANT, ANYOX, B.C.

Location.—This plant is being erected to smelt the ores from the Hidden Creek mines near Granby bay, on Observatory inlet, about 110 miles northeast of Prince Rupert.

General Statement.—The plant at Anyox will consist of three rectangular water-jacketed blast furnaces, 50″ × 360″, and three basic converters, Great Falls type, each 12 feet in diameter. The accompanying plates and figures have been prepared from material supplied through the courtesy of the Traylor Engineering and Manufacturing Company, who are building the furnaces and converters. The plates represent the appearance of the furnaces as set up at the works before shipment.

Blast Furnaces.—Each furnace measures 50″ × 360″ at the tuyères. The height from tapping floor to charging floor is 26′–4″; the sole plates stand 4 feet above the tapping floor, and the top of the upper tier of jackets is 17′–2″ above the sole plates, the lower jackets being 10′–6″ in height, and the upper jackets 6′–8″. There are six jackets, each 54″ in width, and one tap hole jacket, 36″ in width, on each side of each furnace, the larger jackets being provided with 5 tuyère openings, and the narrow jacket with 3. The tuyère openings are of an improved form, the steel thimble being fused to the fire sheet, and forming a smooth joint. The outer end of the thimble projects through the air sheet, and is beaded in place. The upper tier consists of 6 jackets on each side, each 60″ in width (Figures 23, 24, Plates XXXIII and XXXIV).

The sole plates are of iron cast around coiled pipe, through which cooling water can be circulated. They are carried on 24 pedestals, each 3′–8″ in height, the sole plate being 4″ thick, with 2″ flanges.

The jackets are connected together by bolts and brackets in the usual manner. To prevent bulging, a jacket binder frame is built around the furnace, between the corner columns. Cast steel spacing rods extend from this frame to each jacket, fitting into sockets that are riveted to the jacket. These binder rods fit over the I beams with a hook connexion, and wedges driven in behind the binder frame make a very rigid fastening. This type of construction makes it possible to easily remove or replace a jacket without disturbing the binder frames. The simple removal of the wedges releases the binders on any individual jacket without disturbing the others.

Each blowpipe leading from the bustle pipe to a tuyère opening is fitted with a ball and socket joint, which is placed below the blast gate. This allows the blow-pipe, together with the tuyère casting, to be swung down clear of the furnace when it is necessary to remove or replace a jacket. The tuyère casting is released from the jacket by removing two hook bolts.

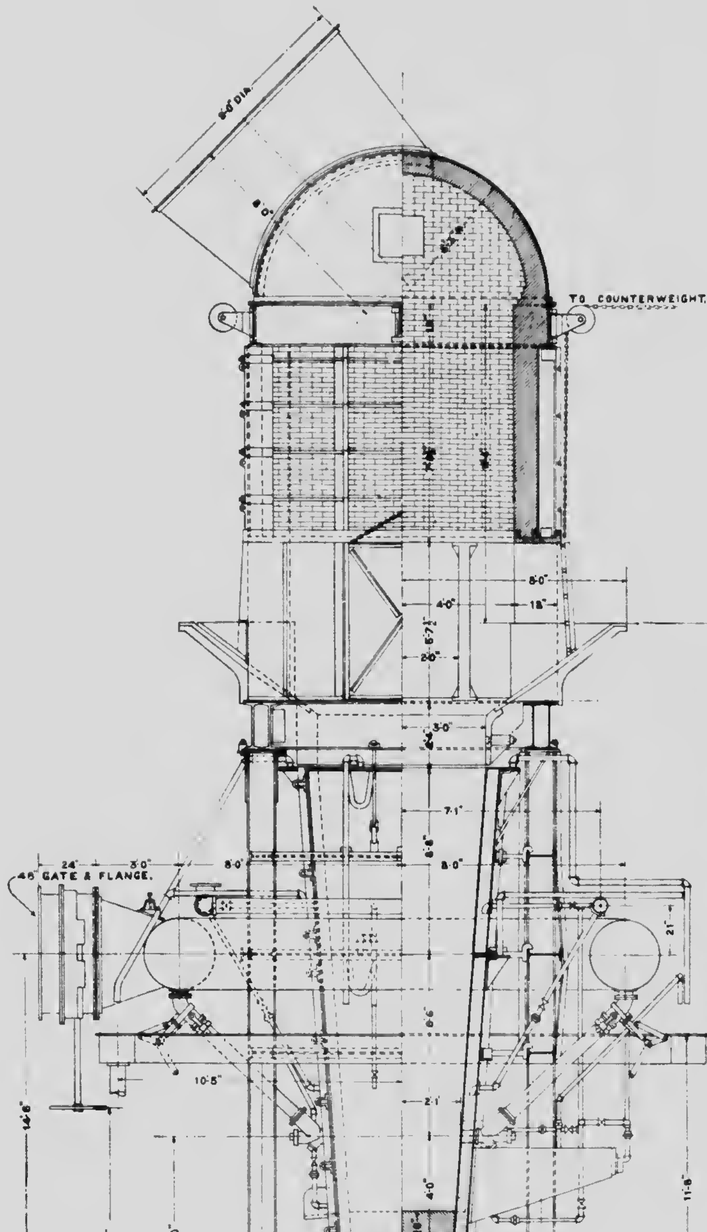
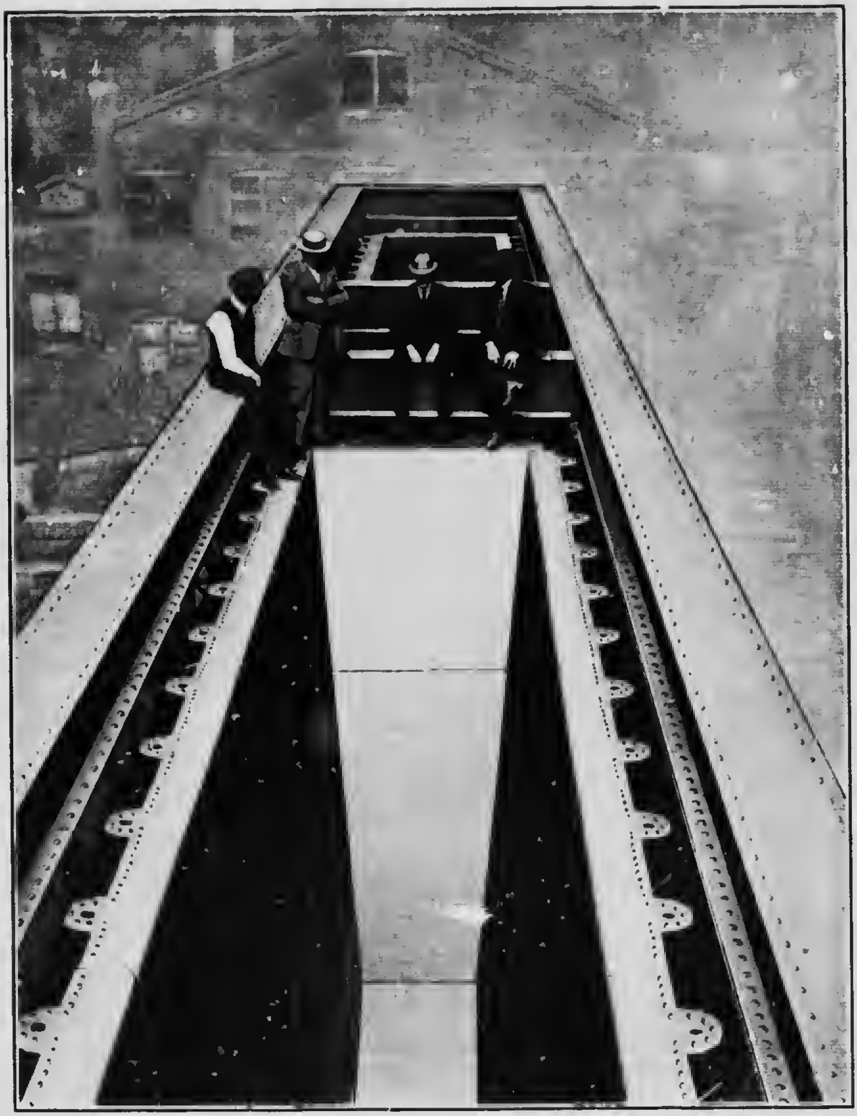


FIG. 24. Copper blast furnace, Anyox plant, Granby Consolidated Mining and Smelting Company (T. E. M. Co.) Vertical transverse section.

PLATE XXXIII.

New furnaces for the Anyox plant, Granby Consolidated Mining and Smelting Co., Anyox, B.C.



Interior of a blast furnace, Anyox plant, Granby Consolidated Mining and Smelting Co., Anyox, B.C.

The upper tier of jackets is supported from the mantle frame in such a way that the lower jackets may be removed without disturbing them.

The breast jackets are constructed of iron cast around wrought iron pipes for carrying the cooling water.

The furnaces are arranged to be charged from either side, and the charging doors are operated by counterweights.

The furnaces are designed in such a way that the mantle frames are connected together, forming one continuous mantle for the three furnaces. The sole plates extend beyond the end jackets so that the furnaces may be extended at any time. The three furnaces are placed with two 15 ft. spaces between the middle and the end furnaces. Eventually this space may be filled, making one furnace 120 feet in length, in place of three, each 30 feet in length.

The hoods are built of brick, with straight sides, and semi-circular top, stayed with structural steel and tie rods. The crown stands 16′-7″ above the charging floor, the arched top being built with a 5′-3″ radius. The steel downcomber, 9 feet in diameter, leaves the middle of a long side of the furnace at an angle of 45°.

Converters.—The converter equipment includes three of the Great Falls type of converters, each 12 feet in diameter and 17′-7″ in height. They are each provided with 13 tuyères, 2″ in diameter, in place of the 25-30, 1·5″ in diameter, used on the standard Peirce-Smith converter (Figures 25-28).

The tuyères are placed with their axes at right angles to the axis of the shell so that they blow directly into the converter.

Each tuyère pipe projects into the converter, and is connected with the tuyère casting by a special coupling so designed that it may be screwed off the back of the tuyère and the casting removed without interfering with the tuyère pipes. The tuyère pipes have individual tuyères, with the Shelby improved tuyère valve; a projection in the middle of the valve comes into contact with the point of the barring rod; this projection is made high enough to enable the bar to clear the seat of the valve.

The converters are each turned by 50 H.P. electric motors through worm gears. The equipment is designed to operate the converter through about 235°, or nine-tenths of a revolution in one minute.

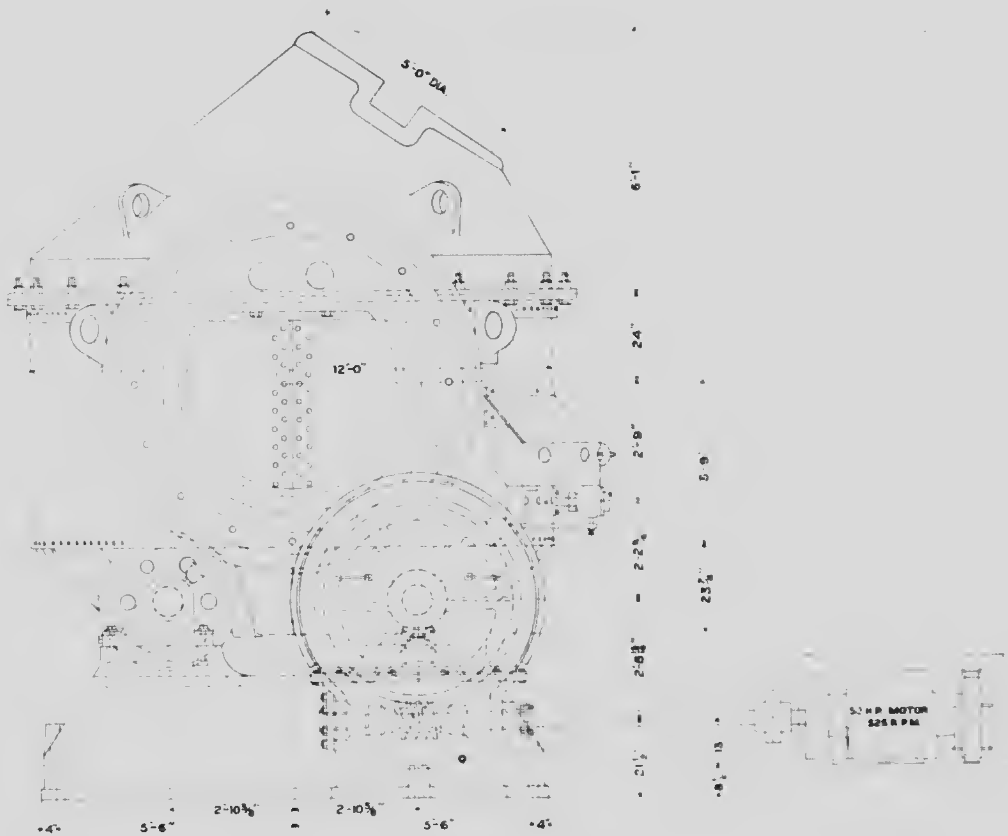


Fig. 25. Basic copper converter, Anyox plant, Granby Consolidated Mining and Smelting Company (T. E. M. Co.) Vertical transverse section.

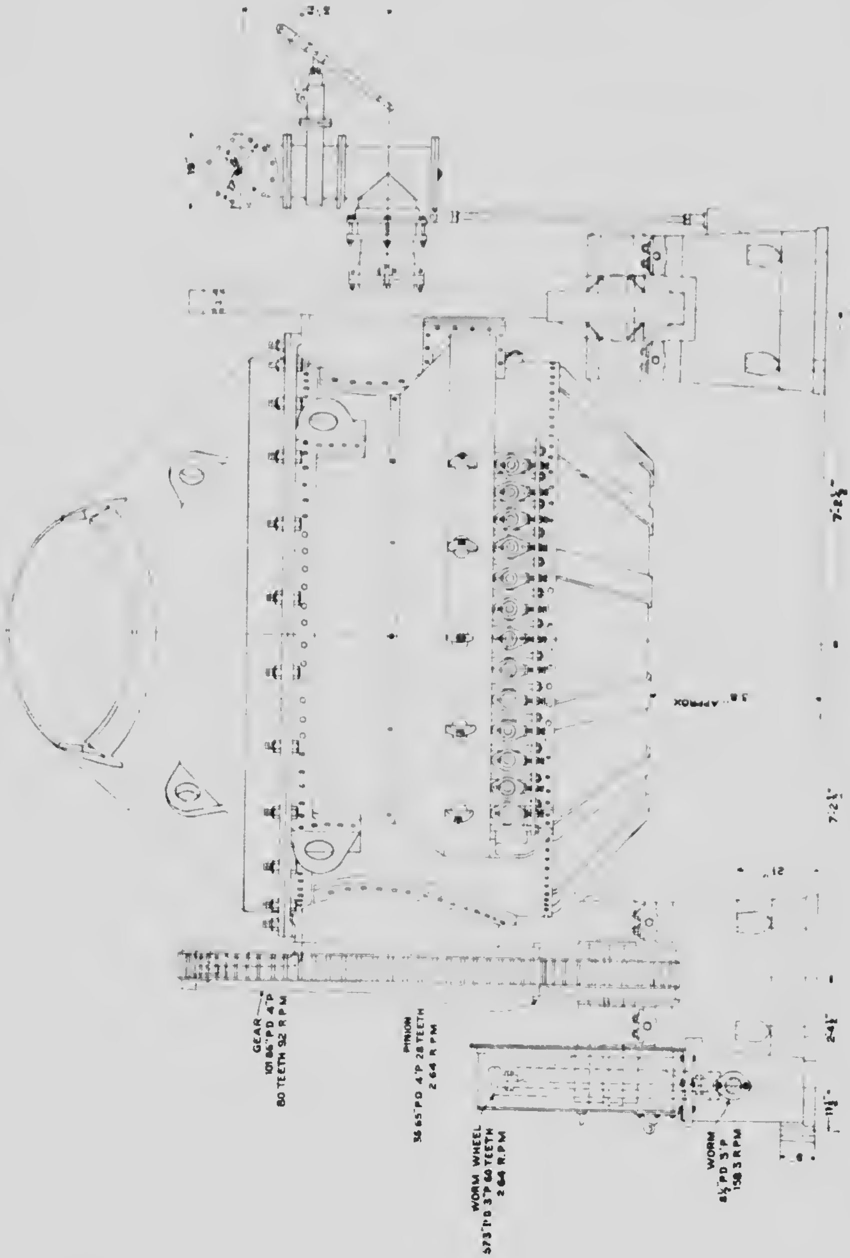


FIG. 26. Basic copper converter, Anyox plant, Granby Consolidated Mining and Smelting Company (G. C. M. Co.) Front elevation.

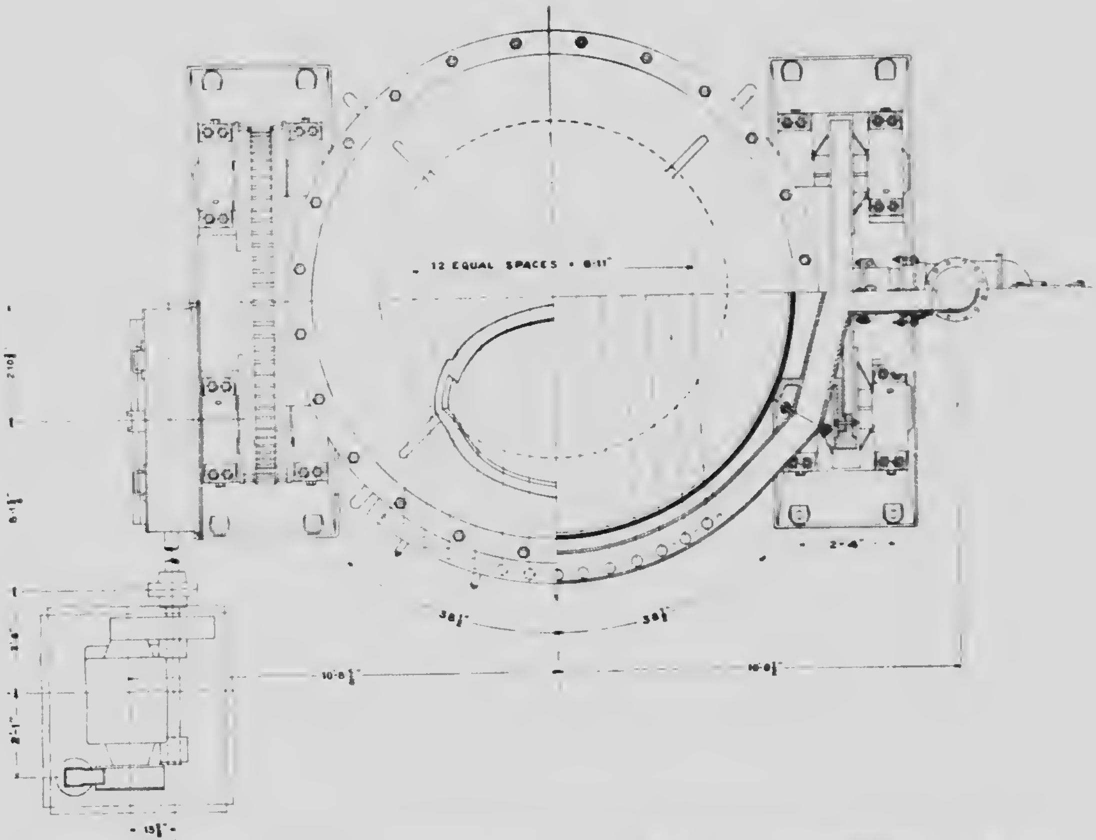


Fig. 27. Basic copper converter, Anyox plant, Granby Consolidated Mining and Smelting Company (T. E. M. Co.) Horizontal section on wind box and blast connexions.

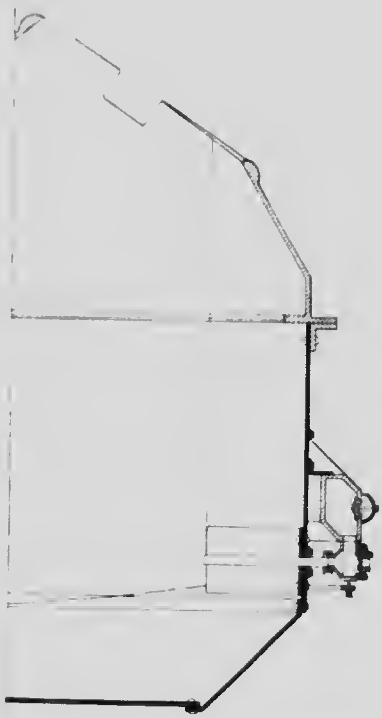


FIG. 28. Basic copper converter, Anyox plant, Granby Consolidated Mining and Smelting Company (T. E. M. Co.) Section on a tuyère.

CHAPTER VI.

BRITISH COLUMBIA COPPER COMPANY, LIMITED.

INCORPORATION. Incorporated in 1898 under the laws of West Virginia, operating in British Columbia under license as an extra provincial company. Capital stock authorized,600,000 shares par value $5 each = $3,000,000; issued 591,709 shares = $2,958,545. *President*, Newman Erb, New York; *Vice-Presidents*, Charles H. Burke, New York, and C. A. Starbuck, New York; *Secretary-Treasurer*, R. H. Eggleston, New York; *General Manager*, Oscar Lachmond, Greenwood, B.C.; *Consulting Engineer*, J. E. McAllister, 60 Wall St., New York; *Mining Engineer* and *Geologist*, Frederick Keffer, Greenwood; *Smelter Superintendent*, W. L. Bell, Greenwood. *General Offices*, 31 Nassau St., New York; *Mine and Smelter Office*, Greenwood, B C. Fiscal year ends November 30. Annual meeting held second Tuesday in February.

This Company carries on the general business of mining and smelting copper and gold ores; it is also a purchaser of custom ores. It owns a large area of mining lands in southern British Columbia, the principal mine being the Motherlode, near Deadwood, and 4 miles from Greenwood. Through the ownership of 63% of the stock of the Dominion Copper Company, it has acquired large interests in a number of other claims, particularly in the district around Phoenix. The smelting plant at Greenwood, B.C., belongs to this corporation.

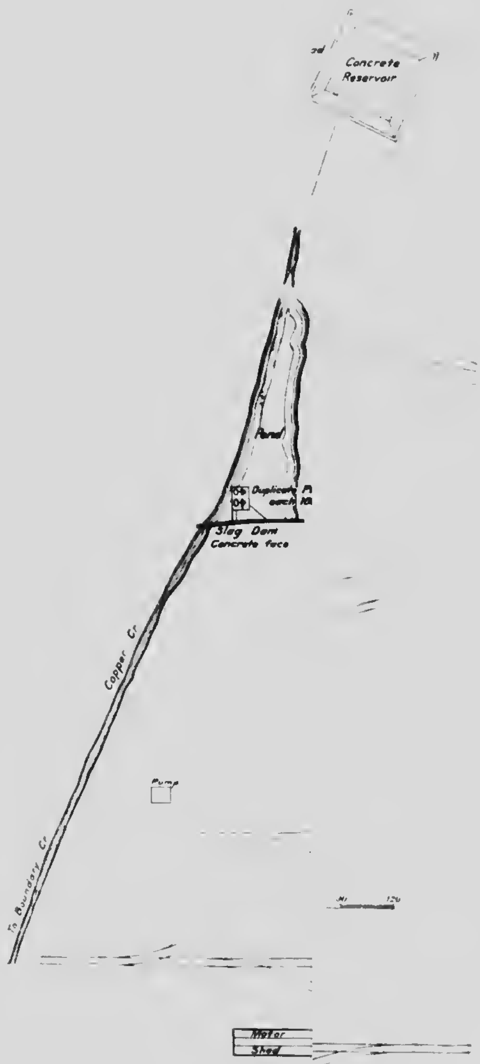
The principal mines, and the mining methods of this Company, will be described in the Report on the Copper Mining Industries of Canada. The following description deals only with the copper smelting plant at Greenwood.

GREENWOOD SMELTER.[1]

Location. The smelting plant of the British Columbia Copper Company is located about half a mile south of the town of Greenwood in the Boundary district of British Columbia. The works are erected upon terraces near the southern extremity of an intervalley spur formed by the junction of Copper creek with Boundary creek. The site has proved an excellent one for the purpose; the works are terraced throughout, which greatly facilitates the handling of ores and products.

[1] Description based on personal notes and on 'Greenwood Copper Smelting Works,' by J. E. McAllister, Engineering and Mining Journal, Vol. XCI, May 20, 1911, pp. 1011-1015.

The author is also indebted to the members of the staff at Greenwood for many courtesies when this report was being prepared. Mr. F. Keffer and Mr. W J Bell were kind enough to read the preliminary manuscript of this chapter. Mr. Bell also placed a copy of his paper 'Description of the Copper Smelter of the B. C. Copper Co.' at the writer's disposal.



Concrete
Reservoir
Pond
Slag Dam
Concrete face
Copper Cr
To Boundary Cr
Pump
Motor
Shed

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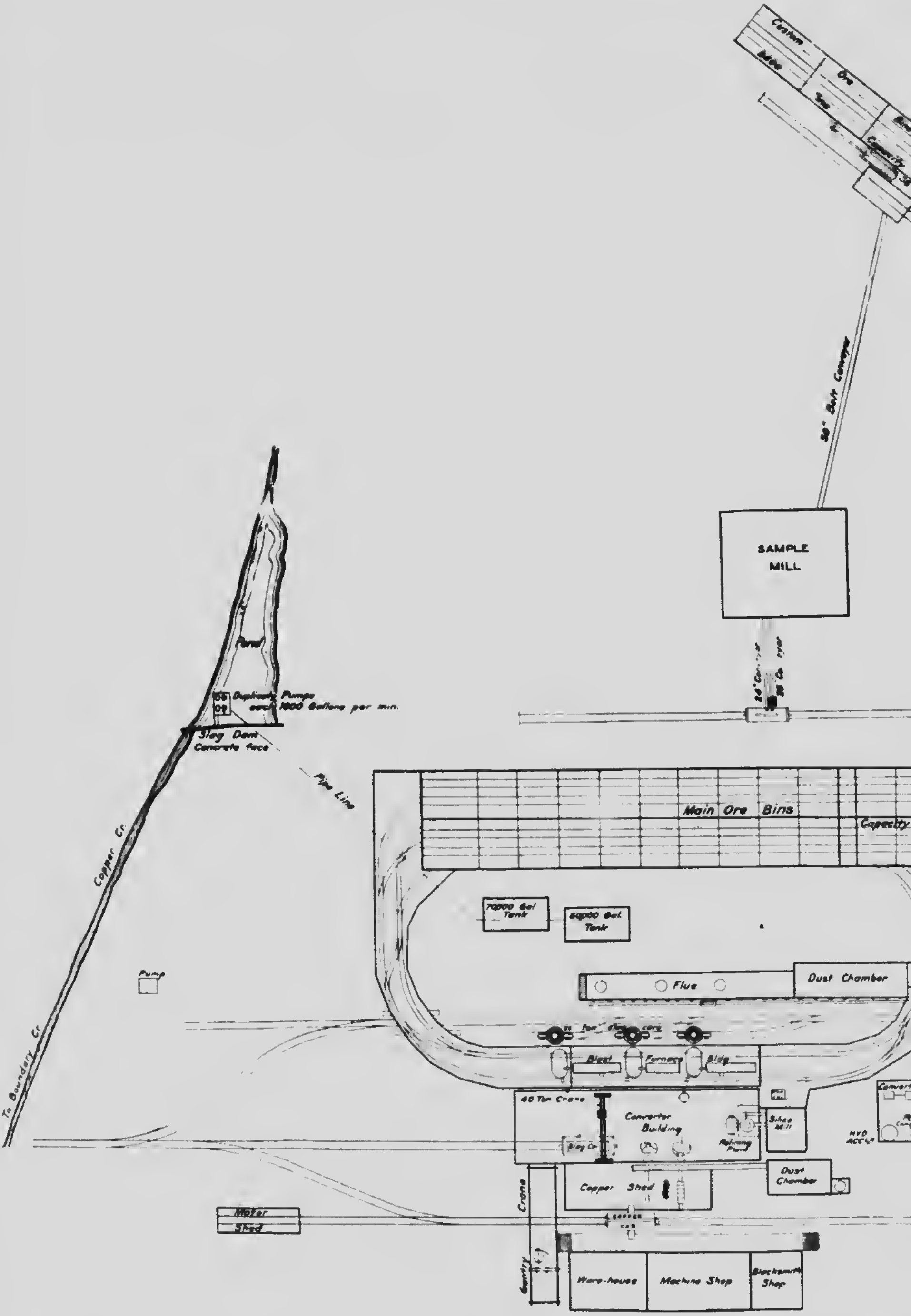
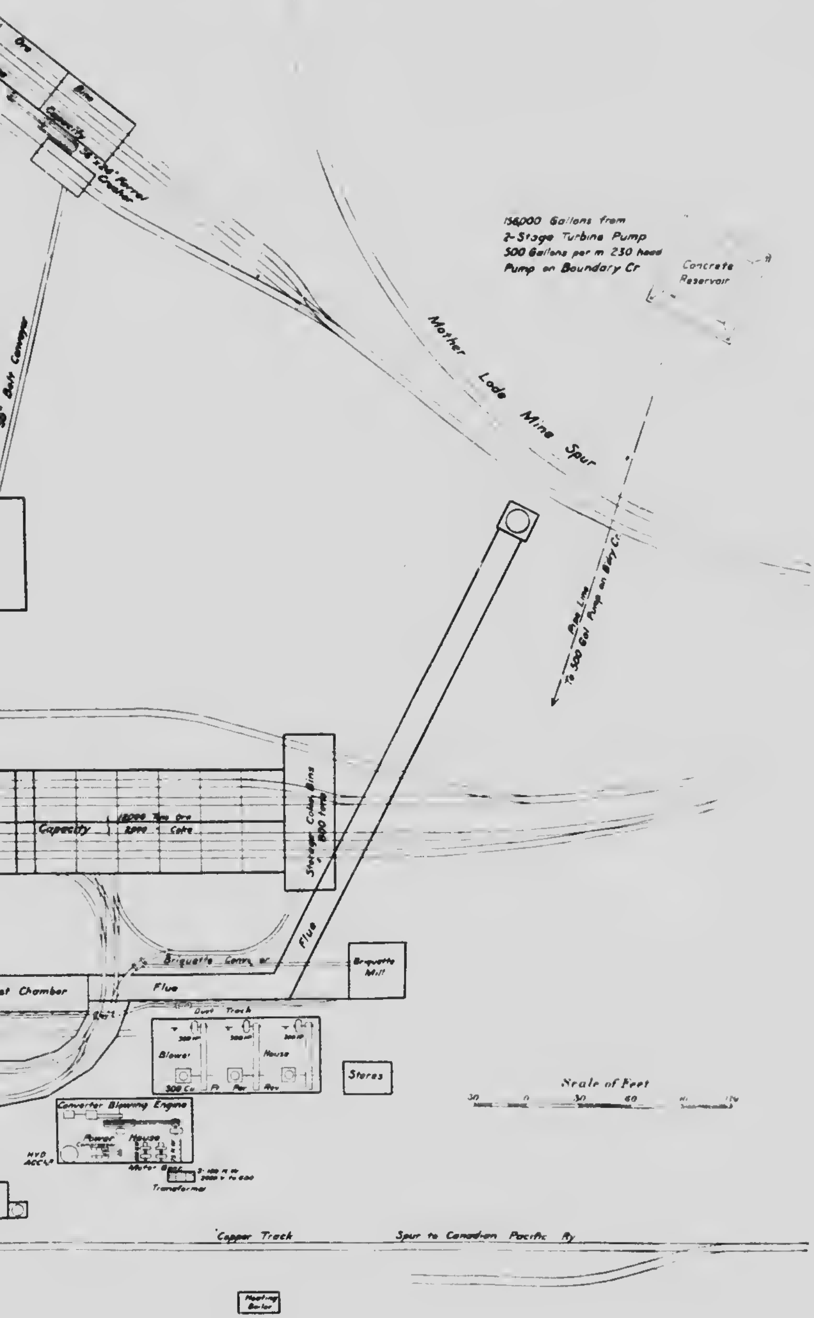
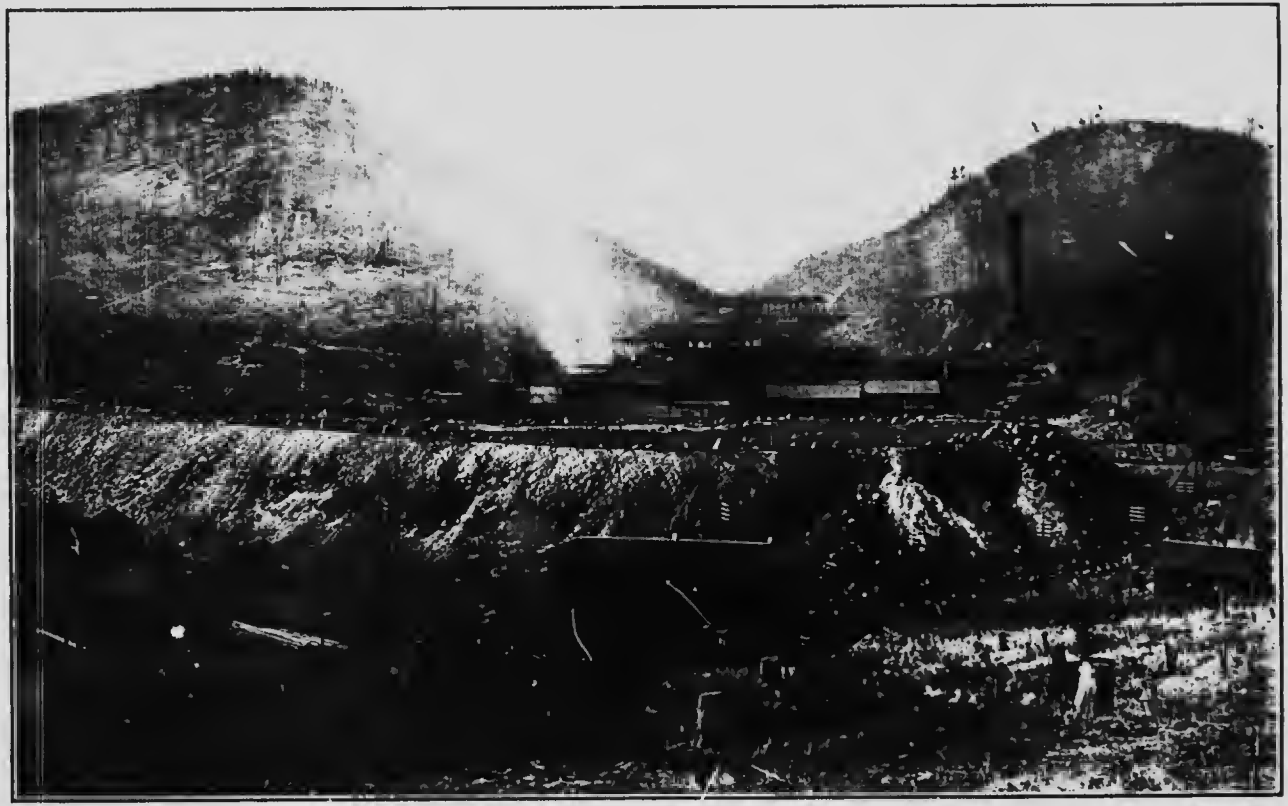


FIG. 29. Ground plan of reduction works at Greenwood. British Co



British Columbia Copper Company, Greenwood, B.C.

Plate XXXV.



Birdseye view of the Greenwood smelting works, British Columbia Copper Co.

Historical. The erection of a smelter on this site was begun in 1900; the first furnace, designed to smelt 250 tons per day, was blown in on February 18, 1901, and smelted on the average 360 tons per day. The plant was gradually enlarged and finally in 1907 it was remodelled with an increase to a capacity of 1,700 tons per day. The total time between the blowing out of the old furnaces and the blowing in of the new plant was a few days less than five months. The plant was again enlarged in 1910 to its present capacity of 2,200 tons per day.

General Statement. The ore treated at this plant is derived almost entirely from the Company's own mines; a small amount of custom ore is also obtained from neighbouring mines. The principal mine is the Motherlode, 4 miles distant, and connected directly with the smelter by a spur line of the C. and W. branch of the Canadian Pacific railway. The distance to the Rawhide is 17 miles, to the Oro Denoro and Emma group 10 miles; to the Wellington camp group 18 miles. The Lone Star group is 9 miles away, 5 by aerial tram, 4 by rail. The Napoleon group is 60 miles away, on the Great Northern. Coke supplies are obtained from the International Coal and Coke Company, with mines at the Crowsnest pass, over the line of the Canadian Pacific railway.

The works are laid out in terraced plan. The power required is obtained from the Bonnington Falls power plants, through the Greenwood transformer station. The smeltery is fully equipped with ore storage bins, sample mill, blast furnace plant, converter plant, briquetting plant for flue dust, machine, blacksmith, and carpenter shops, power house, and an efficient water supply for all purposes. About 125-130 men are employed at the works.

The general appearance of the works, as seen from a short distance south of them, is shown in Plate XXXV. The slag piles form the well developed terrace in the immediate foreground, and the works are seen in the rear. The panorama view shown in Plate V, is a closer view of the works as they were in 1906.[1] On the left of the picture the converter building is prominent by reason of its corroded roof; behind this the down-combers of the three furnaces are visible beneath the roof of the furnace building. The buildings on the right are the power houses, while the main flue leading to the main stack on the hill is clearly shown in the background.

Electric Power. —Power is transmitted to Greenwood from No. 2 power house at Boundary Falls by two 3-phase 60 cycle 60,000 volt lines. Here the current is stepped down to 2,200 volts for use at the smelter and at the mines. The Cascade plant, which is a 22,000 volt plant, is so arranged that auxiliary service can be supplied to Greenwood, and other points, if necessary.

The Greenwood sub-station is owned by the West Kootenay Power and Light Company. It is equipped with one bank (three transformers) 1,250 K. W. each, 60,000 2,200 volts, oil insulated, water cooled,

[1] By W. J. Carpenter, of Vancouver.

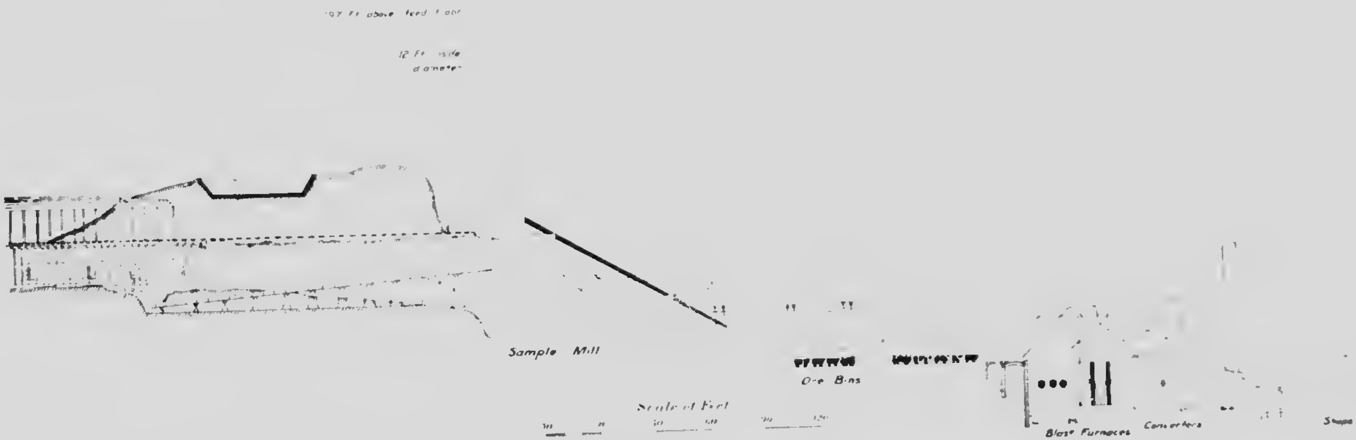


FIG. 30. Section through reduction works at Greenwood. British Columbia Copper Company, Greenwood, B.C.

Westinghouse manufacture. All switchboard apparatus, motor operated oil-break switches, storage battery set, lightning arresters, etc., were manufactured by the Canadian General Electric. When this installation is complete there will be two banks (six transformers), 1,250 K. W. each, 60,000 2,200 volts, oil insulated, water cooled.

The total capacity of the motors installed at the mines and smelter is about 3,800 H.P.; about 1,600 H.P is required at the smelter, the balance at the mines.

The power house is in two adjoining sections. Section A contains the switchboard, 3 motor generator sets, converter blowing engine, high pressure air compressor and hydraulic accumulator; section B contains the blast furnace blowers.

The switchboard, located in section A of the power house, consists of line and feeder panels, upon which are mounted measuring instruments for both alternating and direct currents, and the recording wattmeter which registers the entire power consumption.

Direct current for operating the travelling crane and the slag and charging railways is generated by 3 direct-connected motor generators, one of 75 K.W., one of 100 K.W., and the third of 150 K.W. capacity.

Receiving Ores and Supplies.—A spur of the Canadian Pacific railway runs to the yards; the yard lines enter the works on three different levels by nine spurs. The upper level delivers all ore that requires sampling to a series of bins under the sidings; the intermediate level delivers coke, and all ore that has been sampled before arrival to other bins; the lowest level is used to deliver supplies, to remove the converter slag, and to ship the blister copper.

The accompanying diagrams (Figures 29 and 30)[1] show the arrangement of the plant both in plan and section. On the intermediate level a set of 100 ton self-registering track scales is placed, and all incoming material can be weighed. On this level there are five spurs diverging from the incoming track which has previously passed across the weighing scales. One of these is for the purpose of transferring material which has passed through the sample mill to the smelting bins; the other four are for delivering ore, coke, and converter slag, there being two lines of bunkers with two tracks running the length of each.

The high level storage bins have a capacity of 2,000 tons of ore. The ore bins served by the intermediate level are of 12,000 tons capacity, and the coke bins hold 3,000 tons.

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[1] From a drawing supplied by the late General Manager.

The difference in level between the upper and intermediate railway levels is 48 feet.

The tracks on the lowest level are 61 feet below the intermediate railway level; these tracks pass between the converter building and the repair shops and warehouses to facilitate the unloading of supplies and the shipping of the blister copper. To unload heavy material a gantry crane, which crosses this lower spur, is provided.

Sample Mill.—The sample mill building is three stories high and 65 feet × 79 feet in area. The sample mill bin discharges by chutes into a Farrell-Bacon crusher, 36″ × 24″, driven by a 100 H.P. Allis-Chalmers-Bullock variable-speed, 2,200 volt motor, with countershaft and belt drive. The crushed ore passes to the sampling mill by a 30″ belt conveyer, 225 feet in length, driven from the line shaft in the mill. This conveyer delivers into a bucket sampler cutting 11½%. This bucket sampler consists of two steel boxes 2′ 6″ × 2′ 6″ × 2′ 10″, attached to double sprocket chains and moving around three sides of an inverted isosceles triangle.[1] The sprockets are driven from the line shaft by a bevel gear. This device takes the entire stream of ore from the belt-conveyer at regular intervals; the rejects, about 88½% of the total quantity delivered to the belt, pass to another belt conveyer (24″ belt), thence to a standard 50 ton dump car which is switched to the stock bins. The boxes of the sampler, as they reach the end of the horizontal drive, deliver to a No. 5 Gates crusher. The further course of the sample through the mill is shown on the accompanying flow sheet (Figure 31). With custom ores the first cut is omitted and the entire stream is delivered to the No. 5 gyratory crusher and a 20% cut taken.

The sample mill is designed with sufficient flexibility to give samples of approximately uniform size for hand quartering irrespective of the original quantity passed through the mill. This is accomplished, when handling small lots, by cutting out one of the units of the sampling mill. The amount left for hand sampling is 1 5434th part of the original quantity; mill lots of low grade ores up to 3,500 tons in weight are sometimes carried to one final sample.

The entire mill is operated from a line shaft driven by a 100 H.P., 550 volt induction motor, the low voltage being used on account of the dusty atmosphere of the mill. The two reject conveyers are driven by 15 H.P. and 10 H.P., 550 volt motors. The bucking room is provided with a 5 H.P. motor. The mill has a capacity of 2,000 tons in 16 hours and requires a total of 11 men for operating the two shifts, but it has never been necessary to operate to capacity.

[1] See Engineering and Mining Journal, Dec. 25, 1909, p. 1282, and Feb. 12, 1910, p. 358.

Haulage and Distributing System. The main section of the smelting ore bunkers consists of 18 bins in two lines, each bin having a capacity of 600 tons of ore. In addition there are 2 bins at the extreme south end

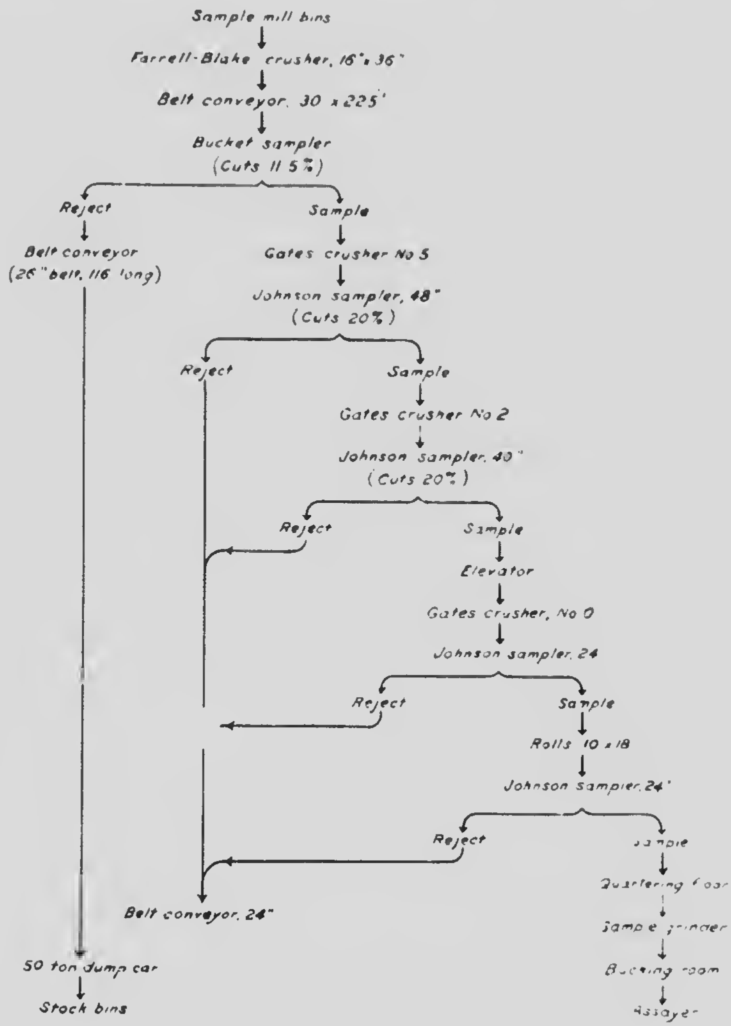


FIG. 31. Sample mill flow sheet, British Columbia Copper Co., Greenwood, B.C.

having a total capacity of 100 tons of coke. An extension section has 12 bins of the same size as the main section, and at its extreme north end is a coke storage bin of 800 tons capacity. The total capacity of these bunkers amounts to 12,000 tons of ore and 3,000 tons of coke. All coke beyond this amount is stored in stock piles. Three of the bins of the main section are subdivided into two equal compartments and one into four equal compartments, to afford storage for small lots of ore and for converter slag.

Under the bunkers, 31 feet below the level of the intermediate line of railway tracks, are four parallel electric tramway lines, 36″ gauge, each line being provided with three sets of automatic platform scales, located at regular intervals on the tangent which passes under the ore bunkers. The four lines converge at each end to a semi-circle of double track ending in two parallel lines which pass, one on each side of the blast furnaces. The entire system thus forms two flat-sided ellipses, one inside the other; switching arrangements are provided at both ends to permit the charging trains to run from either track to the other.

Three 7·5 ton electric locomotives are used on these lines for hauling the charging trains, and other purposes; a fourth locomotive is held in reserve. The current operating the locomotives is used at 220 volts.

The charging cars, 26 in number, are hopper shaped, side dump cars, 55 cubic feet capacity. When discharging the body is released by a foot trip placed underneath the car.

In operation there is a charging train to each blast furnace, 8 cars to a train for the larger furnaces, and 6 for the smaller; each train carries an equal number of cars of coke and charge. The charge trains make a complete circuit, receiving from any part of the bin system, coke, stock-pile or briquettes, and for discharging they can pass on either side of the three blast furnaces. A train crew consists of a motorman and two loaders, 3 in all.

A tram line which runs through a cut in the cupola building back of the furnaces leads out to the slag dump. One 35 ton electric locomotive, and a pair of 15 ton locomotives, coupled to act as a unit, are used on this line to haul the slag trucks.

Flue System and Stack. From each furnace a sheet steel downtake 7 feet in diameter, in the form of an inverted V, links with the dust flue across the cut in which the slag tram operates. The dust chamber forms the opposite side of this cut; it is a flue, 180 square feet in cross section and 200 feet in length. It conducts the flue gases to an expansion chamber 550 square feet in cross section in which the flue dust is collected; the flue passes onward at an oblique angle as it ascends on the natural rise of the ground a distance of about 500 feet to a brick stack 121 feet in height and 12 feet inside diameter. The height from the top of the stack to the feed floor is 197 feet.

Buildings.—All buildings at the smeltery are of steel. The cupola building 60′ × 150′ contains the three blast furnaces; the converter building adjoining measures 44 feet × 150 feet, the power house 40 feet × 84 feet. The approximate dimensions of the other buildings on the property can be determined from the accompanying plan. An office and assay laboratory, and several residences for officers of the Company, located east of the works, are not shown on the plan.

Shops. The works are provided with fully equipped machine shop, blacksmith shop, and carpenter shop. The machine shop equipment includes a lathe, planer, large and small radial arm drill press, pipe machine, bolt cutter, a 1·5 ton air hammer, splitting shear punch, and 5 ft. rolls.

Assay Office. The assay office is fully equipped to handle all types of ore received at the smelter, as well as slags, mattes, and blister copper.

Copper Blast Furnaces. There are three water-jacketed blast furnaces in the cupola building. Originally these furnaces were 48″ × 240″ at the tuyères; the capacity was recently increased about one-third by widening the two end furnaces to 51″ and lengthening them to 360″.

The furnaces are each erected on a concrete base, about 4 feet above the converter floor, and 8 feet above the track for slag cars. They are placed longitudinally, and in charging the side dumping cars used at the plant discharge to an inclined plate against baffle plates. The length of the cars is such that three (or four) can be discharged simultaneously throughout the length of the furnace; coke is supplied separately by three (or four) cars.

The end furnaces are each 51″ × 360″ at the tuyères, being 9 jackets in length; the middle furnace is 51″ × 240″ at the tuyères, being 6 jackets in length. The furnaces have 15 feet of available ore column, from tuyères to feed floor, 12-13 feet of this are used. The dimensions and other principal features of the construction of these furnaces are shown in the table of furnace data given in chapter VIII, page 146 (See Plates XXXVI and XXXVII).

The bustle pipe on each furnace is carried completely around the furnace, tending to equalize the air pressure at the tuyères.

The furnace doors are operated by compressed air at 85 pounds furnished by a two-stage duplex compressor, belted to a 50 H.P., 550 volt motor.

For the purpose of distributing the charges properly, each furnace is provided with two lines of hanging baffle plates which swing from heavy 4″ hydraulic piping, supported upon the feed floor level by the end castings of the furnace. The material from the charge cars is discharged against the apron plates and by these is deflected against the suspended baffle plates; these swing inward, their weight causing them to move gradually and producing a satisfactory distribution of the charge in the furnace.

The furnaces are each provided with two water-jacketed trapped spouts, with a water-cooled copper lip, one at either end of a furnace, and may be tapped at either or both ends as required.

Between each pair of furnaces a large square settler, 10′-6″ in width, 18″ in length, and 4′-6″ in depth, lined with chrome brick, is placed to receive the matte and slag. These have a holding capacity of 20 25 tons of matte. Slag overflows to a 25 ton pot on a standard gauge carriage. During the interval of changing the slag pots, a small ladle operated by hand intercepts the stream.

Matte is tapped directly to 5 ton ladles handled by a travelling crane o. the opposite side to the slag railway.

Converter Equipment.—The converter floor is abreast of and about 4 feet lower than the blast furnace floor. It contains 2 converter stands and 5 extra converter shells, 7 shells in all, each 84″ × 126″. Hydraulic power is used for tilting (Plates XXXVIII and XXXIX).

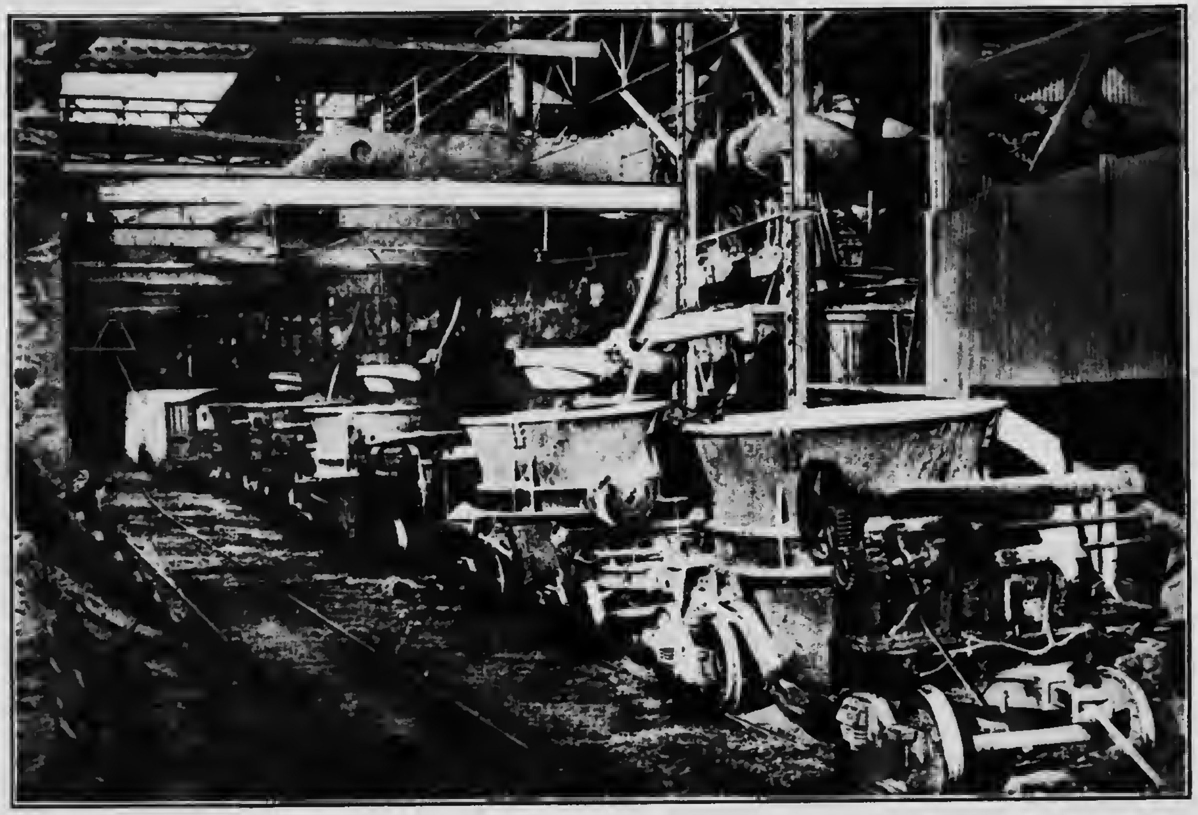
The converters are usually lined with siliceous gold ores, from the Republic mine, Washington, or from the Snowstorm mine in Idaho, the latter containing 80% silica. This ore is mixed with local clay as a binder, a firebrick lining being placed next the shell on the tuyère side. The ore for the silica lining is crushed to 1″ cubes in the sample mill, ground and mixed in a 6 ft. Carlin silica mill, belted to a 40 H.P. motor, and it is tamped by pneumatic rammers.

The plant is served by a Niles electric four motor travelling crane; the main hoist of this crane is 40 tons capacity, the auxiliary hoist 10 tons capacity.

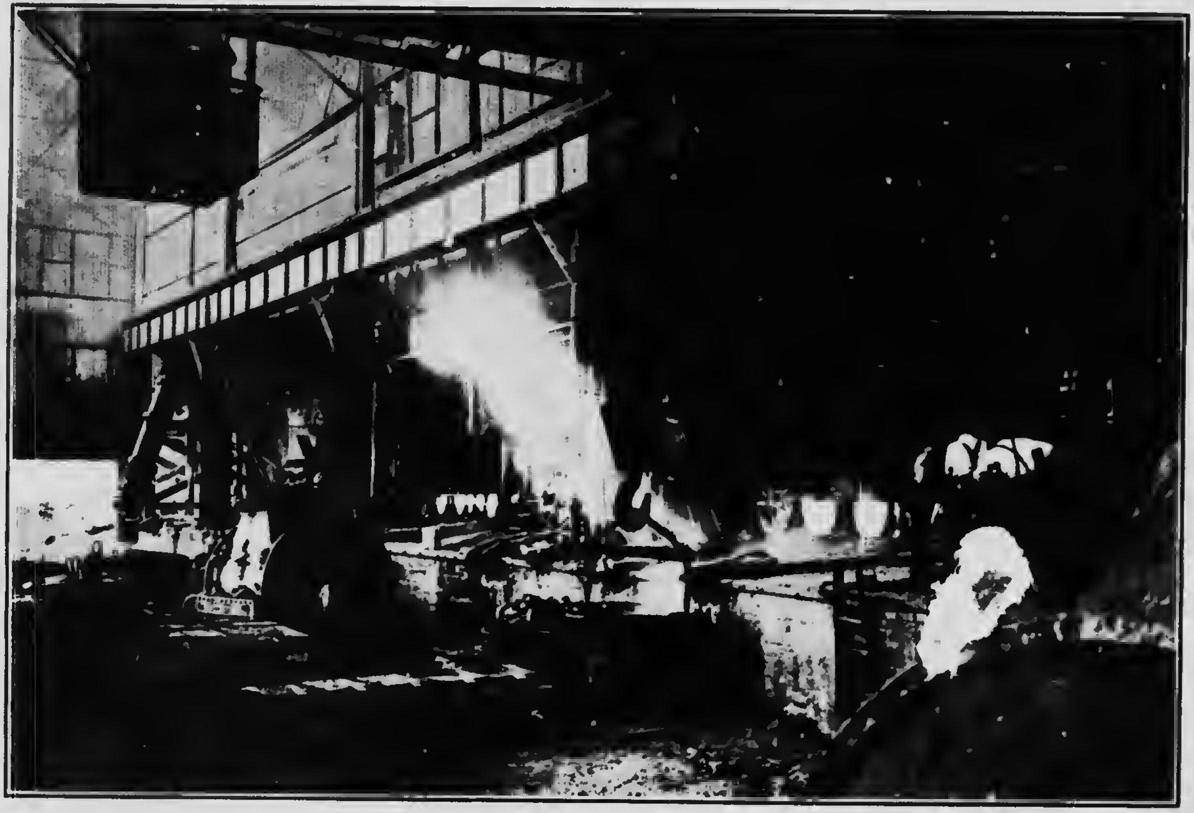
The converter plant has a capacity of 40 – 50 tons of 35% matte per 24 hours, the production being about 1,000,000 pounds of blister copper per month.

Blower Plant.—Each furnace is supplied with an individual Number 10 Root blower of 300 cubic feet capacity per revolution, operated at 85 r.p.m. Each blower is belt driven by a 300 H.P. type C Westinghouse squirrel-cage induction motor, the belts being 40″ wide. The blowers are designed to deliver their rated capacity at any pressure up to 40 ounces. Blast at 22 ounces is piped directly from each of the three blowers to its respective furnace. At the point where the blast pipes leave the power house they enter a header with a valve system which permits the interchange of blowers to the different blast furnaces, when necessary. The pipes are 43″ in diameter.

The converters are supplied with air at 8 – 10 pounds per square inch [illegible]ssure by one side of a Nordberg cross-compound single stage compre[illegible] having an air cylinder 40″ diameter, stroke 42″ capacity 5,000 cu[illegible] per minute. The engine was designed for steam, but it is now d[illegible]th rope drive, by a 300 H.P. Canadian General Electric variable spee[illegible]luction motor. This machine has foundations, driving wheel, and [illegible]ank shaft arranged for the addition of the other side whenever necessity requires.



Interior of the blast furnace building, slag side, British Columbia Copper Co., Greenwood, B.C.



Interior of the blast furnace building, matte side, British Columbia Copper Co., Greenwood, B.C.

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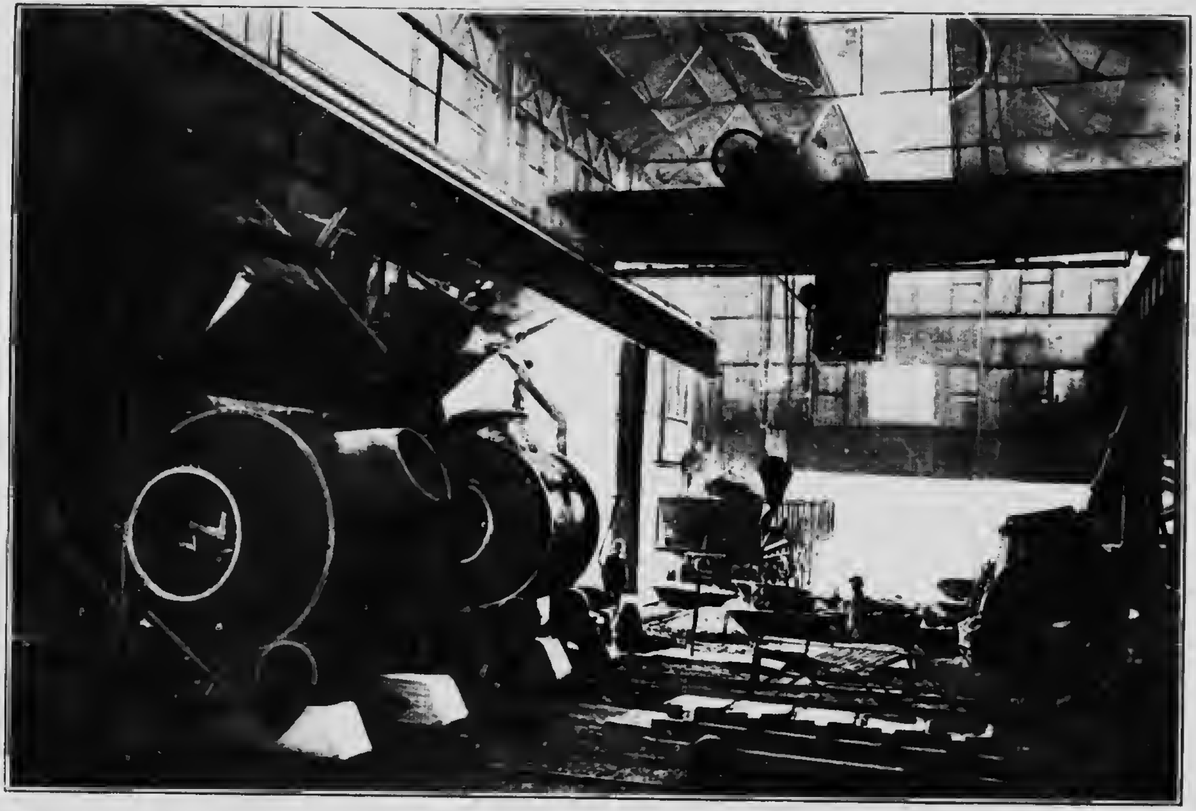

Acid copper converters, British Columbia Copper Co., Greenwood, B.C.

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Plate XXXIX.

An electric operated silica lined copper converter. (A. C. Co.)

A compound duplex Canadian Rand compressor of 340 cubic feet capacity, belt-driven by a 51 H.P. induction motor, running at 150 r.p.m., supplies air at 75 pounds pressure, for operating the tampers used in lining the converters. It is also used for operating the blast-furnace charging doors and pneumatic tools.

Hydraulic Accumulator.—A triplex plunger pump, 5″ diameter, 8″ stroke, 60 r.p.m., capacity 120 gallons per minute at 200 pounds pressure, belted to a 20 H.P. motor, operates the Gould hydraulic accumulator that is used for operating the converters. The ram of this accumulator is 24″ in diameter, the stroke is 10 feet.

Briquetting Plant.—The blast furnace flue dust is briquetted in a White press having a capacity of 5 tons per hour. This machine is a 3-plunger press, driven by a 40 H.P. motor. About 1·5% of the material delivered to the blast-furnace charge is collected as flue dust. This contains enough calcite to constitute a lime-bond for the briquettes so that it is not necessary to add any material. The dust from the flue passes automatically through a mixer where the requisite quantity of water is added. The briquettes are delivered from the machine on trays where they are permitted to dry for 24 hours. They are then charged back to the blast furnaces.

Water System.—A concrete reservoir, 150,000 gallons capacity, holds a reserve supply of water at a head of 144 feet above the converter floor. This reservoir is served by a two-stage turbine pump, direct connected to 100 H.P. induction motors, and located on Boundary creek. The furnace water is supplied by a pump driven by a 50 H.P. motor. These motors are operated directly from the Power Company's pole line and are independent of the Copper Company's powerhouse switchboard, in order to ensure protection from fire.

Overflow and seepage from Copper creek are conserved in a pound into which the jacket water of the furnaces also flows when required. When it is necessary to conserve the jacket water and use it over again, this pond serves as a cooling pond. A pair of 60,000 gallon service tanks and one of 100,000 gallons are used to receive the jacket water pumped from the pond. Three direct-connected Byron-Jackson centrifugal pumps, each of 1000 gallons per minute capacity, operated respectively by one 50 H.P., two 40 H.P. induction motors, are used for this purpose. A 14″ main connects these pumps with the service tanks. The blast furnaces require about 4,000 gallons per minute.

The piping of the water system is arranged in independent circuits as an added protection against fire and also to permit of the shutting off of any section for repairs. Twenty-two hydrants and numerous valves serve for fire protection.

Smelting Practice.—Blast Furnaces.—The height of the charge in the furnaces is maintained at 13 feet. The ore is of such a nature that it decrepitates readily upon heating, this permitting coarser crushing (to about 8″) than would otherwise be necessary. The ore from the different mines is mixed in the charging cars to form a rapidly smelting mixture, the furnace capacity being about 6·176 tons per square foot of hearth area per 24 hours, or 2100 tons per day for the three furnaces. With favourable ore and furnace conditions a duty of 7·5 tons per 24 hours has been attained, but this is too fast running for the settlers and breast jackets, and especially for loading the charge trains, and is not desirable.

A charging train makes up its charge at the bunkers by running under the bins, loading in the first constituents and weighing on the nearest scale, then adding the next and weighing on the next scale, and so on until the charge is complete; it then backs under the coke bins to receive the coke charge. When loaded it goes forward under the bins and around by the semi-circular loop to the feed floor tracks passing to either side of the furnaces as desired. At the furnaces the coke charges, which are 12-14% of the ore charges, are first dumped, followed by the ore charges, the size of the latter being from 15,000 to 20,000 pounds, or 5,000 pounds per car. The average copper content of the furnace charge would be from 1·1% to 1·3% in the form of chalcopyrite, carrying also from $1.10 to $1.20 in gold and silver. Iron occurs in the ores as pyrite and magnetite; there is also a little pyrrhotite; lime occurs as calcite. A deficiency in sulphur has to be supplied; at present this is obtained from the Company's Napoleon mine, the ore from which is pyrrhotite. To smelt the charge, from 12% to 14% of coke, carrying 22-25% of ash, is required.

The following are approximate average analyses of the principal ores received at the smelter:—

TABLE X.

Ore Analyses, B.C. Copper Co., Smelter.

Mine.	Silica %	Iron %	Lime %	Alumina %	Sulphur %	Copper %	Au. and Ag.
Motherlode..........	38·0	12·0	22·0	6·0	2·0	1·2	1·00
Rawhide............	36·0	11·0	19·0	......	3·0	1·3	0·90
Napoleon............	30·0	33·0	7·0	....	[illegible] 0	....	....
Lone Star...........	65·0	1·5	4·0	....	[illegible] 5	....	....
Emma[1]............	15·0	43·0	12·0	....	1·4	1·25	0·70

[1] Not at present operated.

An effort is made to maintain a slag of an analysis, in its chief constituents, of SiO_2, 43-46%; FeO, 19-27%; CaO, 21-28%; Al_2O_3, 9%. The matte produced has a 35-45% copper tenor. Since the ores carry only 1·1%-1·3% copper it will be seen that a very low matte fall is obtained, necessitating very careful work in order to maintain rapid smelting and to prevent the building of large incrustations of chilled material in the furnace.

In operating the furnaces Motherlode and Rawhide ores are charged about equally, and Napoleon is added to the charge as required to regulate the grade of matte. The low matte fall, taken together with the sudden and considerable charges in the ore analyses, and the presence of magnetite in considerable but varying quantities, necessitates careful observation of furnace conditions.

The scarcity of sulphur makes a low sulphur elimination necessary. The blast pressure is maintained between 16 and 24 ounces according to conditions. This and the percentage of fuel in the charge are carefully regulated to keep oxidation to the lowest possible limits.

The following table gives the principal data with respect to the operation of these furnaces:—

TABLE XI.

Operating Data, B.C. Copper Co., Smelting Furnaces.

Charge, in tons per sq. ft. hearth area in 24 hours	6·2	Men in 8-hour shift	20
Cu % in charge	0·8-1·2	Matte % of charge	2·0
S % "	1·6-3·5	" % of copper	40
S % burnt off	80	" Specific gravity	5
Coke % of charge	12·0-14·0	Slag % of SiO_2	43-46
" " of ash	22-25	% of Fe (Mn) O	19-27
Blast, cubic feet per min.	25,000	% of Ca (Mg) O	21-28
" temperature	Atmosphere.	% of Al_2O_3	6- 9
Cooling water for jackets, gallons per hour (3 furnaces)	4,000	% of Cu	0·2-0·25
		Specific gravity	3·2

The blast furnace slag overflows from the settlers into slag cars. The slag trucks used are oval trucks of the type of cinder car used at iron and steel works; each truck has a capacity of 250 cubic feet of molten slag or about 25 tons. The slag trucks are hauled, one at a time, to the slag dump by 35 ton electric locomotives. Each slag truck is provided with a 15 H.P. motor, mounted on its frame, which furnishes the power to tilt the slag pot on the car frame, in order to discharge the molten slag. The tilting motors are operated from a controller located in the locomotive cab, and the current is transmitted to these tilting motors from the trolley wire by extension cables coupled between the locomotive and slag trucks.

These trucks are designed with an especially steep angle dump of 17°, to enable the bowls to clear themselves of the shell of slag [illegible] tilted to the extreme limit of the worm gear.

Converters.—Matte is tapped from the settlers into [illegible] ton [illegible]lles which are moved by the travelling crane to the converters. In the event of difficulty in tapping matte, which may arise through lack [illegible] tention to the tapping bar in the settler, and because of the low m[illegible] the frozen matte is fused by an electric arc formed by applying [illegible] carrying a current at 110 volts. This rod is about 30″ in leng[illegible] and 1″ in diameter.

Converter slag is received in ladles and poured in[illegible] on the ground. When sufficiently cool it is lifted to a griz[illegible] of steel railway dump cars, through which it breaks readily into [illegible] The cars when loaded are transferred to the ore bunkers a[illegible] is discharged into a bin for re-charging to the blast [illegible]

The converter gases are taken off separately from [illegible] blast furnaces to prevent the high grade converter flue dust entering [illegible] ong blast furnace flue. The converter flue discharges the gases into an expansion chamber 281 square feet in cross section, in which the dust is collected; the gases pass onward to a steel stack 78″ in diameter and about 75 feet in height. The converter flue dust is returned to the converters and is fed into the molten charge.

The air blast at the converters is used at 8–10 pounds pressure to the square inch.

Two charges of blister copper are made from each lining.

The blister copper is cast into slabs which are weighed and sampled and loaded into railway cars at the lower spur.

Labour.—Open shop is the policy of the smelter. To operate the plant at its present capacity, the following force is required per 24 hours: superintendents and warehouse clerks, 4; shift bosses, 5; sampling mill, 11; blast furnaces and briquette mill, 61; converting department, 15; powerhouse, 3; mechanical and electrical force, 12; slag dump and general labour, 9; total, 120. The plant is thus treating approximately 20 tons of ore per day to each employee, including superintendents and foremen. The sample mill staff, and the men engaged around the furnaces and converters work 8 hour shifts; the major portion of the other labour works 9 hour shifts.

CHAPTER VII.

THE TYEE COPPER COMPANY, LIMITED.

INCORPORATION. Organized April 1, 1900, in London, England. Licensed by the British Columbia Government as an extra provincial Company. Authorized capital, 180,000 shares £1 par value; issued, 180,000 shares. *Chairman*, Thomas Headland Wilson, London, England; *Secretary*, William Gardner, London, England, *General Manager*, W. J. Watson, Victoria, B.C. Fiscal year ends April 30. *Head Office*, 15 Leadenhall St., London, E.C. *Works Office*, Ladysmith, Vancouver island, B.C.

This Company was organized in 1900 to carry on the business of mining and smelting copper ores in British Columbia. They own about 1,247 acres of land on Vancouver island, including 800 acres of timber lands, 342 acres of mineral claims, the smelter site at Ladysmith, and a terminal railway yard. The principal property of the Company for many years was the Tyee mine on Mount Sicker, 50 miles from Victoria and 11 miles northwest of Duncan station on the Esquimalt and Nanaimo railway; this mine, however, was closed in 1907.

The principal property of the Company at the present time is the smelting works at Ladysmith. Between 1907 and the winter of 1911 this plant was operated as a custom smelter. Since then it has been idle, but everything has been kept in first class condition so that a new start could be made at any time; for this reason it has been considered advisable to include a description of the plant. Since the completion of this report word has come that arrangments have been made to re-open the plant at Ladysmith to treat ores from the Ptarmigan Mines, Limited, V.I.

LADYSMITH SMELTING WORKS.[1]

Location.—The smelting plant belonging to this Company, known as the Ladysmith Smelting Works, is located at Oyster harbour, on the east coast of Vancouver island, about 58 miles north of Victoria. The site is located near the head of navigation on a well protected natural harbour; it has a water front of 3,000 feet, and an area of 45 acres. The ground rises from the harbour in a series of terraces, and advantage has been taken of this to arrange the plant to handle supplies and products largely by gravity.

Historical.—The first smelter on this location was designed and erected for the Company by Mr. Thomas Kiddie. This was a single furnace plant,

[1] The author is indebted to Mr W. J. Watson for assistance in revising the first draft of this manuscript describing the Ladysmith smelter. Additional references are given in the text.

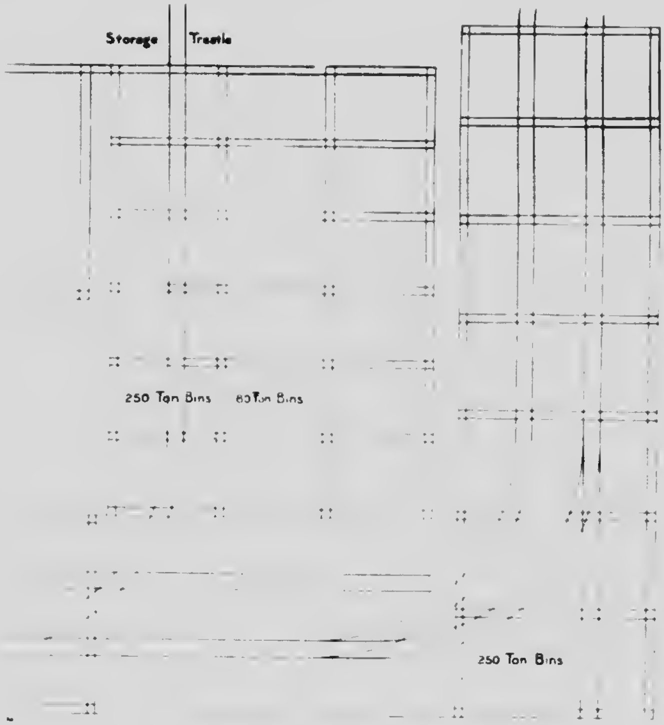
which was first blown in December, 1902. The plant was considerably improved and enlarged in 1907–8 to meet changed conditions; it was further remodelled and practically rebuilt in 1909–10.

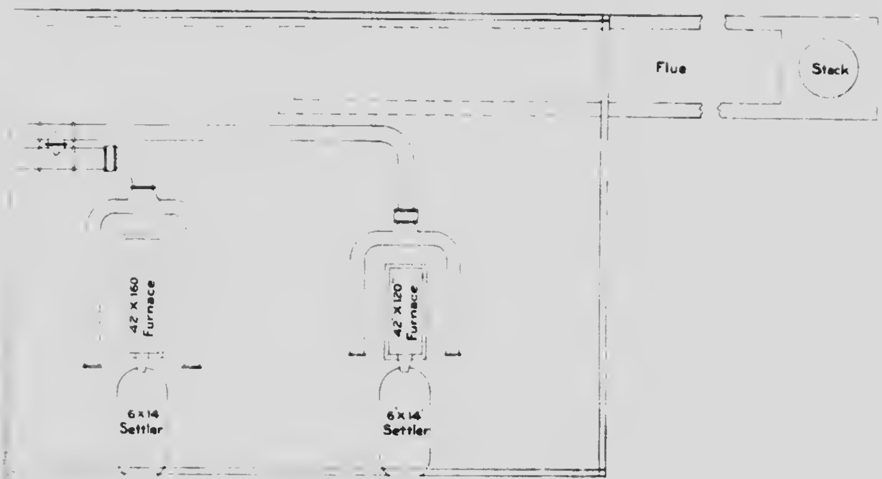
General Statement of Equipment.—The general equipment includes railway yards, railway scales and automatic scales for weighing train carloads, ore bins of 7,000 tons capacity, with yards affording any additional storage space required. The smelting plant comprises two large copper blast furnaces and auxiliary equipment, including 2 Connersville blowers and an Ingersoll-Sergeant air-compressor. There is a special mixing plant for handling fine ore, concentrates, and flue dust. The buildings include a sample mill, an assay office, machine, carpenter, and blacksmith shops, all of which are equipped to handle most of the repairs and minor construction work required around the plant. Fire protection is provided by a system of water lines, hydrants, and a pump. The efficient ore handling system includes special unloading docks with electric operated unloading machinery and an incline trestle leading to the ore bins (Figure 32).

Power.—The power required for the plant is supplied by 4 return tubular boilers—two 80 H.P., one 100 H.P., and one 120 H.P. The engine room contains a high speed Corliss engine 150 H.P., which is connected to an Allis-Chalmers-Bullock 100 K.W. direct current generator. This supplies power to the dock hoists and to the electric locomotive on the tram line. As an alternative for supplying power to the hoists or locomotive alone there is a 35 K.W. direct-current turbine. A Connersville blower, having a capacity of 8,000 cubic feet of free air per minute at a pressure of 32 ounces is connected by a rope drive with a Reliance-Corliss 100 H.P. engine. A second Connersville blower, delivering 14,000 cubic feet of free air per minute, is driven by a high pressure Corliss engine of 150 H.P. capacity, 12″ and 23″ cylinders, 30″ stroke.

The sample mill is operated by a 75 H.P. slide valve steam engine.

Receiving Ores.—Ore arriving by sea is received at the Company's dock on the water front. Upon this dock are two storage bins, one fixed and having a capacity of 300 tons, the other movable, being mounted on railway trucks running on tracks, and having a capacity of 100 tons (See Plate XI). This smaller bin can be moved the whole length of the dock; this arrangement makes it possible to quickly adjust the bins to unload simultaneously from any two hatches of a vessel. Both bins are equipped with electric hoists and movable arms; the latter can be projected to any required length by a small winch. The hoisting cables pass through a special trolly, the design of Mr. W. J. Watson, which operates without jar or strain when the hoist changes from the vertical to the horizontal motion. The ore is hoisted in sheet steel buckets, about 1,000 pounds capacity each, at the rate of 20–30 tons per hour per hoist, dependent upon the nature of the ore, and the rate of shovelling of the loaders.


Storage
Trestle
250 Ton Bins
80 Ton Bins
250 Ton Bins


Flue
Stack
42 X 160 Furnace
42" X 120" Furnace
6 X 14 Settler
6' X 14' Settler

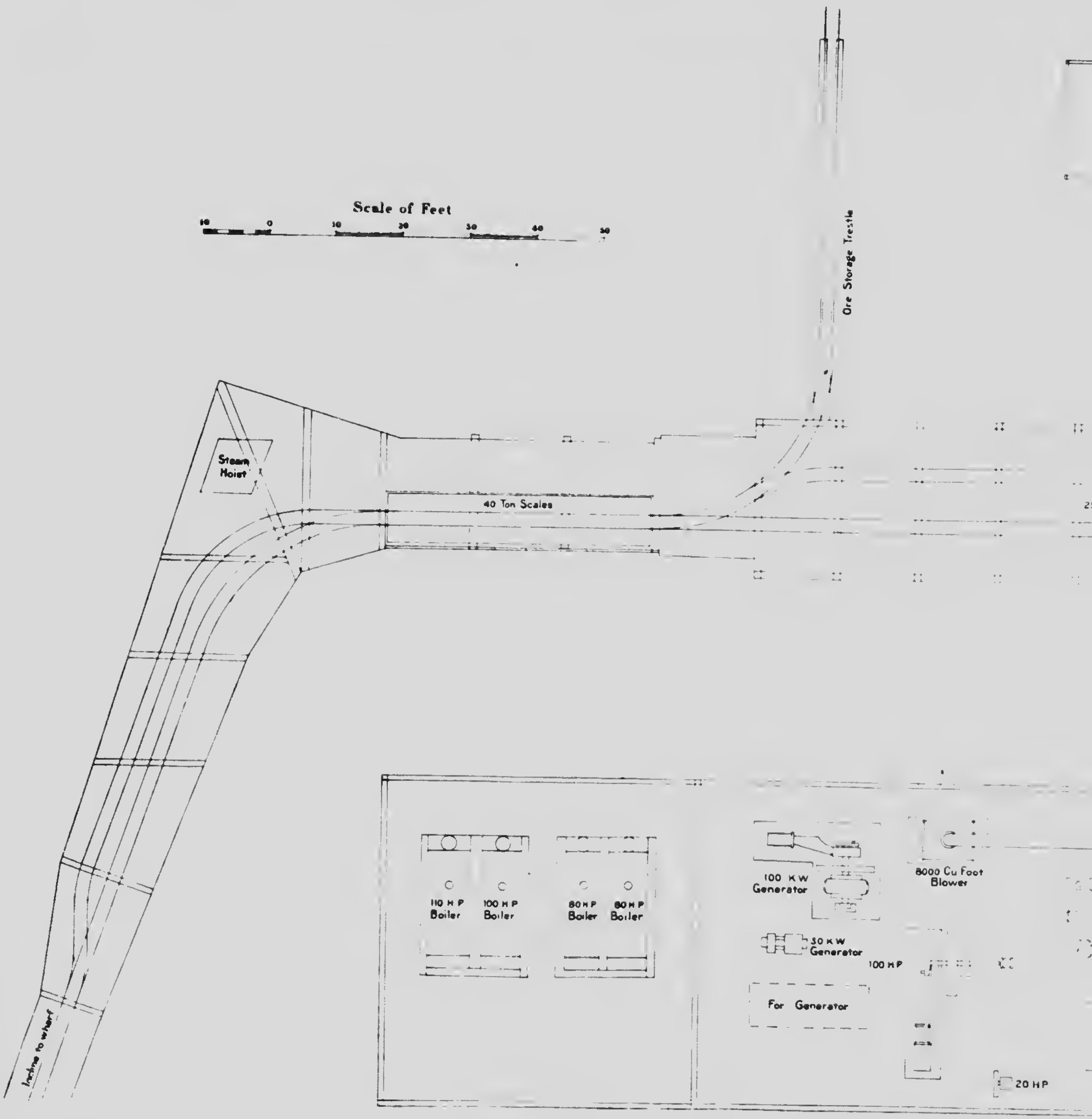
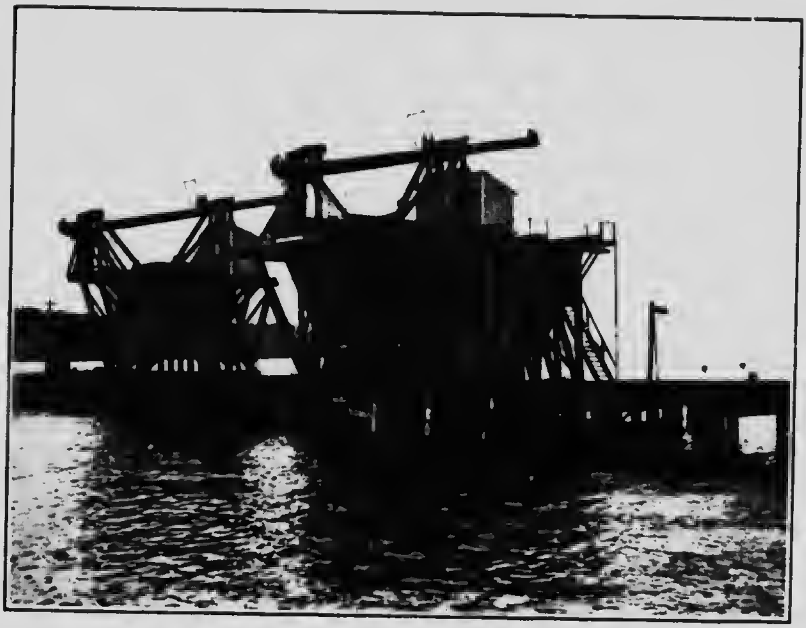


FIG. 32. Ground plan of Ladysmith sr

dysmith smelting works, Tyee Copper Company.

Ladysmith smelter, Tyee Copper Co., Ladysmith, B.C.



A. Unloading bunkers.

B. Drum hood erected over a copper blast furnace.
Ladysmith smelter, Tyee Copper Co.

The wharf bins are built with a row of posts down the middle and loading chutes on either side to facilitate the loading of the trains of cars which convey the ore to the smelter bins (Plate XLI A).

The dock itself is 40 feet in width and 210 feet in length; it is connected with the smelter bins by an incline nearly 1,000 feet in length. Ore from the dock bins is conveyed up the incline to the storage bins in trains of 5 cars each. These cars are side-dumping, of wooden construction, and hold about 2 tons each. Three trains are used: while one train is being weighed and its load discharged, the second is descending the incline and the third is being loaded at the dock. The arrangement of the tracks and double row of ore chutes at these bins enables the train of empties to be run into place for loading, while the other train is being loaded and the third train is at the top discharging its load. Operating in this way, the plant can handle about 1,000 tons per 10 hour shift.

The loaded trains are hauled up the incline by a steam hoist; at the top of the incline an electric locomotive runs the train upon the 40 ft. weighing platform of a Fairbanks automatic scale. This scale, which has a self registering beam, weighs all five cars at the same time. After weighing, one car or more of each train, as required, is switched to the sample mill bins which feed directly into the sample mill crusher. The other cars are run over the storage bins and dumped.

Ore arriving in railway cars from Vancouver Island points or over Canadian Pacific Railway mainland lines, via the car ferry, is switched to the ore yard where there are bins of 1000 tons capacity. When additional storage is required, ore is stock-piled in the yards; for this purpose several hundred feet of trestling running over the storage yards have been provided.

There are in all 4 sets of ore bins having a capacity of 7,000 tons, in addition to the yard facilities.

Sample Mill and Equipment. The sample mill building is a wooden structure 29′ × 34′ and 70 feet in height. A No. 4 Gates gyratory crusher of a capacity of 30 tons per hour is located in a pit 11 feet in depth. The ore is fed directly to this crusher and is broken to pass a 2″ ring. The crusher discharges into the boot of an elevator; this elevator raises the ore to a bin in the top of the mill from which it passes downward successively through a 48″ Snyder disc sampler cutting $\frac{1}{10}$, a 10″ × 7″ Gates crusher (to $\frac{3}{4}$″) a 36″ Snyder sampler cutting $\frac{1}{5}$, two pairs of rolls, both 20″ × 12″, and thence into a steel barrow with a covered top (See Flow Sheet, Figure 33). The sample is wheeled into the finishing room where it is quartered down, sheet iron crosses being used. The final sample, weighing about 120 pounds, is ground through a small rotary crusher and then through a Braun disc pulverizer. Ordinary low grade copper ores are passed through a 100 mesh sieve; the pulp of high grade ores is passed through a 150 mesh sieve. Ore for sampling is cut up into lots of about 200 tons each.

The proportion of any shipment that is sent through the mill depends upon its richness and uniformity. In some cases all the ore is sent through; in others the quantity will vary, being usually $\frac{1}{5}$ or $\frac{1}{10}$. As already noted in describing the methods of receiving ore, every fifth car hoisted up the incline is usually switched to the sample mill bins, the balance going to the storage bins. The discards are elevated into a special discard bin from which they are loaded into 2-ton cars and transferred to the bin containing the original shipment.

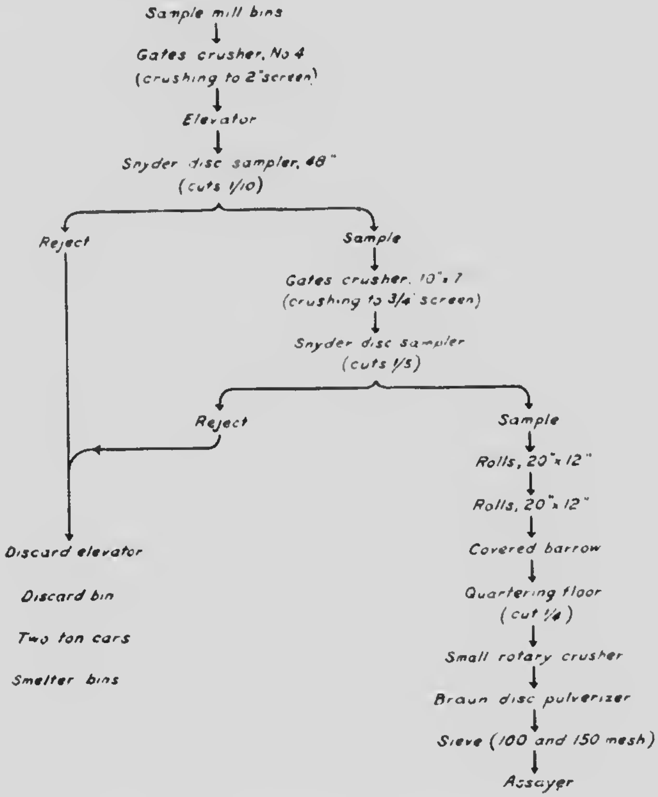


FIG. 33. Sample mill flow sheet, Tyee Copper Co., Ladysmith, B.C.

Haulage and Distributing System.—The Esquimalt and Nanaimo railway, now operated by the Canadian Pacific Railway Company, connects directly with the yards by a spur line. Standard gauge tracks are laid in the yards past the principal shops, and also upon several hundred feet of trestle work extending over the storage bins and stock piles.

A tram line track runs from the wharf up the incline to the weighing scales. This line also extends on trestles over the tops of the smelter bins and to the sample mill bin. The incline is operated with a steam hoist. The level portion of the line is operated by an electric locomotive.

On the charging floor steel hand barrows are used. These have a capacity of about 1000 pounds each.

The location of the ore bins and other bins, for storing ores and fluxes, with respect to the charging floor, is shown on the accompanying general plan of the works (Figure 32).

Flue System and Stacks.—A rectangular dust flue, 8′ × 11′ in section, and 165 feet in length, built with brick sides and an arched corrugated iron top, leads to the stack. Small doors are provided along each side of the flue, at the base, for raking out the dust. Along each side, below the level of the doors, is a water-tight concrete trough, 1 foot deep and 3 feet wide, into which the dust is raked and in which it is puddled with water to be returned to the furnaces.

The stack is circular in section and is built of brick, 90 feet in height and 7 feet in diameter.

Buildings.—The furnace building, 56′ × 81′, is of wooden construction with a corrugated iron roof. The boiler and engine plants are housed in similar buildings adjacent. The other buildings upon the property are of wood. The office and assay laboratory are located in a separate building a short distance from the main works.

Shops.—The works are provided with shops equipped to carry out all necessary repairs or to construct new equipment when not too heavy.

Ore Supplies.—The plant was originally constructed to handle ore from the Tyee mine on Mount Sicker, in the Somenos district, B.C. This property has, however, been idle since 1907. During the last few years the smelter has been treating custom ores received from many points on the Pacific coast—from as far north as Valdez, Alaska, and as far south as Peru; shipments have even been received from Korea. The plant is located at a strategic point for securing cheap freights on ore in both directions. The main traffic northbound along the coast consists of provisions, machinery, and drygoods. There is a shortage of return freights, which makes it possible to obtain special rates for ore cargoes southbound. Ore can be carried from Skagway to Ladysmith, about 1000 miles, in bulk, for $1.50 per ton.

Ladysmith is also the shipping point for the Wellington Collieries, of the Canadian Collieries, Limited, and a considerable quantity of lumber is also shipped from this or adjacent points on Vancouver island. Southbound vessels in the coal and lumber trades have to come back in ballast unless return cargoes can be obtained. This results in low back rates to Ladysmith on bulk cargoes of ore. A rate of $4 per ton has been secured from South American ports.

Coke is obtained from the Canadian Collieries Limited. It is made in beehive ovens at the Wellington collieries a few miles west of Ladysmith, and is delivered at the works in hopper-bottomed cars. These cars dump over a pit in which runs an elevator belt carrying iron steps. This belt elevates the coke as fast as it is discharged from the cars, to a height of about 40 feet, where it is distributed over a pile adjacent to the charging floor of the furnaces; movable chutes are used to distribute the coke evenly over the pile. The elevator is operated by a 15 K. W. shunt-wound direct current motor.

Limestone when required for flux is obtained from Tod inlet and also by rail from Shawnigan lake, 22 miles distant. As a rule fluxes are not required.

Assay Office. The assay office is fully equipped to handle all ores, slags, and matte treated at the works.

Copper Blast Furnaces. There are two Allis-Chalmers water-jacketed furnaces installed in the plant. Number 1, the smaller furnace, has tuyère dimensions 42″ × 120″, is boshed, and has a capacity of about 275 tons of ore per day; this furnace has smelted as much as 330 tons per day, when running on a smooth mixture. Air for this furnace is supplied by the smaller Connersville blower at a pressure between 24 and 30 ounces. There are 14 tuyère openings, inside diameter 6″, 7 on each side (Figures 34 and 35.)

The larger furnace is built without bosh, tuyère dimensions 48″ × 160″. The jackets are 9′-9″ in height, the width at the base is 42″ and at the top 62″; the end jackets are vertical and 160″ apart. This furnace has a capacity of about 400 tons of ore per day. Air is supplied by the larger Connersville blower at a pressure of 32 ounces. There are 22 tuyère openings, inside diameter 5′-5″. Further data are given in Table XV, chapter VIII, page 146.

With both furnaces in operation, the works have a capacity of about 20,000 tons per month.

Each furnace is provided with a forehearth of special design, invented by Mr. W. J. Watson. The Watson settler is constructed to provide for a continuous flow of matte as well as slag, to obviate the necessity of tapping at intervals. This is accomplished by an adaptation of the old Orford type of settler, to a water-jacketed receiver of larger size than formerly used (Figure 36 and Plate XLII).

The matte compartment is also placed outside the main settler, making it possible to remove this for repairs without shutting down the furnace, ordinary tapping jackets, one on each side, being provided for use in such an emergency.

The accompanying drawing, from plans supplied by Mr. Watson, makes clear the construction of the settler for the small furnace. The settler proper is 4 feet wide and 12 feet long; the matte compartment is 2

Fig. 34. Copper blast furnace, Tyee Cop

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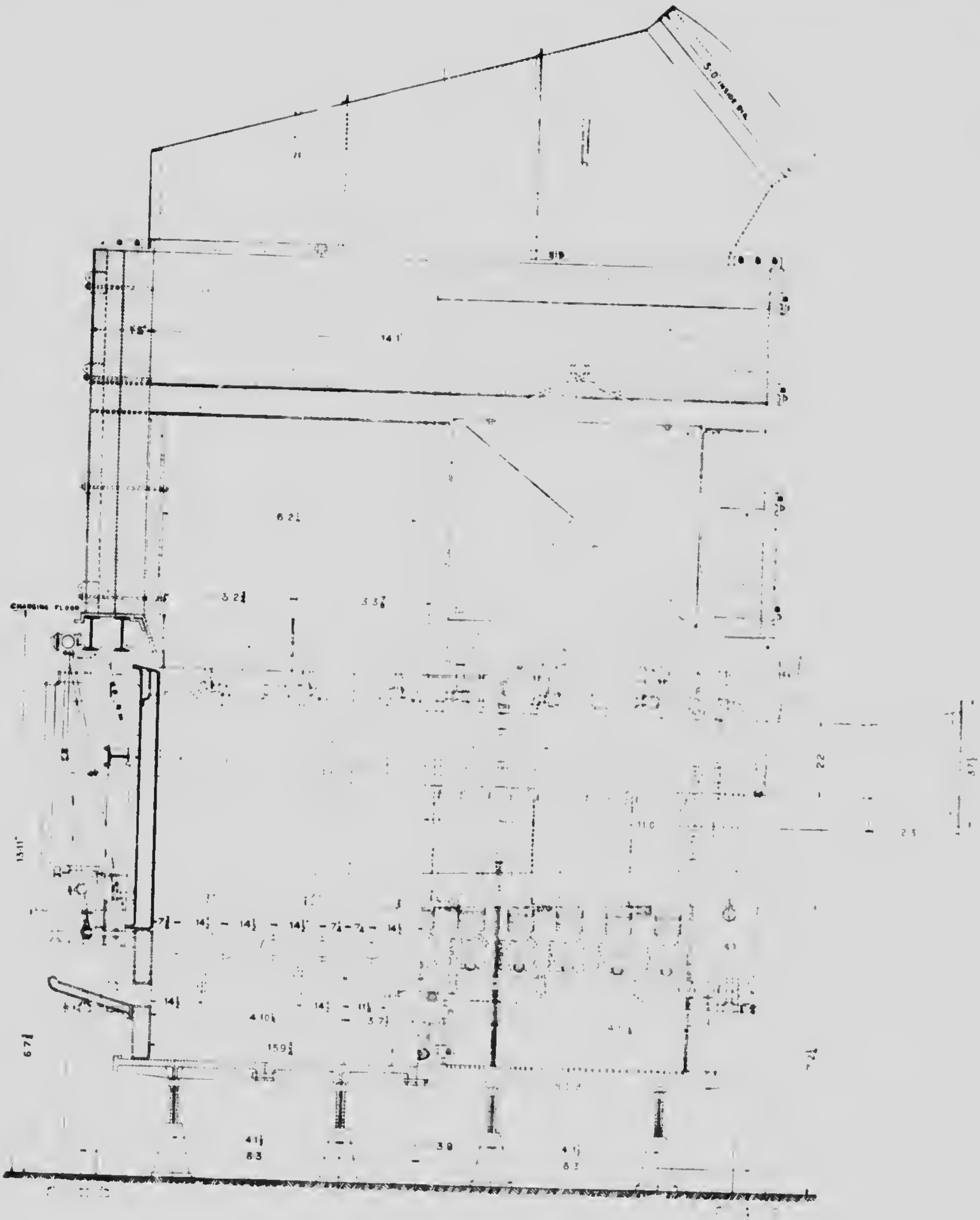

FIG. 34. Copper blast furnace. Tyee Copper Co. Vertical longitudinal section. A. C. Co.

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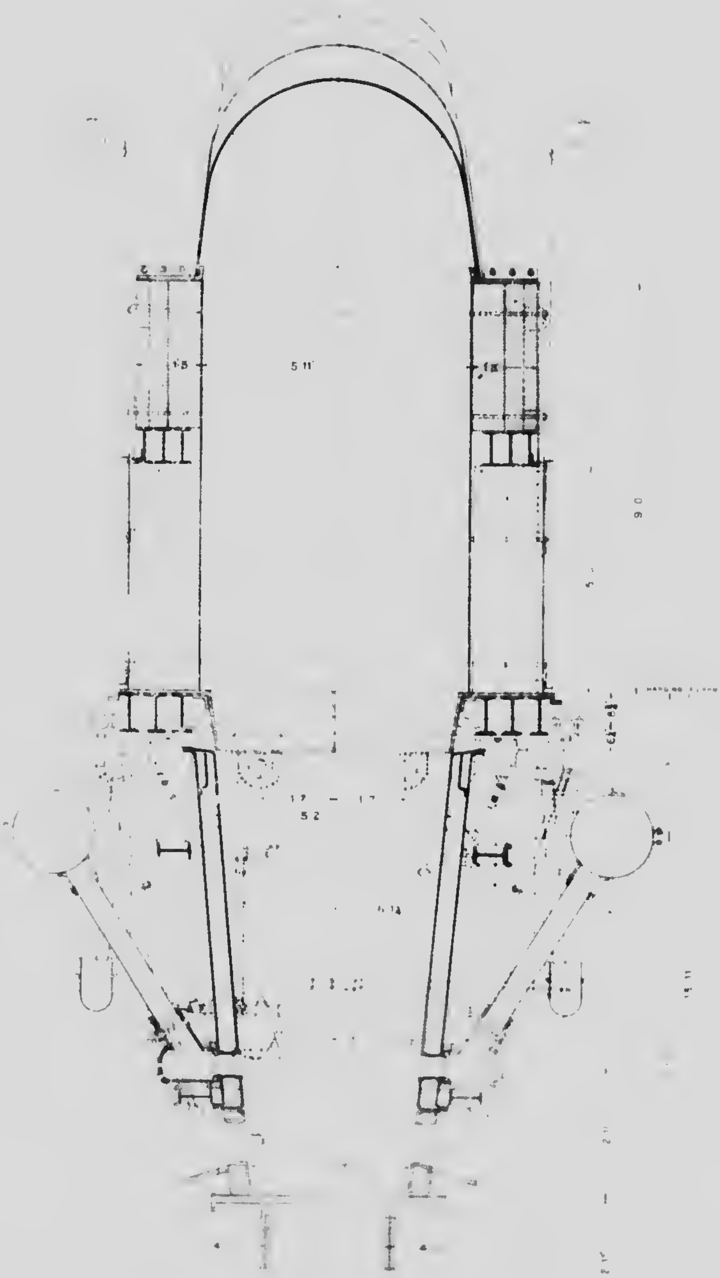
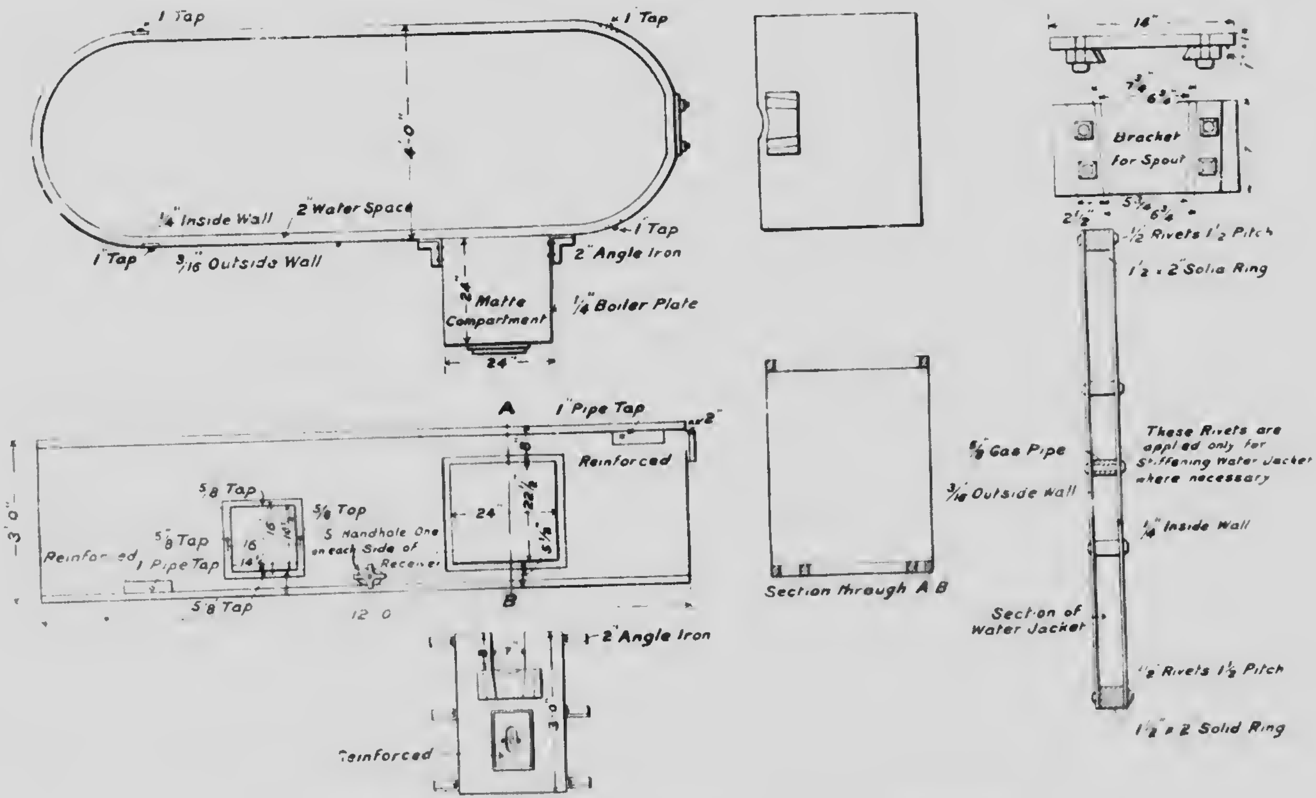


Fig. [illegible] Copper blast furnace, Tye[illegible] Copper Co. Vertical transverse section. [illegible] Co.



Water-jacketed matte separating forehearth, Tyee Copper Co., Ladysmith, B.C.

Settler and slag pots, Ladysmith smeltery, Tyee Copper Co., Ladysmith, B.C.

feet square and is lined with 8″ firebrick. The opening between the settler and the matte pocket is 24″ × 22″, but in operation this space, except for a connecting channel 6″ square, at the bottom, is filled with chrome brick. The level of the matte is controlled by adjusting the height of the slag outlet; to increase the flow of matte a ball of clay is pressed into the slag spout, to reduce it the outlet is opened up. If a sufficient amount of matte is being made, the flow will be continuous; if not, it can be operated at intervals of an hour or so. As far as possible, the depth of matte in the settler is maintained at 10″.

The newer settler for the larger furnace is 6′-2″ in width, 14 feet in length, and 4′-6″ in depth, having a water space of 3″; the fire plate is made of $\frac{3}{8}$″ boiler plate, while $\frac{1}{4}$″ plate is used for the air plate.

It has been found that with this settler a much cleaner slag is obtained; a tapper is not needed on any shift, the element of danger to the men, of being burned when tapping, is removed, and there is a reduction in the wear and tear on the matte pots, since the stream of molten matte does not strike the side of the pot as in the tapping of the ordinary settler.

Another feature of special interest in the construction of the larger furnace is the use of a large cylindrical drum, 12 feet in diameter, made of boiler plate, that is placed above the feed doors of the furnace as a hood. One end of the drum is connected with the dust chamber by a 'goose neck' which leaves the drum at the top. The function of this drum-hood is to return as much of the dust as possible directly to the furnace; the large cross section offered by the drum to the escaping furnace gases momentarily checks their velocity and causes nearly 40% of the dust which they are carrying in suspension to be returned directly to the furnace (Plate XLI, B)

Smelting Practice.[1]—This plant is operated almost wholly on custom ores derived from many sources. As might be expected no uniform system of treatment can be followed for any great length of time, the practice having to be varied to suit varied conditions. The ores received are usually ores of copper chalcopyrite chiefly, bornite or other sulphides occasionally, and more rarely carbonates or oxides. These ores usually carry gold and silver, and sometimes zinc. The gangue matter consists of quartz, iron (as magnetite or pyrite), and some alumina. At one time there was a considerable amount of barium sulphate in the gangue, presenting a very difficult smelting problem that was successfully met by the then Smelter Superintendent, Mr. Thomas Kiddie. Small lots of siliceous gold ores are also received and smelted.

The copper recovery varies considerably but probably averages 80 pounds per ton. The copper losses in the slags are close to 0.3%. The

[1] Consult "Tyee Copper Smelting," E. Jacobs, B.C. Mining Record, 1904, p. 43; Trans. A.I.M.E., Vol. XXXVI, pp. lxxv-lxxxiii, "Smelting Practice of the Tyee Copper Company," Geo. W. Maynard, Eng. and Min. Jour., Vol. LXXXVIII, 1909, pp. 905-908.

slag analysis is very variable, depending on the available stock of ore; during the past year, 1911, the silica ranged between 40 and 46%, while barium oxide, once a prominent constituent, was entirely absent.

The following sets of typical analyses of ore, slags, and mattes, representative of the year 1906, were furnished to Maynard,[1] by Mr. Watson, who took charge of the smelting works in September, 1905.

TABLE XII.

Tyee Ore Analysis.

	No. 1.	No. 2.
Cu.	4·36%	4·39%
Ag.	2·60 oz.	2·85 oz.
Au.	0·13 oz.	0·14 oz.
Fe..	11·70%	10·70%
SiO_2..	13·40%	12·70%
$BaSO_4$	38·60%	42·40%
Zn... ..	8·00%	8·02%

TABLE XIII.

Slag Composition, Tyee Smelter.

From smelting Tyee ore No. 1 with 11% carbonate ore

Cu.	0·33%
Ag.	0·12 oz.
Au..	Trace.
FeO	17·70%
SiO_2..	31·70%
BaO.	28·50%
CaO..	4·9 %
Al_2O_3..	8·2 %
ZnO.	6·40%

[1] *Op cit.*, p. 998. These analyses as quoted here were subsequently revised for the author by Mr. Watson. Some errors in the original publication have been corrected.

Low grade matte, made from a low-grade barytic ore carrying an excess of silica and over 10% zinc, fluxed limestone gave the following analysis: Cu_2S, 33·34%; FeS, 25·45%; BaS, 15·83; ZnS, 23·53%; Sp.G., 4·232. The slag produced while making this matte, analysed: Cu, 0·37%; FeO, 12·21%; SiO_2, 31·57%; BaO, 27·11%; CaO, 11·36%; ZnO, 7·92%; Al_2O_3, 6·75%; specific gravity, 3·487, a difference of 0·745.

At that time, May 1906, the practice was to smelt the Tyee ore, analysis of which is given above, with 11% of a carbonate ore containing Cu, 3·5%; insoluble 80%; Ag, 6 oz.; Au, trace; the coke used made 12·5% of the charge; blast pressure was 29 ounces.

The night matte and slag made from smelting No. 2 Tyee ore with 11% of the siliceous carbonate ore had the following composition: Cu_2S, 50·37%; ZnS, 16·10%; FeS, 29·13%; BaS, 3·58%; and a Sp. G. 4·3816. The flue dust analysis showed: Cu, 3·77%; Fe, 11·77%; SiO_2, 18·56%; $BaSO_4$, 28·30%; CaO, 1·5%; Zn, 6·79%; MgO, trace; S (as sulphides) 5·82%; Ag, 2·71 oz.; Au, 0·14 oz.

The following slag analysis, supplied by Mr. Watson, shows the operating conditions during the year 1910: slag Cu, 0·36%; SiO_2, 36·25%; FeO, 19·26%; Al_2O_3, 10·03%; CaO, 3·47%; MgO, trace; BaO, 23·70%; ZnO, 7·40%; giving a total of 100·48%. The specific gravity of the slag was 3·66, being 0·7246 less than the specific gravity of the slag obtained in former years with Tyee No. 2 ore.

Flue Dust and Fines. About 50% of the charge at the time of my first visit to the plant in 1911 consisted of flue dust and fine ore, including concentrates. The practice was to puddle the flue dust in the water-tight concrete troughs before-mentioned as lying beside the dust chamber, drain it, and feed it to the furnace. In a similar way, fine concentrates from the Britannia mill were passed through an ordinary brick pugging mill and fed to the furnace wet.

The results obtained were very satisfactory. The lumps of fine material apparently become sintered on the outside and bound together before all the water has time to evaporate; the escaping steam would also render these masses porous. The tendency to discharge an undue amount of dust into the chamber and flues is counteracted by the special drum dust-hood over the top of the furnace.

Matte for the year averages 40·13% copper, 26 ounces of silver, and 1·3 ounces of gold. The matte is run into pots and cooled. It is then dumped out, broken with hammers and passed through two sets of jaw crushers, and a single disc sampler, to obtain a sample. The crushed matte is shipped to the smelter at Tacoma, Washington, for further treatment. (Provision has been made to install a converting plant at the works as soon as conditions warrant it.)

The slag is granulated as it leaves the settlers and is sluiced down to the tidal flats on the Company's property at the head of the bay. Water for this purpose is pumped from a reservoir whose bottom lies below high tide level, by a direct connected Westinghouse motor and pump, by the Dolier Engineering Company, Pittsburgh, Pa. The supply of water in the reservoir is renewed every tide by a flume and automatic gate; this gate opens with the rising tide but closes as soon as it begins to ebb, thus impounding a supply of water in the reservoir.

CHAPTER VIII.

MISCELLANEOUS SUMMARIES.

COPPER BLAST FURNACES IN CANADA.

There are 29 rectangular water-jacketed copper blast furnaces in Canada at the present time, the majority of which are in active operation. The total of the hearth areas of these furnaces is 2,580 square feet. The total rated capacity is 15,600 tons of charge per 24 hours, but the actual duty varies considerably at the different plants, chiefly because of the marked differences in the ores treated.

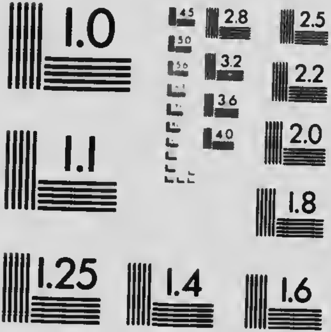
TABLE XIV.

Copper Blast Furnaces in Canada, 1913.

Operating company.	No. of furnaces.	Tuyere dimensions.	Hearth area in square feet.	Ore column, in feet.	Rated capacity (approx'y) in tons of 2,000 lbs.
Canadian Copper Company	5	50″ × 204″	70·83	11	400
	1	50″ × 240″	83·33	11	550
Mond Nickel Company	2	50″ × 240″	83·33	12	550
Consolidated Mining and Smelting Company	1	42″ × 210″	61·25	8	350
	1	42″ × 360″	105·00	8	670
	1	42″ × 264″	77·00	8	460
	1	42″ × 420″	122·50	8	700
	1	50″ × 420″	145·80	8	875
Granby Consolidated Mining and Smelting Co.					
Grand Forks	6	44″ × 266·5″	81·41	12	700
	2	48″ × 260″	86·67	12	550
Anyox	3	50″ × 360″	125·00	12	750
British Columbia Copper Co.	2	51″ × 360″	127·50	12	800
	1	51″ × 240″	85·00	12	500
Tyee Copper Company	1	42″ × 120″	35·00	6	200
	1	48″ × 160″	53·33	6	300

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

There are also several small oval or circular water-jacketed furnaces available, but none of them are in commission on copper ores at the present time.

In addition to the blast furnaces, there are two Steptoe type reverberatory furnaces in use at the plant of the Canadian Copper Company, having a total hearth area of 4,256 square feet.

The principal dimensions of Canadian blast furnaces are exhibited in Table XV, designed after a similar table prepared by H. B. Lowden of Denver, Colo., and published by Dr. Peters.[1] This table includes all the principal furnaces that have been erected in Canada; data with respect to furnaces in a few foreign plants are also included at the end of the table.

COPPER CONVERTING.

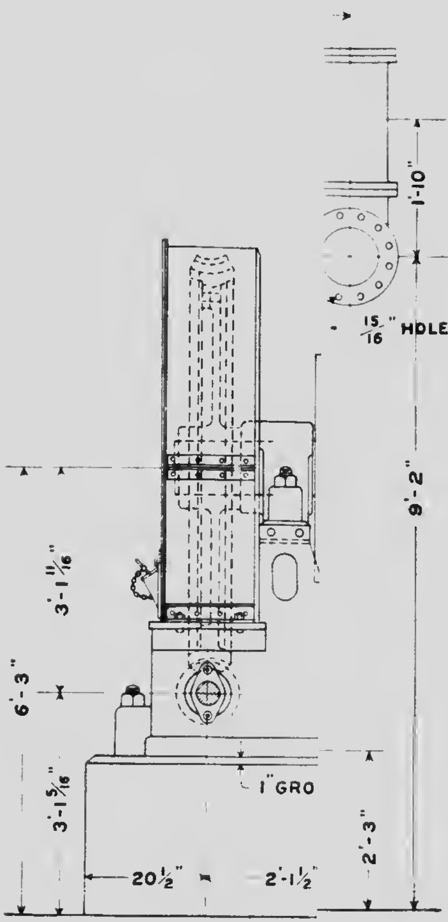
The last five years have seen the development of the basic lined copper converter, and its adoption at nearly all of the important copper producing plants in America. According to the Peirce-Smith Converter Company[2] about 80% of the copper now produced is being converted either in the Peirce-Smith type of converters or on basic lining, under license, in the old acid shells. Within the last two years, a number of plants have adopted the upright form of shell, which is known as the Great Falls type. These latter are now in use in the following plants: Boston and Montana plant of the Anaconda Copper Mining Company at Great Falls, Montana; the Greene-Cananea Consolidated Mining Company, Cananea, Mexico; the Calumet and Arizona Mining Company, and the Copper Queen Company, at Douglas, New Mexico; Arizona Copper Company, Clifton, Arizona; United Verde, Jerome, Arizona; the Anyox plant of the Granby Consolidated Mining and Smelting Company. According to Mathewson,[1] this type of converter is easier to build and to keep in repair, and has become the standard during the past year.

Illustrations of the Peirce-Smith type of shell have been shown in Plates XXII and Figures 13-16. The general appearance of the Great Falls type is shown in Plate XLIII, adapted from an illustration of the Power and Mining Machinery Company. Through the courtesy of the Allis-Chalmers Company, Figures 37, 38, and 39 have been prepared from drawings of a standard basic converter of the Great Falls type. The modified form in use at Anyox has already been illustrated on pages 116 and 117.

The Arizona smelters, and the smelter at Anyox have adopted the size which is 12 feet in diameter; the height of the Arizona converters is 19 feet, while those at Anyox are 17′-7″. A larger shell, 20 feet in diameter, has been developed by the Anaconda Copper Company's experts at Great Falls. This shell weighs 65 tons, exclusive of the bearings, and has a capacity of about 50 tons. It is reported to have been proven very satisfactory in operation.

[1] Practice of Copper Smelting, p. 146.

[2] Eng. and Min. Jour., Vol. 94, p. 48, 1912.



35783 - p. 146.

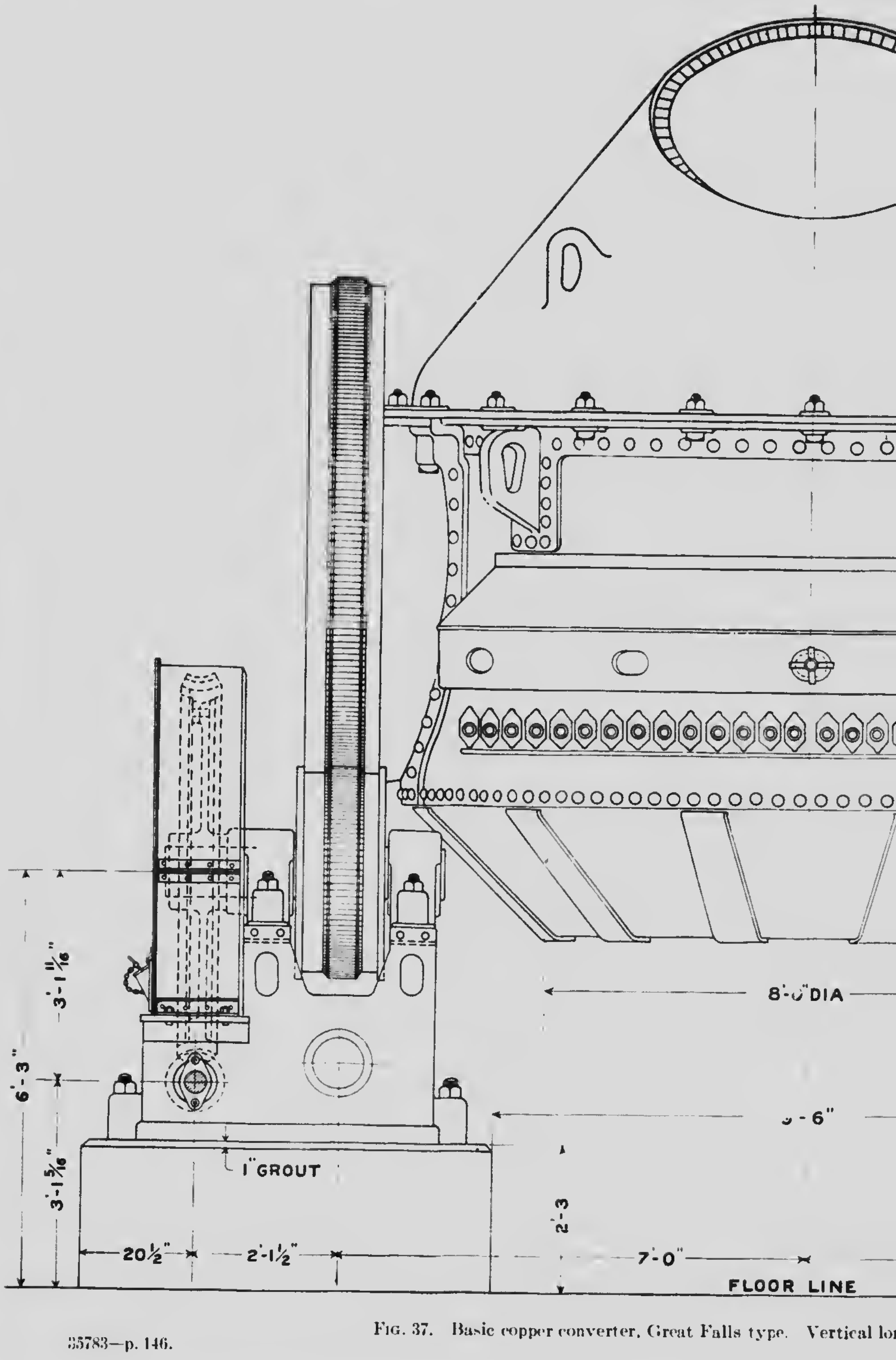


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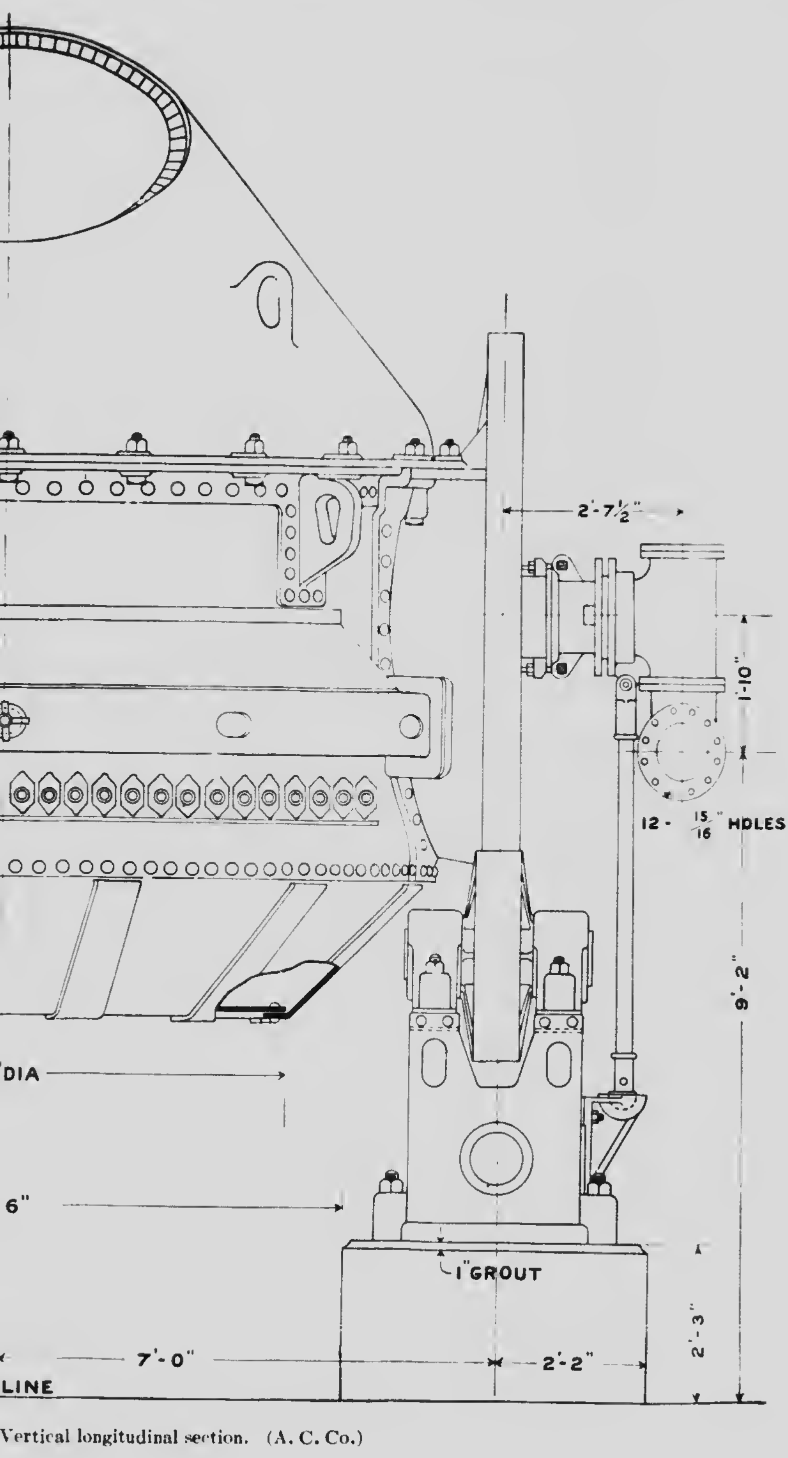
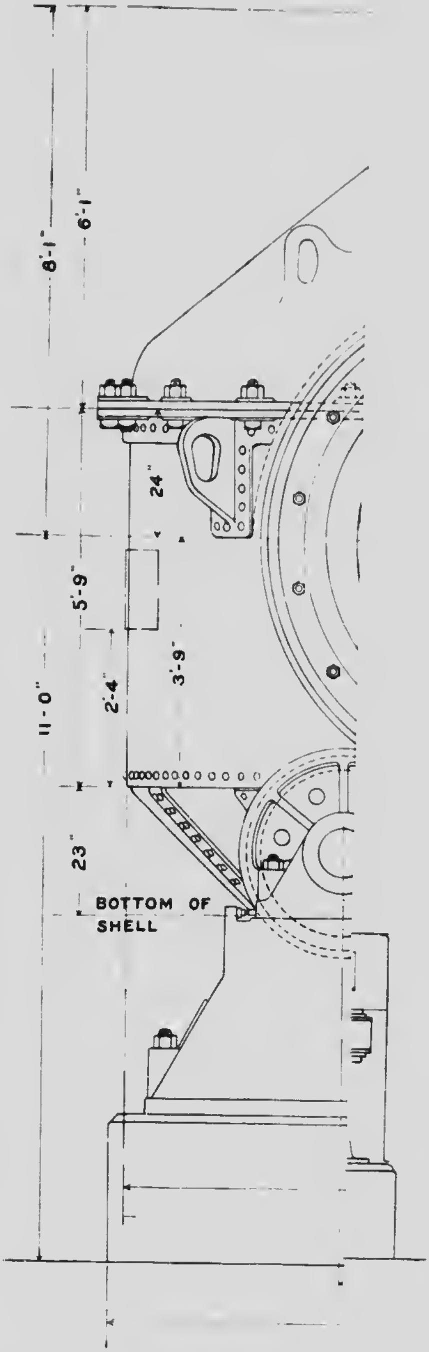
FIG. 37. Basic copper converter, Great Falls type. Vertical lo



Vertical longitudinal section. (A. C. Co.)


8'-1"
6'-1"
24"
5'-9"
3'-9"
2'-4"
11'-0"
23"
BOTTOM OF SHELL

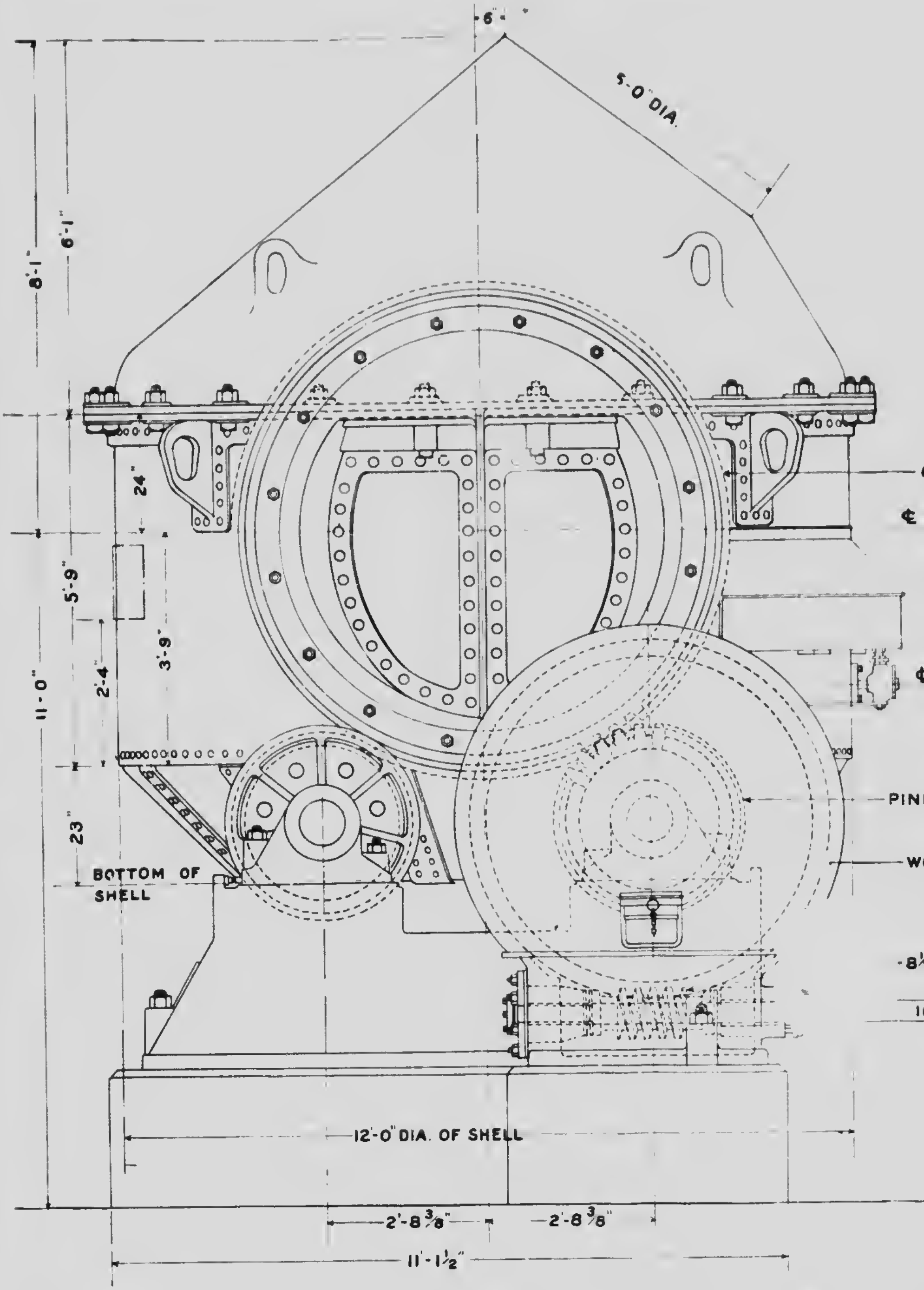
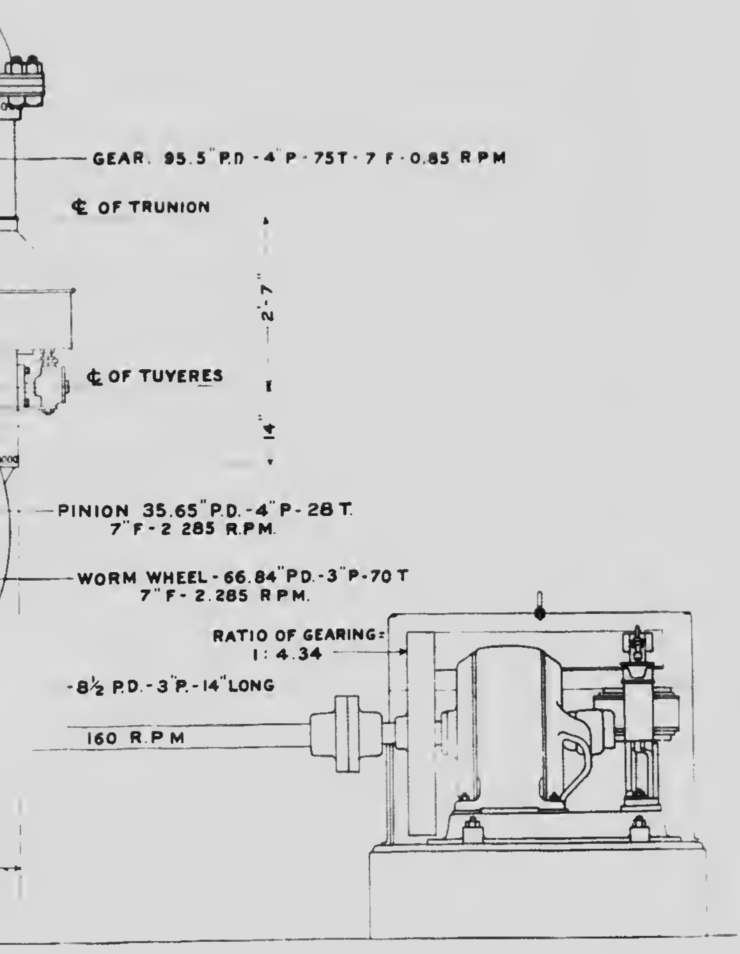


FIG. 38. Basic copper converter, Great Falls type. Vertic

35783—p. 146.



...ype. Vertical transverse section (A.C.Co.)

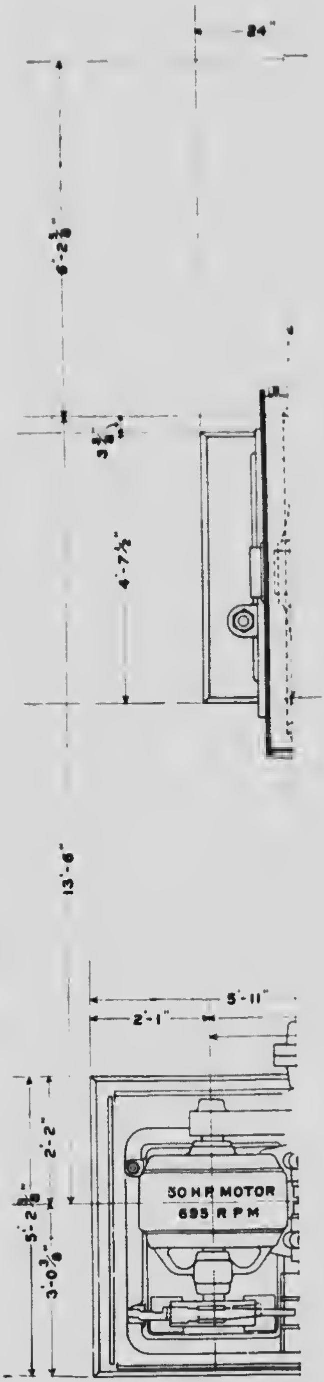


Fig. 31

35783—p. 146.

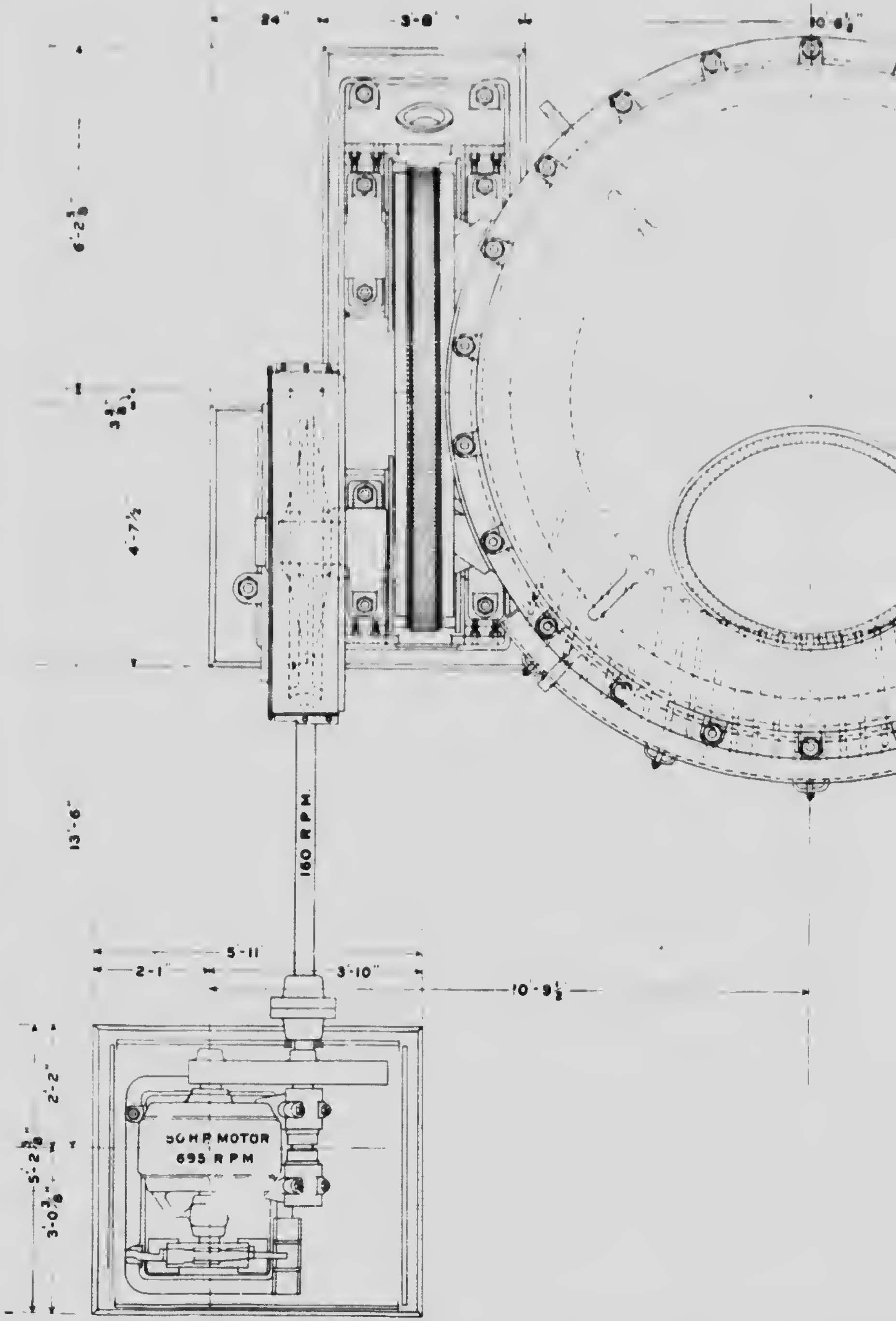
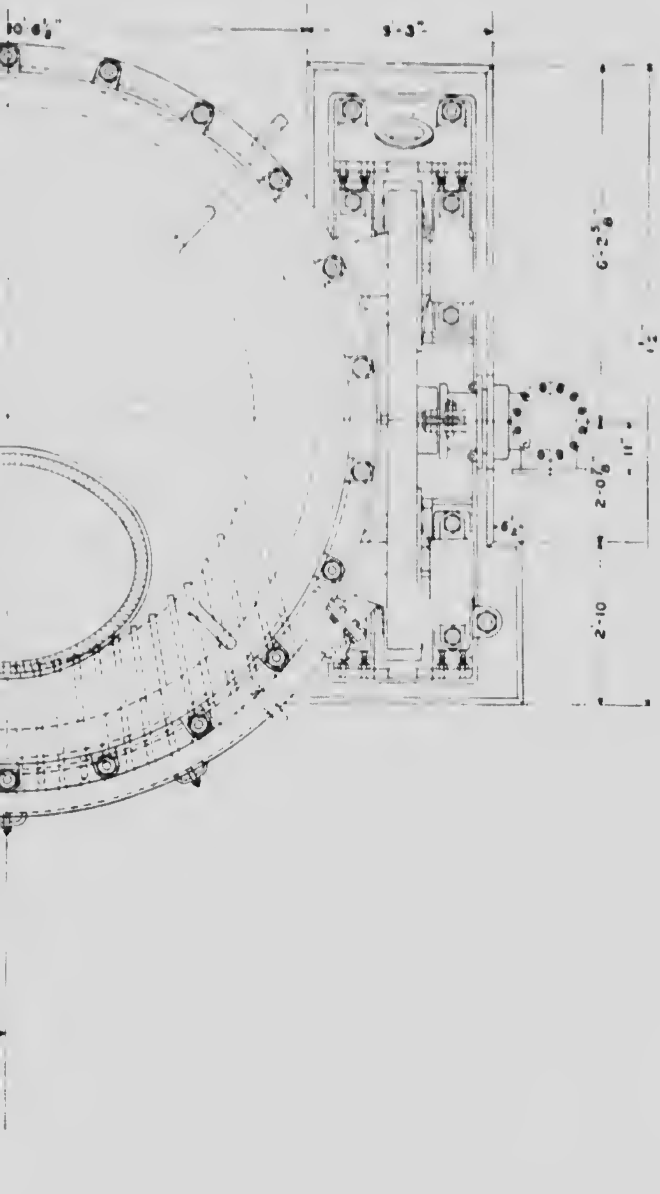


FIG. 39. Basic copper converter, Great Falls type. Section on wind box show



d box showing arrangement of tuyères. (A. C. Co.)

Width o lower sid jacket.
....
....
....
....
60″
....
40″
40″
....
....
....
....
60″
....
60″
30″
....
....
52″
53″
54″
25·5″ [7]
....

Width of lower side jacket.	Number and diameter of tuyères.	Centre to centre of tuyères.	Total area of tuyères in sq. inches.	Sq. inch tuyère opening per sq. foot hearth area.	Width of water space.	Plate used. Inside, lower, upper.	Plate used. Outside, lower, upper.	Available ore column.
....	....	....	....	....	....	....	....	....
....	12, 3″	16·6″	84·86	2·91	....	....	....	....
....	16, 4·75″	18″	282·21	6·41	....	....	....	....
....	14, 6″	....	396	12·50	....	....	....	....
60″	10, 4″	12″	125·7	8·38	....	....	....	....
....	20, 3·5″	15″	192·5	4·40	....	....	....	....
40″	48, 4″	12·25 9·25[4]	603·19	7·54	4″	$\frac{5}{8}$″ $\frac{1}{2}$″	$\frac{5}{8}$″, $\frac{1}{2}$″	12
40″	72, 4″	12·25 9·25[4]	904·8	7·09	......4″	....	....	12
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	6
....	50	....	....	....	....	....	....	10
....	....	....	....	....	....	....	....	8
60″	40, 4″[5]	15″	502·8	5·75	4·25″, 3·375″	$\frac{3}{8}$″	$\frac{1}{4}$″	8
....	....	....	....	....	....	....	....	8
60″	56, 4″	15″	704	5·75	....	....	....	8
30″	56, 4″	15″	704	4·83	....	....	....	8
....	5″	17·75″	....	....	....	....	....	9
....	3·5″	8·625″	....	....	....	....	....	9
52″	60, 3·5″	8·625″	577·2	6·66	3·4125, 4·875″	$\frac{7}{16}$″	$\frac{3}{8}$″	13
53″	30, 4·5″	17·75″	589·0	7·23	3·4125, 4·875″	$\frac{7}{16}$″	$\frac{3}{8}$″	13
54″	66, 4″	10·8″	829·71	6·64	5″	....	....	13
25·5″[7]	28, 4″	12·75″	351·85	4·97	4·8″, 1·25″pipe.	$\frac{1}{2}$″	$\frac{3}{8}$″	14
....	....	....						

Principal Dimen

Company.	Location at works.	Date.	Size in inches at tuyères.	Hearth area in sq. feet.	Centres of tuyères to feed floor.	Centres of tuyères to tapping floor.	H j
Labourers' Co-operative G.S. and C. Mining Co.	Golden, B.C.	1890	38″ × 78″	20·58	.....		
Hall Mines, Limited	Nelson, B.C.	1895	42″ × 100″	29·16	13′-4″	3′-8″	lov
		1896	44″ × 144″	44	12′-6″	4′-6″	lov
British Columbia Smelting and Refining Co.	Trail, B.C.	1896	38″ × 120″	31·66	9′-0″ (?)	5′-0″(?	lo
Copper Crown Mining Company[2]	Pictou, N.S.	1900	36″ × 60″	15·00	8′-9″	5′-2″	1(
British Columbia Copper Company	Greenwood, B.C.	1900	42″ × 150″	43·75	.....	.....	.....
		1907	51″ × 240″	85	15′-0″[3]	5′-0″	1(
			51″ × 360″	127·5	15′-0″[3]	5′-0″	1(
Northwestern Smelting and Refining Co.	Crofton, B.C.	1901	44″ × 160″	48·89	.....	.....	.....
Standard Pyritic Smelting Company	Boundary Falls, B.C.	1901	40″ × 176″	48·89	.....	.....	.....
New Dominion Copper Company	Boundary Falls, B.C.	1907	46″ × 255″	81·61	.....	.....	.....
Canada Consolidated Mining and Smelting Co.	Trail, B.C.	1902	42″ × 120″	35	.....	.....	.....
			42″ × 300″	87·50	8′-6″	5′-6″	90
			42″ × 264″	77·00	.....	.....	.....
		1913	42″ × 420″	122·50	8′-6″	5′-6″	90
		1913	50″ × 420″	145·80	8′-6″	5′-6″	90
Granby Consolidated Mining and Smelting Co.	Grand Forks, B.C.	1899	44″ × 160″	.....	.....	.....	.....
		1905	48″ × 213″	.....	.....	.....	.....
		1909	48″ × 260″	86·66	12′-10″	5′-2″	9(
		1909	44″ × 266·5	81·41	12′-10″	5′-2′	9(
	Anyox, B.C.	1913	50″ × 360″	125	18′-4″[6]	8′-0″	12(
Canadian Copper Company	Copper Cliff, Ont.	.....	50″ × 204″	70·83	14′-10·5″	10′-3″	55″[7]-
		1912	50″ × 240″	83·33	14′-10·5″	.....	.....
Tyee Copper Company	Ladysmith, B.C.	.....	42″ × 120″	35	8′-2″	5′-8″	
			48″ × 160″	53·33	8′-2″	5′-8″	
Mond Nickel Company	Victoria Mines, Ont.	1908	44″ × 120″	36·67	.....	.....	.....
		1908	44″ × 180″	55	.....	.....	.....
	Coniston, Ont.	1913	50″ × 240″	83·33	16′-11″	7′-3·5″	low
Cananea Consolidated Copper Co.[2]	Cananea, Mex.	1908	48″ × 210″	70·00	10′-4·5″		150
Mammoth Copper Mining Company	Kennet, Cal.	1908	50″ × 180″	62·5	14′-9″	5′-3″	.....
Tacoma Smelting Company	Tacoma, Wash.	.....	42″ × 160″	46·67	8′-11″	8′-10″	96″
Anaconda Copper Mining Co.[2] 87 ft. Washoe furnace.	Anaconda, Montana	1906	56″ × 1044″	406	19′-0	7′-9	90

1. The practice was to use thimbles to reduce the diameter of the tuyère opening.
2. After Peters.
3. But only 13 feet to top of jacket.
4. The first figure is between two jackets, the second in same jacket.
5. Plate opening 6″, a thimble with 4″ opening is used.
6. To top of jackets, 13′-2″.
7. The lower and
8. There are two
9. Middle lower j
10. Middle lower ja
11. Two tuyères at
12. Lower part up

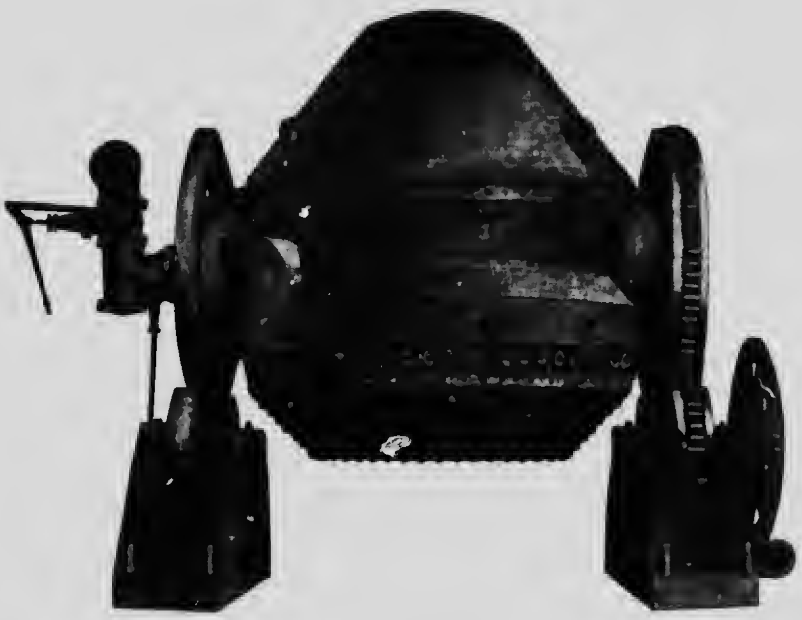
TABLE XV.

Dimensions of Canadian Copper Blast Furnaces.

...s of ...s to ...ng	Height of jackets in inches.	Centres of tuyères to lower line of bosh, in inches.	Centres of tuyères to upper line of bosh, in inches.	Centres of tuyères to lower edge of jacket.	Bosh, in inches.	Width of lower side jacket.	Number and diameter of tuyères.	Centre to centre of tuyères.	Total area of tuyères in sq. inches.	Sq. inch tuyère opening per sq. foot hearth area.	Width of water space.	Plate used. Inside, lower, upper.	Plate used. Outside, lower, upper.	Available ore column.
	2 tiers													
'	lower 4'-6"						12, 3"	16·6"	84·86	2·91				
'	lower 5'-6"				10"		16, 4·75"	18"	282·21	6·41				
'(?	lower 5'-6"						14, 6"		396	12·50				
	108 + 27	6"	70"	30·5"	6"	60"	10, 4"	12"	125·7	8·38				
							20, 3·5"	15"	192·5	4·40				
	108 + 72	stra ight		36"	1"-3·5"	40"	48, 4"	12·25 9·25[4]	603·19	7·54	4"	5/8" 1/2"	5/8", 1/2"	12
	108 + 72	stra ight		36"	1"-3·5"	40"	72, 4"	12·25 9·25[4]	904·8	7·09	4"			12
														6
							50							10
														8
	90" + 37"	10"	56"	34"	10"	60"	40, 4"[5]	15"	502·8	5·75	4·25", 3·375"	3/8"	1/4"	8
	90" + 37"	10"	56"	34"	10"	60"	56, 4"	15"	704	5·75				8
	90" + 37"	10"	56"	34"	10"	30"	56, 4"	15"	704	4·83				8
														8
							5"	17·75"						9
							3·5"	8·625"						9
	90" + 94"	22"	56"	32"	12"	52"	60, 3·5"	8·625"	577·2	6·66	3·4125, 4·875"	7/16"	3/8"	13
	90" + 94"	22"	56"	32"	12"	53"	30, 4·5"	17·75"	589·0	7·23	3·4125, 4·875"	7/16"	3/8"	13
	126' + 80"	stra ight		48"	11"	54"	66, 4"	10·8"	829·71	6·64	5"			13
	55"[7] + 48"[7] + 76	stra ight		46"		25·5"[7]	28,[8] 4"	12·75"	351·85	4·97	4·8", 1·25" pipe.	1/2"	3/8"	14
														14
	117"	20"	83"	34"	11"	Note [9]	14, 5·5"	17"	332·75	9·51	4"	7/16"	5/16"	6
	117"	20"	83"	34"	10"	Note [10]	22, 5·5"	14·5"	522·89	9·08	4"	7/16"	5/16"	6
						60"	20, 4"	12"						8
						60"	24[11], 4"	12"	301·71	5·49				8
	lower 8'-2"	7·5"	90"	9"	9·5"	30"	32, 4"	15"	402·28	4·82	4·5"			13
	150·75"	straight	115"	36"	9"		36, 4·75"	11·67"	637·9	9·11				8
			124"	42"	3·25"	30"	34, 3·625"	10"	304·17	4·87		5/8"	3/8"	
	96" + 30	10"	116"	34"	10"	43" 58·54"	22, 4"	14·5"	276·6	5·92	4"[12]	5-16"	1/4"	
	90" + 90"	straight	78"	11 and 17	8"	84" and 90"	150, 4"	12 to 14	1885·0	12·57				

...lower and middle jackets are special cast iron jackets, 2 lower and 2 middle replacing one jacket 103" × 51". The upper jacket is an ordinary plate jacket 76" × 51".
...e are two openings in each tuyère jacket, and 8 jackets on a side, the two end tuyères are not used.
...lle lower jacket 51" wide, one on each side of this 34·5".
...lle lower jacket 43·5", one on each side of this 58".
...tuyères at each end not used.
...er part up to bosh 4", above bosh tapers to 6", upper jackets all have 2·5" water space.

PLATE XLIII.



Vertical copper converter, Great Falls type (P. and M. M. Co.)

TABLE XVI.

Copper Converters in Canada, 1913.

Operating company.			Stands.	Shells.	Dimensions.
Canadian Copper Company	Basic..	Peirce-Smith, special..	5	5	10'-0"×37'-2"
Mond Nickel Company...	Basic..	Peirce-Smith, standard....	2	2	10'-0"×25'-10"
Granby Consolidated Mining and Smelting Company[1] Grand Forks..	Basic..	Power and Mining Machinery Co., Acid shells.....	3	10	84"×126"
Anyox........	Basic..	Great Falls type..	3	3	12'-0"×5'-9"
British Columbia Copper Co	Acid..	Allis-Chalmers....	2	5	84"×126"

Five out of seven copper smelting plants in Canada are equipped with copper converters. The converter equipment of Canadian plants has already been described, in connexion with the descriptions of the individual plants given in the preceding pages.

SMELTING CENTRES IN EASTERN CANADA.

At the present time, there are no copper smelters in operation in Canada east of Coniston, Ontario. As has been shown in the historical review in the introductory chapter of this report, small matting furnaces have from time to time been erected at several eastern points, and on one occasion a plant was equipped with a large rectangular water-jacketed furnace. Few of these attempts at operation appear to have been commercially successful for any length of time, with the exception of some of the plants in the Eastern Townships of Quebec. These latter were successfully operated for some years when the market price of copper was high, but at the present time, while Quebec's copper ore production is the largest in its history, all the ore is exported. The lack of success which appears to

[1] "Development of the Basic-Lined Converter for Copper Mattes," E. P. Mathewson, Bulletin Amer. Inst. Min. Eng., June, 1913, p. 1033.

have attended these various attempts at copper smelting was, doubtless, due in individual instances to a number of contributory causes, but in every case the prime factor has been the lack of a supply of suitable ores. Very few ore deposits of commercial size have been discovered in eastern Canada. Those which have been available were worked at different times and by independent operators, who did not find it to their advantage to co-operate to found a single smelting industry.

The question of the establishment of smelting industries at some point in the Eastern Townships of Quebec and at some point in eastern Nova Scotia has frequently arisen, and proposals with this end in view have, on several occasions, been brought forward. For this reason it has been thought desirable to review the present situation with respect to each of these localities.

Eastern Townships, Quebec.—During the year 1912, the production of sulphur-copper ores was about 200 tons per day. Towards the close of the year, this average output was very materially exceeded, and at the present time the output is probably in excess of 350 tons per day. These ores contain about 40% recoverable sulphur (42%-48% assay) and 2·6% copper on the average (1·5%-5%, occasionally higher). They also contain small amounts of gold and silver. A portion of the ore is used for the manufacture of sulphuric acid in Canada, the cinder being subsequently shipped to a United States smelter for recovery of the copper, gold, and silver. So far as I am aware, the iron is not recovered, being used for matting and slagging. The greater part of the Quebec ores is shipped directly to the United States, where most of the sulphur is recovered, as well as the metals, except the iron.

In addition to the producing mines, there are, in the Eastern Townships of Quebec, particularly within a radius of about 50 miles from the city of Sherbrooke, a great many points from which small quantities of copper ores were obtained many years ago. The majority of these prospects are probably not of much value, but most of the work has been so unsystematic that further careful prospecting is, in the opinion of the writer, desirable in some cases. No experience or learning can enable any one to predict success or failure at every point, though a qualified expert, through previous training, may be able to exclude certain localities as lacking in indications which warrant exploration. With regard to all others, he must classify them, either as doubtful or promising. Only actual exploration will enable one to reach a final decision as to the occurrence or non-occurrence of a workable deposit.

The establishment of a smelting industry in the Eastern Townships is seriously handicapped by the distribution of ownership of mining properties, and the lack of co-operation among the owners. At present, the ownership of the two producing mines is in the hands of separate and independent operators, both of whom appear to be able to market all their product.

No doubt, if they could, by co-operation, dispose of their product at a higher profit in a nearer market, they would be willing to do so when existing contracts are fulfilled.

The ownership of the non-producing properties, most of which fall into the class of prospects, is widely distributed.

If the various interests of the different owners could be satisfactorily adjusted, so that it would be possible to unite them and form a single organization, it appears to the writer that there is, in Quebec, the basis for an important industrial development along certain lines of chemical manufacture. It does not lie within the province of this report to consider the various problems that would arise in preparing for the formation of such an organization, but, assuming that this unification of interests is possible, the writer wishes to point out certain of the possibilities which appear to him to be within the limits of practical attainment by a united corporation, but which can scarcely be realized by an individual.

The situation as it stands at present may be summed up in a few words. There are two well developed properties which are said to have a two years supply of ore already developed, and additional reserves, which come within the classification of probable ore. There are also a number of good prospects, concerning whose productive capacity little is known. It is, therefore, certain that about 400 tons of ore per day for a period of two years could be assured; beyond this, further exploration is first needed to increase the known ore reserves.

Assuming that systematic preliminary investigation shows ore reserves which would warrant the establishment of a series of industries based on this daily output of 400 tons, the possibilities in this direction may be considered.

The average content of the ore, for purposes of discussion, may be assumed to be 40% of recoverable sulphur, 2% of copper, and 58% of residues, which contain about one dollar's worth of gold and silver per ton of ore. A daily output of 400 tons of ore would then represent an available sulphur supply of 160 tons of sulphur, 8 tons of copper, $400 worth of gold and silver, and cinder residues, which might or might not be an asset. If the copper and precious metals are recovered by a smelting process the cinder residues will pass into slag and will be lost, unless the slag itself can be utilized. If the copper, and precious metals are recovered by a leaching process, the iron residues will be available. These residues might be used in an iron blast furnace, provided there are any in operation in the district, or they can be used for the manufacture of paints.

The utilization of the sulphur is a special problem. The supply available in these ores is much in excess of the supply required by sulphuric acid works now established in the Province. It is probable that there is room for some expansion, but it is very doubtful if there will be a very much larger market for acid for some time to come. The only other outlet for a large supply of sulphur is the sulphite pulp industry. There are a number of large plants now in operation in Quebec, and several others are also under construction. At present these plants purchase foreign sulphur; they could obtain the requisite sulphur dioxide from native ores, if they installed suitable roasting plants. There is, however, another alternative.

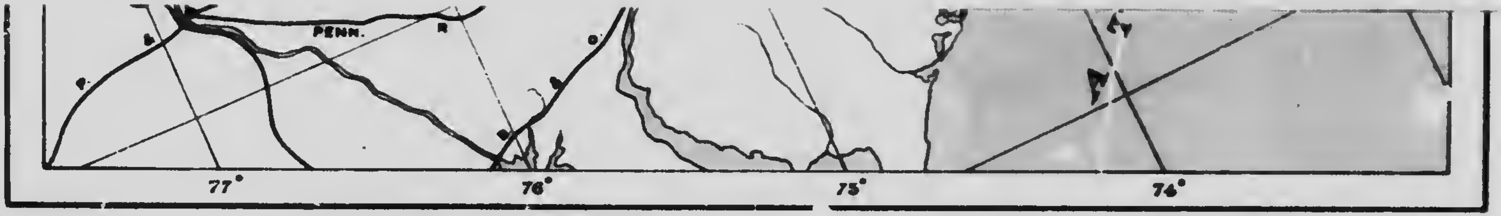
Experimental investigations extending over several years have resulted in the development of the Thiogen process for the recovery of sulphur from sulphur dioxide, and a commercial plant is under construction at the time of writing.[1] No data are available as to costs, but it is understood that they are very moderate. It will be a matter for investigation and experiment to determine if this process could be utilized to recover sulphur from the Quebec ores *at a profit*. If so, the home market for the sulphur content of these ores is sufficiently broad to utilize all that may be produced from an output of 400 tons of 40% ore per day.

The Thiogen process is designed to recover the sulphur from sulphur dioxide gas, the separation being obtained in specially designed chambers through the agency of some hydrocarbon gas, and in the presence of calcium sulphide. The sulphur in the Quebec ores could be converted into sulphur dioxide either by direct roasting, or during the progress of smelting operations; in the latter event, the gas produced would be weaker, and the mechanical losses would be greater, but much of the sulphur could be recovered by the above, or some similar process. The hydrocarbon gas could be obtained from fuel oil, from a gas producer plant, or from a by-product coke-oven plant. The calcium sulphide is made during the operation of the process, the raw material used being gypsum in the form of plaster of Paris, or a pure limestone could be used.

Were smelting operations undertaken, there are two sources of fuel: eastern Canada and Pennsylvania. The location of Sherbrooke, the centre of the district, with respect to the St. Lawrence River route, and the railway lines leading to the Atlantic sea-board, and to the Pennsylvania coal-fields, is shown on Map Number 212. The haulage distance for Pennsylvania coke will vary with the location of the source of supply, and will be nearly 500 miles. No data with respect to rates or to relative costs of Nova Scotia coke and Pennsylvania coke have been obtained. The question of suitable fuel supply is not, however, a very difficult problem. If pyritic smelting is adopted, only a very small coke supply would be required.

Another alternative, however, suggests itself, namely, the manufacture of by-product coke somewhere in the vicinity of Montreal, from Nova Scotia soft coal, brought to the works in barges, a very cheap and efficient means of transportation. The city of Montreal appears to offer a good market for fuel gas. There would also be the opportunity of establishing chemical works in connexion with the by-product coke-ovens, and the

[1] The Thiogen Company, 260 California St., San Francisco.



No. 212

EASTERN TOWNSHIPS, QUEBEC, AS A POSSIBLE SMELTING CENTRE

35 Miles to 1 Inch

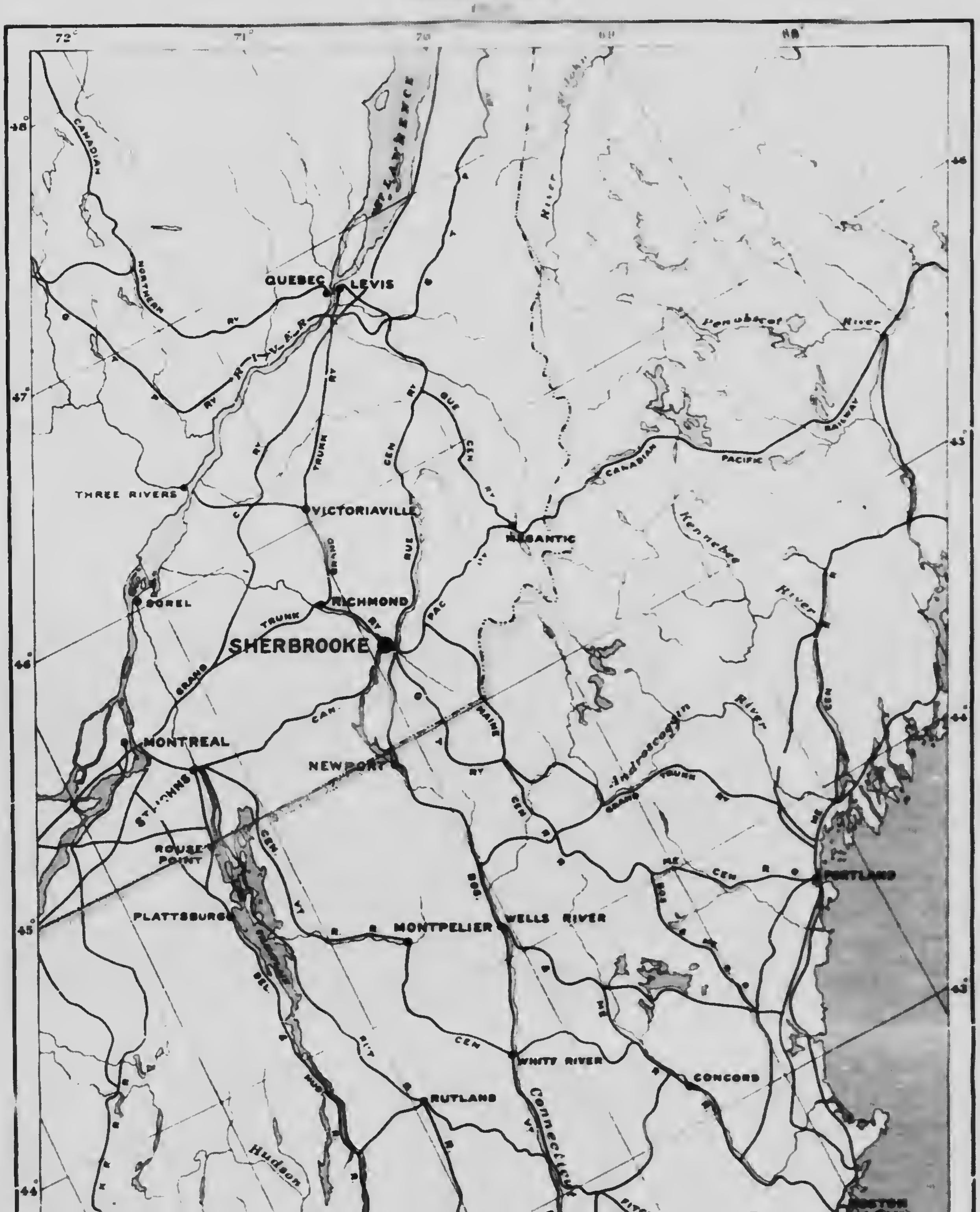
TABLE OF MILEAGE
FROM SHERBROOKE, QUEBEC, TO

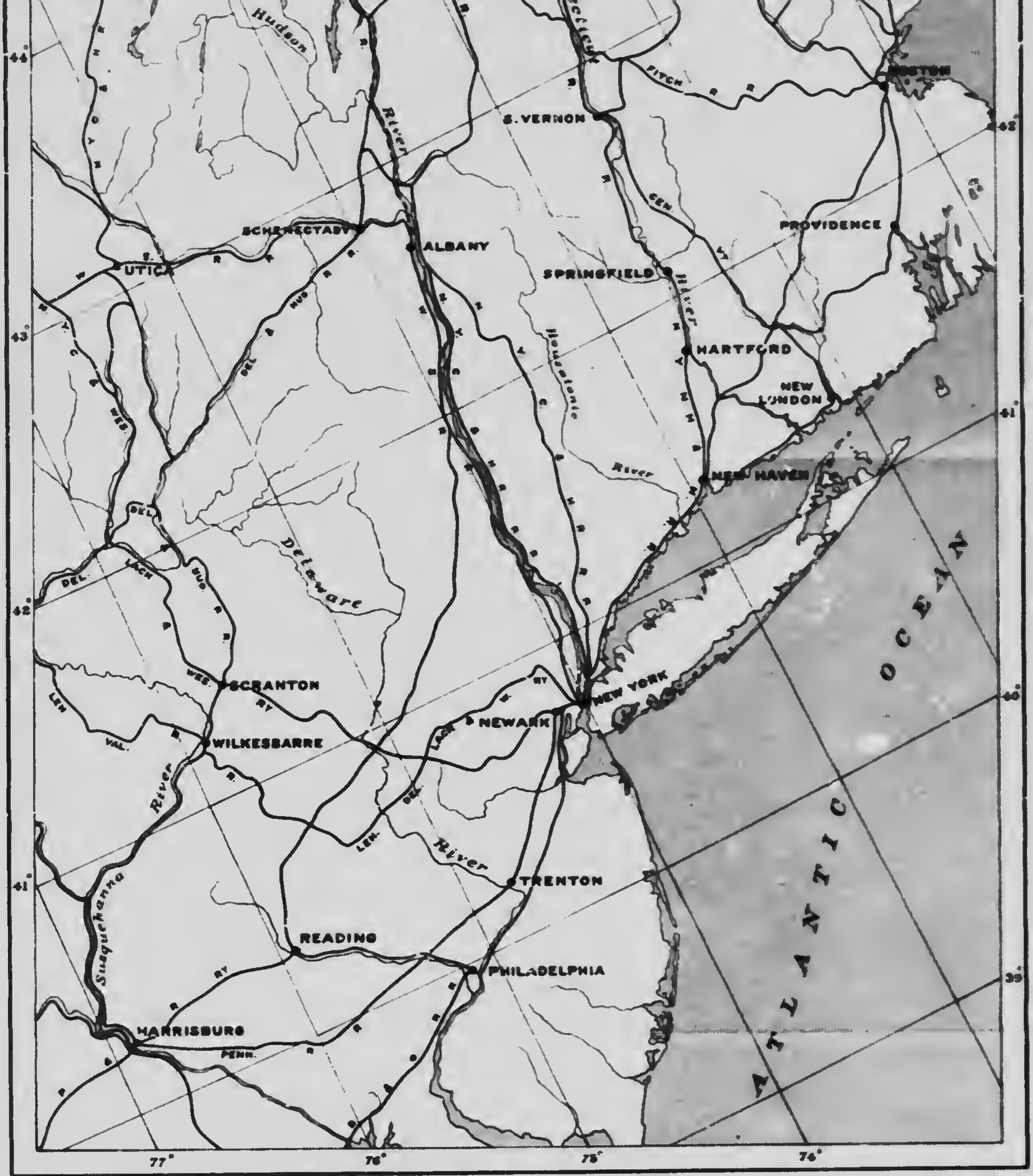
MONTREAL	100	NEW YORK	406
THREE RIVERS	82	SCRANTON	451
LEVIS	143	WILKESBARRE	470
PORTLAND	196	HARRISBURG	588
BOSTON	293	CONNELLSVILLE	827

CANADA

DEPARTMENT OF MINES

MINES BRANCH





№ 212

EASTERN TOWNSHIPS, QUEBEC, AS A POSSIBLE SMELTING CENTRE

35 Miles to 1 Inch

TABLE OF MILEAGE
FROM SHERBROOKE, QUEBEC, TO

MONTREAL	100	NEW YORK	406
THREE RIVERS	92	SCRANTON	461
LEVIS	143	WILKESBARRE	470
PORTLAND	196	HARRISBURG	588
BOSTON	293	CONNELLSVILLE	827

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smelting works. Also, a portion of the gas could be utilized to recover the sulphur from the sulphur dioxide gases from the smeltery. It is now a well known fact, that the value of the by-products from a coking plant is practically sufficient to meet all the costs, including both operating and all overhead charges, and the coke produced is practically so much extra profit. It might also be noted that, according to a recent bulletin issued by the United States Geological Survey, by-product ovens in the United States are selling from 40 to 50 million cubic feet of gas a day for illuminating and domestic purposes. Almost the entire supply of gas in some cities is derived from by-product ovens: among the list of cities so supplied, we find Boston, Mass.; Camden, N.J.; Indianapolis, Ind.; Baltimore, Md.; Duluth, Minn.; South Chicago, Ill.; and Milwaukee, Wis.

Any excess of coke produced in such an establishment, above that required in the smeltery, could be easily marketed, since coke is being used as a substitute for hard coal for various domestic uses in many cities and towns of the Province.

The best location for a group of industries such as has been suggested in the foregoing paragraphs can only be determined by a close study of the ground, and a comparison of freight rates and markets. Were a smeltery only to be established, the natural location would be in the vicinity of the mines, and, therefore, not far from Sherbrooke. The surrounding country is largely given over to agriculture, which would require that the smelter fumes be reduced to a minimum. This fact alone would necessitate the introduction of methods to prevent the escape of sulphur dioxide gas in quantity, quite apart from the fact of the value of the gas or the sulphur which it contains. Since the recovery of this portion of the ores most economically implies the development of allied industries, these also have to be taken into account in selecting a location.

The successful operation of a group of industries, which would be developed through the establishment of a plant to recover the various valuable constituents of the Quebec ores, means the centralization of the works. It also implies their location at the point most advantageous for assembling the raw materials, and for the distribution of the various manufactured products. The relatively low freight rates on the St. Lawrence would suggest the desirability of locating at some point close to navigable water, and also convenient for rail connexion. The possibility of disposing of the surplus gas and other products of the by-product coke ovens in a centre of large population would appear to indicate that some site near Montreal would be the most desirable. At such a point, Nova Scotia coal for use in the by-product plant could be delivered easily and cheaply during the summer months; the ores from the various mines in different parts of the Province could be assembled at the smeltery by rail; the surplus gas, not required in the works for power or other purposes, could be sent to Montreal by pipe line, and the location on tide water would also facilitate the shipment of the other products of the works to various points on the St. Lawrence, to Boston or New York, or to European points.

The substance of the suggestions in the foregoing paragraphs may be briefly summarized as follows: –

(1.) The present outlook in the copper-sulphur mining industry of the Eastern Townships of Quebec is such that the question of a unification of the various interests for mutual support and benefit appears worthy of consideration.

(2.) Assuming a consolidation of interests, there appears to be material for the foundation of a series of new industries, based on the products of these copper-sulphur producing mines.

(3.) The establishment of an allied industry to produce either gas or coke, or both, would be necessary to facilitate the economical recovery of all the valuable constituents in these Quebec ores.

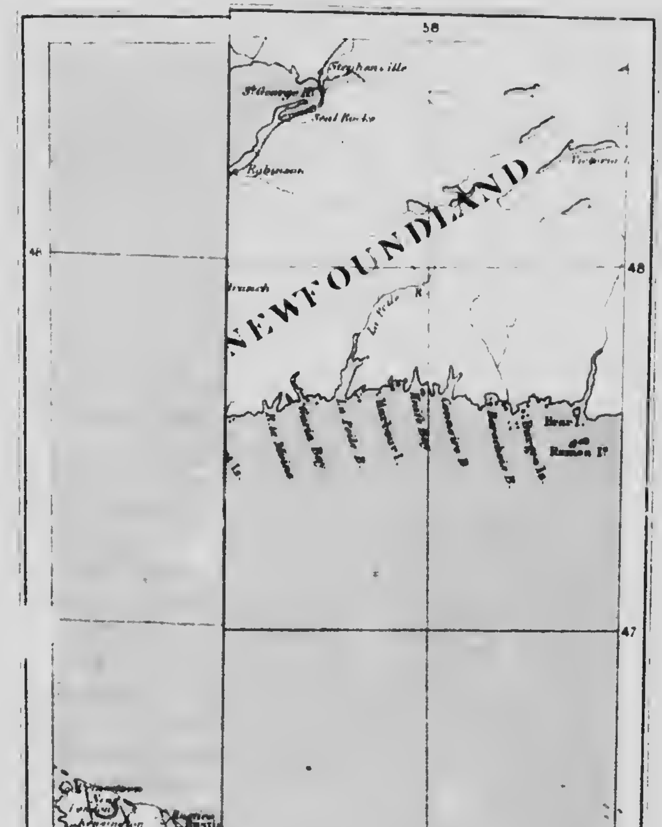
(4.) The products of the auxiliary establishment would in themselves be a source of profit.

(5.) The various products of the allied industries would be: precious metals, copper, sulphur, possibly iron oxide paints, gas, coke, ammonia, and ammonia salts, tars, and many minor products, largely light hydrocarbons. The production of gasolene from the tars is now also commercially practicable.

Maritime Provinces.—The situation in the Maritime Provinces is not so favourable as in Quebec. The total copper production of these provinces has been very small, and at the present time no copper ores are being mined. There are only a very few known prospects of sufficient promise to warrant further investigation, and until an ore supply is assured the establishment of a smelting industry is hardly a practicable question.

On the island of Newfoundland there are a number of very promising prospects and the development of good producing mines is a possibility of the future.

The fuel supply available because of the coal resources of eastern Nova Scotia, and the shipping facilities by both rail and water offered by several points on the island of Cape Breton make eastern Cape Breton a very desirable place for the location of a smelter to treat ores from the Maritime Provinces or Newfoundland, should these become available in the future.



H E BAINE, Chief Draughtsman
Base Map Dept. of Interior

MAP No 213

DEPARTMENT OF M

MINES BRANCH

H. E. BAINE, Chief Draughtsman
Base Map Dept. of Interior

EASTERN CAPE BRETON AS A POSSIBL

Scale 35 Miles to 1 Inch

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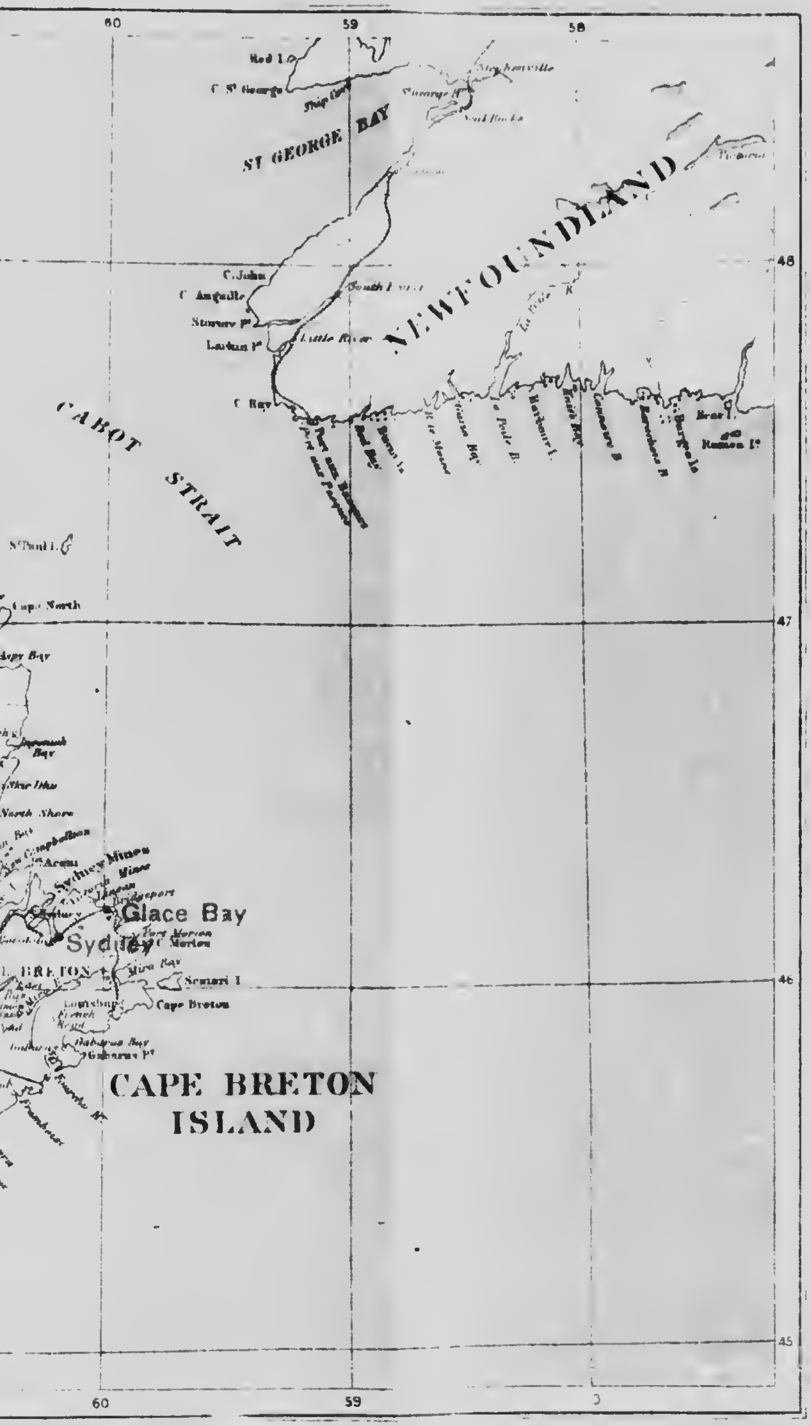
RANCH



MAP No 213

POSSIBLE SMEL CENTRE

to 1 Inch

50 75 miles

CHAPTER IX.

STATISTICS OF COPPER PRODUCTION.

The recovery of copper from its ores involves three distinct groups of processes: (1) the mining; (2) the smelting (or hydro-metallurgical treatment); (3) the refining.

The copper production of any country can be obtained by collecting statistics from any one of three sources: from the mines, from the smelters, or from the refiners, but each group should be kept separate from the others. Each group of figures will be found to have both certain advantages and disadvantages. The mine figures will show the tonnage of ore produced, and its average metallic contents. They make no allowances for ore lost in transit, or for copper lost in the various smelting and refining operations, and, therefore, even when subject to certain arbitrary deductions, do not fairly represent the amount of metal recovered, and made commercially available from the mining operations of the country. The mine figures, however, are the first available near the commencement of a calendar year, and where early publication is desired, are the only ones available early in the year.

Statistics obtained from smelter recoveries more nearly represent the actual amount of metal recovered from the ores treated during the year. They are not, however, available as early in the year, as a period of about two months usually elapses between the time when ore is received and when its valuable contents are recovered. The smelter recoveries for a calendar year approximately represent the contents of the ores received for the last two months of the preceding year and for the first ten months of the calendar year under consideration.

Refining returns are probably the best gauge of the actual amount of metal made available for commercial uses. The refinery returns for a calendar year would probably correspond with the mine output for three months of the previous year, and for nine months of the calendar year under consideration.

There are but two sources available from which to obtain statistics relating to the copper production of Canada: they must be obtained either from the producing mines or from the smelters treating Canadian ores. There are no copper refineries in Canada, and, therefore, the third group of statistics is not available. With the exception of a small amount of copper recovered as copper sulphate at Trail, all Canadian copper is recovered in foreign refineries. At these refineries both foreign and domestic products are treated together, and it is difficult to obtain accurate figures showing the recovery from each source of supply. The mine statistics do not accurately represent the amount of metal made commercially available because the assay returns and smelter recoveries are not necessarily the same, nor is there any established constant ratio between them. The smelter returns are probably the best source for the most accurate statistics with respect to the output of Canadian copper mines. The collection of statistics from this source is somewhat complicated by the fact that some foreign ores are treated in Canadian smelters, and some Canadian ores are treated in foreign smelters. Returns obtained directly from Canadian smelters make it possible to make proper allowances for metal recovered in Canada from imported ores; return from the foreign smelters treating the great bulk of the exported Canadian ores are also available. There is, however, a small quantity of ore exported to foreign smelters for which no direct return is available. In these cases the copper recovery is assumed to be that for which payment has been made by the smelter.

Since 1909 the statistics published by the Federal Department of Mines have been compiled from these smelter returns and have been on a uniform basis for the whole Dominion. The value assigned to the output has been based on the average annual value of the refined metal on the New York Market, as reported by the Engineering and Mining Journal of New York. It will be found that this valuation differs slightly from the market valuations published officially by the New York Metal Exchange, but it is supposed to represent more closely the average price at which actual sales take place. It is recognized that this price does not represent actual values returned to producers within the Dominion or to their employees. It appears, however, to be the only valuation that can be uniformly applied to all parts of the country, and the *one open to least objection*. All settlements made for ores at the point of production are based on this valuation, but uniform methods of arriving at a settlement valuation are not in use throughout the country; also the allowance to be made for transportation, smelting, refining, and other charges, differs for different localities. The difference between the valuation on a refined metal basis and that on the somewhat hypothetical basis of value at the point of production, very rarely represents an amount which is wholly lost to Canadian industry, since a very large percentage of the transportation charges are collected by Canadian railways. On the other hand, mining profits, which are included in the 'pit mouth' valuation often go to foreign stock holders and are as much lost to Canada as are refiners' charges and profits.

The method of determining copper production on the basis of smelter returns is that which is now adopted by "Mineral Industry" and by most foreign Statistical Bureaus. The experience of the editors of "Mineral Industry" has shown that it is impracticable to carry back the statistical investigation of copper production to the mouth of the mine,[1] and since 1909 they have taken the reports of the producers of pig copper as representing most nearly the production of the mines.

The Bureau of Statistics of the United States Geological Survey collects copper production statistics from the mines, from the smelters, and from the refineries, compiling in all three separate sets of data. In the Mineral Resources of the United States for 1911, Mr. B. S. Butler writes as follows with respect to the mine returns: "The mines and smelters of the large copper producers are, with few exceptions, under the same management, and their production is thought to be reported on the same basis. In the case of mines that ship to custom smelters or have only matting furnaces and ship their matte for conversion there is likely to be considerable discrepancy, as the mines may report a considerable quantity that has not reached the stage of blister by the close of the year, and is consequently not included in the smelter production, or material that was reported by the mines in one year may be treated by the smelters the following year. This discrepancy is more pronounced if a marked curtailment of production occurs at the beginning or at the close of the year, so that there is not the balance of overlap that occurs if the industry is in normal condition throughout the year. A number of operators report the copper in their ores and concentrates on the basis of assay content, in which case it exceeds the smelter recovery from the same material by the amount lost in smelting. Considerable copper is recovered by the smelters from ores that are treated primarily for other metals, the copper content being so low that it is not paid for, and consequently is not always reported by the mines."

Statistics relating to the mineral production of Canada are collected and compiled by the Division of Mineral Resources and Statistics of the Mines Branch, Department of Mines, Ottawa. The governments of the Provinces of Nova Scotia, Quebec, Ontario, and British Columbia have also established provincial Bureaus of Mines whose minor duties include the collection and publication of statistics relating to the mineral production of each of the provinces mentioned. A review of the statistical data relating to copper production furnished by these several bureaus of information shows great diversity of method in compiling these statistics and in the presentation of the results. It is not necessary to enter into a discussion of the different methods employed by the provincial bureaus in determining and valuing their copper production, because the statistics

[1] Mineral Industry, 1909, p. 149.

given in subsequent paragraphs of this chapter are chiefly those compiled in the Division of Mineral Resources and Statistics of the Mines Branch at Ottawa.

Prior to 1909 this bureau compiled its copper statistics from a number of sources no two of which appear to have used the same method for primary compilation. In the earlier years the published figures probably represent the copper content of the ore mined as determined by assays; in more recent years allowances have been made for smelter losses. Since 1909, as already noted, the published figures are based on smelter recoveries and have been compiled on a uniform basis for the whole of Canada.

Statistics, showing Canada's output of copper ores prior to 1886, have not been compiled. The following table (No. XVII) shows the annual production since 1886. The basis on which this table is calculated has been explained in a previous paragraph. The apparent decrease shown in 1909 is not due to diminished production, but to the new basis of calculation which was adopted in that year.

TABLE XVII

Annual Production of Copper, 1886-1912.

Calendar year	Lbs.	Increase or decrease.		Value.	Increase or decrease		Average price per pound
		Lbs.	%		$	%	
				$			Cts.
1886	3,505,000			385,550			11·00
1887	3,260,424	(d) 244,576	6·99	366,798	(d) 18,752	4·86	11·25
1888	5,562,864	2,302,440	70·60	927,107	560,309	152·70	16·66
1889	6,809,752	1,246,888	22·40	936,341	9,234	0·99	13·75
1890	6,013,671	(d) 796,081	11·69	947,153	10,812	1·15	15·75
1891	9,529,401	3,515,730	58·46	1,226,703	279,550	29·51	12·87
1892	7,087,275	2,442,126	25·63	818,580	(d) 408,123	33·27	11·55
1893	8,109,856	1,022,581	14·40	871,809	53,229	6·50	10·75
1894	7,708,789	(d) 401,067	1·91	736,960	(d) 134,849	15·46	9·56
1895	7,771,639	62,850	0·81	836,228	99,268	13·47	10·76
1896	9,393,012	1,621,373	20·86	1,021,960	185,732	22·21	10·88
1897	13,300,802	3,907,790	41·60	1,501,660	479,700	46·94	11·29
1898	17,747,136	4,446,334	33·43	2,134,980	633,320	42·17	12·03
1899	15,078,475	(d) 2,668,661	15·04	2,655,319	520,339	24·37	17·61
1900	18,937,138	3,858,663	25·59	3,065,922	410,603	15·46	16·19
1901	37,827,019	18,889,881	99·75	6,096,581	3,030,659	98·84	16·117
1902	38,804,259	977,240	2·58	4,511,383	(d) 1,585,198	26·00	11·626
1903	42,684,454	3,880,195	10·00	5,649,187	1,138,104	25·23	13·235
1904	41,383,722	(d) 1,300,732	3·05	5,306,635	(d) 342,852	6·07	12·823
1905	48,092,753	6,709,031	16·21	7,497,660	2,191,025	41·29	15·590
1906	55,609,888	7,517,135	15·63	10,720,474	3,222,814	42·98	19·278
1907	56,979,205	1,369,317	2·46	11,398,120	677,651	6·32	20·004
1908	63,702,873	6,723,[illegible]68	11·80	8,413,876	2,984,244	26·18	13·208
1909[1]	52,493,863	......	......	6,814,754	....	....	12·982
1910	55,692,369	3,198,506	6·09	7,094,094	279,340	4·10	12·738
1911	55,648,011	(d) 44,358	0·79	6,886,998	(d) 207,096	2·92	12·376
1912	77,832,127	22,184,116	28·50	12,718,548	5,831,550	45·85	16·341

[1] The decrease is not as large as the figures would indicate because of the calculation of part of the 1909 production on a different basis from previous years. (See explanation in text.)

The average monthly prices per pound for electrolytic copper on the New York market, and for standard copper on the London market, covering a period of six years, are shown on Tables XVIII and XIX. The average yearly prices on the New York and London markets are shown on Tables XX and XXI.

TABLE XVIII

Monthly Average Prices of Electrolytic Copper at New York.

Months	1907	1908	1909	1910	1911	1912
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
January	24·404	13·726	13·893	13·620	12·295	14·094
February	24·869	12·905	12·949	13·332	12·256	14·084
March	25·065	12·704	12·387	13·255	12·139	14·698
April	24·224	12·743	12·563	12·733	12·019	15·741
May	24·048	12·598	12·893	12·505	11·989	16·031
June	22·665	12·675	13·214	12·404	12·385	17·234
July	21·130	12·702	12·880	12·215	12·463	17·190
August	18·356	13·462	13·007	12·490	12·405	17·498
September	15·565	13·388	12·870	12·379	12·201	17·508
October	13·169	13·354	12·700	12·553	12·189	17·314
November	13·391	14·130	13·125	12·742	12·616	17·326
December	13·163	14·111	13·298	12·581	13·652	17·376
Yearly average	20·004	13·208	12·982	12·738	12·376	16·341

TABLE XIX

Monthly Average Prices of Standard Copper at London.

Months	1907	1908	1909	1910	1911	1912
	£	£	£	£	£	£
January	106·739	62·386	57·688	60·923	55·604	62·760
February	107·356	58·786	61·197	59·388	54·970	62·893
March	106·594	58·761	56·231	59·214	54·704	65·884
April	98·625	58·331	57·363	57·238	54·035	70·294
May	102·375	57·387	59·338	56·313	54·313	72·352
June	97·272	57·842	59·627	55·310	56·368	78·259
July	95·010	57·989	58·556	54·194	56·670	76·636
August	79·679	60·500	59·393	55·733	56·264	78·670
September	68·375	60·338	59·021	55·207	55·253	78·762
October	60·717	60·139	57·551	56·722	55·176	76·389
November	61·226	63·417	58·917	57·634	57·253	76·890
December	60·113	62·943	59·906	56·069	62·063	75·516
Yearly average	87·007	59·902	58·732	57·054	55·973	72·942

TABLE XX.

Yearly Average Price per Pound of Copper at New York.[1]

Year	Lake copper.	Year	Lake copper.	Electrolytic copper.
1860	22·250	1887	11·25	
1861	19·125	1888	16·667	
1862	25·750	1889	13·750	
1863	32·875	1890	15·750	
1864	46·250	1891	12·875	
1865	36·250	1892	11·500	
1866	31·750	1893	10·750	
1867	25·125	1894	9·550	
1868	23·625	1895	10·78	
1869	23·375	1896	10·88	
1870	20·625	1897	11·29	
1871	22·625	1898	12·03	
1872	33·000	1899	17·61	16·67
1873	29·000	1900	16·52	16·19
1874	23·250	1901	16·55	16·117
1875	22·500	1902	11·887	11·626
1876	21·000	1903	13·117	13·235
1877	18·625	1904	12·990	12·823
1878	16·500	1905	15·699	15·590
1879	17·125	1906	19·616	19·278
1880	20·125	1907	20·661	20·001
1881	18·125	1908	13·424	13·208
1882	18·500	1909	13·335	12·982
1883	15·875	1910	13·039	12·738
1884	13·875	1911	12·634	12·376
1885	11·125	1912	16·560	16·341
1886	11·000			

[1] After Mineral Industry.

TABLE XXI.

Yearly Average Price of Copper at London.[1]

(Per long ton of 2,240 pounds.)

Year.	Price in pounds sterling.	Year.	Price in pounds sterling.
1860	105·167	1887	46·021
1861	99·250	1888	81·563
1862	97·417	1889	49·733
1863	93·667	1890	54·263
1864	99·667	1891	51·467
1865	92·000	1892	45·658
1866	88·500	1893	43·775
1867	78·000	1894	40·367
1868	76·417	1895	42·979
1869	75·000	1896	46·905
1870	69·583	1897	49·129
1871	74·500	1898	51·829
1872	95·833	1899	73·688
1873	91·833	1900	73·625
1874	86·583	1901	66·983
1875	88·000	1902	52·571
1876	81·750	1903	58·158
1877	74·750	1904	59·025
1878	67·500	1905	69·600
1879	62·750	1906	87·425
1880	62·729	1907	87·083
1881	61·838	1908	60·025
1882	66·520	1909	58·863
1883	62·896	1910	57·158
1884	53·875	1911	56·088
1885	43·550	1912	72·942
1886	40·083		

[1] Based on compilations published by Metallgesellschaft, Frankfort-on-Main. Prices, 1860-1879 are for tough copper, as compiled by Messrs. Vivian, Younger, and Bond, London. Prices 1880 to 1912 are for Standard copper.

[2] "Engineering and Mining Journal," New York.

The production by provinces for the last four years, calculated on the basis of the smelter returns, is shown in Table XXII.

TABLE XXII.

Production by Provinces 1909-1912.

Province.	1909.[1] Lbs.	1909.[1] Value. $	1910 Lbs.	1910 Value. $	1911. Lbs.	1911. Value. $	1912. Lbs.	1912. Value. $
Quebec	1,088,212	141,272	877,347	111,757	2,436,190	301,503	[illegible],282,210	536,316
Ontario	15,746,699	2,011,237	19,259,016	2,153,213	17,932,263	2,[illegible],297	[illegible],250,601	3,635,971
British Columbia[1]	35,658,952	4,629,245	35,270,006	1,492,693	35,279,558	4,366,19[illegible]	5[illegible],526,656	8,256,561
Other districts[2]			286,000	36,431	(Note 3)		1,772,660	289,670
Total	52,493,862	6,814,751	55,692,369	7,091,094	55,618,011	6,886,998	77,832,127	12,718,548

[1] The apparently large decrease in British Columbia copper production in 1909 as compared with 1908 is mainly due to the different basis of compilation adopted in 1909, for explanation of which see the text. The British Columbia copper production in 1909 based on copper content of ores sent to smelters was 15,597,215 pounds. (See Tables XXVI and XXVIII.)

[2] Includes Nova Scotia and Yukon.

[3] A shipment is reported from New Brunswick.

PRODUCTION BY PROVINCES.

The copper production of each of the provinces separately, is shown on the three tables which follow. The total production of Nova Scotia, New Brunswick, and the Yukon is very small, and in some years no ores of copper were mined; no separate tables showing the production of these districts have been compiled.

QUEBEC.

Copper production from the Province of Quebec is almost wholly from the pyritic ores of the Eastern Townships of Quebec. These ores, for the most part, are first treated in acid works to recover the sulphur content of the ore; the metallic contents are afterwards recovered either by a smelting or a leaching process. In the early days of mining in Quebec a considerable quantity of the copper ores was treated for their copper directly. Table XXIII gives the copper production of Quebec as determined from the compilations of the Dominion Statistician.

TABLE XXIII.

Quebec: Production.

Calendar Year.	Lbs.	Value.	Calendar Year.	Lbs.	Value.
		$			$
1886	3,310,000	367,100	1900	2,220,000	359,118
1887	2,937,900	330,514	1901	1,527,412	216,178
1888	5,562,861	927,107	1902	1,640,000	190,666
1889	5,315,000	730,813	1903	1,152,000	152,467
1890	1,740,606	711,920	1904	1,760,000	97,155
1891	5,401,701	695,469	1905	621,213	252,752
1892	4,883,180	561,042	1906	1,981,169	381,930
1893	4,168,352	480,348	1907	1,517,990	303,659
1894	2,176,130	208,057	1908	1,282,021	169,330
1895	2,212,462	211,288	1909	1,088,212	111,272
1896	2,107,200	261,903	1910	877,347	111,757
1897	2,471,970	279,121	1911	2,136,190	301,503
1898	2,100,235	252,658	1912	3,282,210	536,346
1899	1,632,560	287,191			

ONTARIO.

The copper production of Ontario has been almost wholly from the nickel-copper ores of [illegible] Sudbury district. In the early days prior to 1880, there was a small output of rich sulphide ores found at several points in the western part of the Province; at present there is comparatively little production from this class of ore. The nickel-copper ores of the Sudbury district are smelted in Ontario, two large plants being now in operation. A third plant is being projected. The mattes produced at these smelters are all shipped to other countries for refining. The copper production of the Province is determined from the assay returns made on these matte shipments. It is interesting to note that the "Metal Refining Bounty Act" 1907, of the Province of Ontario, makes special provision for the payment of a bounty on copper 95% pure metal, and on copper sulphate produced from ore mined in the Province, provided also the refining takes place within the Province. The clause of the Act which affects copper refiners in Ontario is as follows: "The treasurer of the Province may, under the authority of such regulations as may from time to time be made in that behalf by the Lieutenant Governor in Council, pay in each year to the refiners of the metals or metal compounds hereinafter specified, when refined in the Province from ores raised and mined in the Province, a bounty upon each pound of such metal or compound so refined as follows:—

Class 3. On refined metallic copper or on refined sulphate of copper, 1·5 cent per pound on the free metallic copper or on the copper contained in the sulphate of copper; or on any copper product carrying at least 95% of the metallic copper, one-half cent per pound; but copper upon which a bounty has already been paid in one form of product shall not be entitled to any further bounty [illegible] other form; and the amount to be paid as bounty on the copper [illegible] herein mentioned, is not to exceed in all $60,000 in any one year. [illegible]iners claiming the bounty must be at all times willing and prepared to treat custom ores purchased at current market rates. The Act expires on April 20, 1917.[1]

The Act makes no provision for the payment of bounties on the production of natural alloys of the metals, such as monel metal, which are produced by refining nickel-copper mattes. These mattes, which contain 80-82% nickel-copper, are at present all exported for refining.

The copper production of Ontario since 1886, as compiled by the Dominion Statistician, is show[illegible] Table XXIV.

[1] The full text of the Act, which also provides for bounties on refined nickel and nickel oxide, cobalt and cobalt oxide, and on white arsenic, may be obtained on application to the Deputy Minister of Mines for Ontario, Toronto, Canada.

TABLE XXIV.

Ontario: Production.

Calendar Year	Lbs.	Value. $	Calendar Year	Lbs.	Value. $
1886	165,000	18,150	1900	6,740,058	1,091,215
1887	322,521	36,281	1901	8,695,831	1,401,507
1888	Nil.	Nil.	1902	7,108,202	861,278
1889	1,466,752	201,678	1903	7,172,533	949,285
1890	1,303,065	205,233	1904	4,913,591	630,070
1891	4,127,697	531,231	1905	8,779,259	1,368,686
1892	2,203,795	251,538	1906	10,638,231	2,050,838
1893	3,611,504	391,461	1907	14,104,337	2,821,432
1894	5,207,679	497,851	1908	15,005,171	1,981,883
1895	4,576,337	492,111	1909	15,716,699	2,011,237
1896	3,167,256	314,598	1910	19,259,016	2,153,213
1897	5,500,652	621,023	1911	17,932,263	2,219,297
1898	8,375,223	1,067,539	1912	22,250,601	3 635,971
1899	5,723,321	1,007,877			

Table XXV shows the copper production of Ontario since 1892, the data having been compiled from the annual reports of the Ontario Bureau of Mines. The basis of valuation is the market price of the copper in the matte at the furnaces. How this valuation is obtained is not stated.

TABLE XXV.

Ontario Copper Production 1892-1912.

(Bureau of Mines Basis.)

Calendar Year	Pounds.	Value. Cts. per lb.	Value. Total $	Calendar Year.	Pounds.	Value. Cts. per lb.	Value. Total $
1892	3,872,000	5·995	232,135	1903	8,010,000	8·848	716,726
1893 ..	2,862,000	4·025	115,200	1904	4,326,000	6·868	297,126
1894...	5,496,000	3·561	195,750	1905	9,050,000	7·613	688,993
1895	4,721,000	3·401	160,913	1906	12,061,000	7·135	960,813
1896	3,736,000	3·497	130,660	1907	14,606,000	7·151	1,04[illegible] 511
1897..	5,500,000	3·637	200,067	1908	15,122,000	7·083	1,071,140
1898 ..	8,373,500	3·201	268,080	1909	15,866,000	7·103	1,127,015
1899..	5,668,000	3·109	176,237	1910	19,260,000	7·134	1,374,103
1900 ..	6,728,000	4·751	319,681	1911	17,932,000	7·111	1,281,118
1901...	8,394,000	7·018	589,080	1912	22,232,000	7·111	1,581,062
1902 ..	8,132,000	8·488	680,283				

The production of copper in the Province of British Columbia as determined by the Provincial Bureau of Mines, is shown in the following table:

TABLE XXVI.

British Columbia Copper Content of Ore Shipped.

Year.	Pounds copper contained in ore shipped.	Value ($)	Year.	Pounds copper contained in ore shipped.	Value ($)
1894	324,680	16,231	1904	35,710,128	4,578,037
1895	952,840	47,642	1905	37,692,251	5,876,222
1896	3,818,556	190,926	1906	42,990,188	8,288,565
1897	5,325,180	266,258	1907	40,832,720	8,166,544
1898	7,271,678	874,781	1908	47,274,614	6,240,242
1899	7,722,591	1,351,453	1909	45,597,245	5,918,529
1900	9,997,080	1,615,289	1910[1]	38,243,934	4,871,512
1901	27,603,746	4,446,963	1911[1].	36,927,656	4,571,644
1902	29,636,057	3,446,673	1912[2].	51,000,000	8,338,500
1903	34,359,921	4,547,535			
Totals....	127,012,329	16,803,754	Totals.....	376,269,036	56,849,795

[1] Allowing 5 pounds of copper per ton for smelter losses.
[2] Preliminary estimate.

The production of this Province, on the basis of returns received from the smelter, and including an estimate of smelter recovery for the copper ores exported, has been determined by the Dominion Statistician. This table includes copper in matte, in copper sulphate, and in blister copper.

TABLE XXVII.

British Columbia Production of Copper 1909-1912.

(Basis of smelter returns)

Year.	Pounds	Value. $
1909	35,658,952	4,629,245
1910	35,270,006	4,492,693
1911	35,279,558	4,366,198
1912	50,526,656	8,526,561

The production of British Columbia by districts, as ascertained by the Provincial Department of Mines, is given in Table XXVIII.

TABLE XXVIII

British Columbia: Production[1] by Districts.

	1906	1907	1908	1909	1910	1911	1912[2]
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Cassiar	293,269	671,887	490,873	137,654		19,151	
East Kootenay	6,940		......				
West Kootenay							
Nelson	246,034	434,222	53,243	186,572	231,936		
Slocan	2,861						
Trail Creek	4,750,110	5,080,275	5,042,241	3,509,909	3,577,745	3,429,702	
All other	4,145	.....	...	....			
Yale—							
Boundary	32,226,782	31,521,550	40,178,521	40,603,042	31,354,985	22,327,359	
Ashcroft..	355,377	38,706	3,269	...	4,178	452,723	
Kamloops							
Coast districts	5,138,000	3,083,080	1,506,164	1,160,671	3,078,090	10,998,721	
Total	42,990,488	40,832,720	47,274,644	45,597,245	38,243,934	36,927,656	

[1] Copper content of ores shipped.
[2] After deducting five pounds of copper per ton of ore for slag losses.

In the preceding chapters the various smelting plants in operation in this Province are described in considerable detail. The approximate ore shipments received by these smelters and statistics of the metallic contents recovered from these ores are given for the several periods that the smelters have been in operation, wherever these data are available.

CUSTOMS RETURNS.

The Department of Customs also collects statistics of the copper which is exported or imported. The exports of copper, in ore, matte, or scrap, are given in Table XXIX. The valuation assigned by the exporters is also given in column 3, and the valuation on the basis of the average New York Market quotation, as shown in Table XVIII, is given in column 4.

TABLE XXIX

Exports of Copper in Ore, Matte, etc.

Calendar Year	Lbs.	Value. $	Value on N. Y. market basis. $	Calendar Year.	Lbs.	Value. $	Value on N. Y. market basis. $
1885		262,600		1899	11,371,766	1,499,408	2,002,568
1886		249,259		1900	23,634,523	1,741,885	3,903,928
1887		437,966		1901	32,488,872	3,401,408	5,376,908
1888		257,260		1902	26,034,498	2,476,546	3,401,853
1889		168,477		1903	38,364,676	3,873,827	5,417,389
1890		398,497		1904	38,553,282	4,246,214	5,008,074
1891		348,404		1905	40,710,864	5,443,873	6,395,908
1892		277,632		1906	42,398,538	7,303,366	8,316,897
1893	4,792,204	269,460	515,464	1907	54,688,450	8,719,609	11,299,481
1894	4,625,389	94,917	455,225	1908	54,436,371	5,931,579	6,864,546
1895	3,742,352	236,965	403,426	1909	54,447,750	5,832,246	7,268,775
1896	5,462,052	281,070	594,274	1910	56,961,127	5,840,553	7,427,553
1897	14,022,610	850,336	1,583,452	1911	55,287,710	5,467,725	6,985,049
1898	14,572,381	840,243	1,392,457	1912			

The total values of the imports of copper, as reported by the Departmant of Customs, are given in Tables XXX and XXXI. In detail these imports comprise copper in all forms, of which the principal are crude (pigs, ingots, blocks, and scrap) bars, rods, strips, sheets or plates, tubing, and wire.

TABLE XXX.

Imports of Copper.

(In pigs, blocks, and bars, old and scrap).

Fiscal Year.	Lbs	Value. $	Fiscal Year.	Lbs.	Value $
1880	31,900	2,130	1896	86,905	9,226
1881	9,800	1,157	1897	49,000	5,449
1882	20,200	1,984	1898	1,050,000	80,000
1883	124,500	20,273	1899	1,655,000	216,740
1884	40,200	3,180	1900	1,444,000	480,990
1885	28,600	2,016	1901	951,500	152,271
1886	82,000	6,969	1902	1,767,200	325,832
1887	40,400	2,507	1903	2,038,400	252,594
1888	32,300	2,322	1904	2,445,300	270,345
1889	32,500	3,288	1905	1,944,400	266,548
1890	142,200	11,521	1906	2,627,700	414,851
1891	107,800	10,452	1907 (9 mos.	2,616,600	520,971
1892	343,600	14,891	1908	3,612,400	650,597
1893	168,300	16,334	1909	2,732,300	383,411
1894	101,200	7,397	1910	1,690,700	647,630
1895	72,062	6,770	1911	5,023,700	641,719
			1912	5,542,000	699,442

	Copper, old and scrap or in blocks ... Duty free.	192,300	24,926
1912	Copper in pigs or ingots Duty free.	5,349,700	677,516
	Total	5,542,000	699,442

TABLE XXXI.

Imports of Manufactured Copper.

Fiscal Year	Value $	Fiscal Year.	Value $	Fiscal Year.	Value. $
1880	123,064	1891	563,522	1902	1,284,522
1881	159,163	1892	422,870	1903	1,291,635
1882	220,235	1893	458,715	1904	1,491,610
1883	247,441	1894	175,404	1905	1,775,884
1884	434,534	1895	251,645	1906	2,660,303
1885.	181,469	1896	285,220	1907 (9 mos.).	2,515,600
1886.	219,420	1897	261,587	1908	2,713,060
1887.	325,365	1898	786,529	1909	2,086,205
1888.	303,459	1899	551,586	1910	2,879,630
1889.	402,216	1900	1,090,280	1911	3,742,940
1890	472,668	1901	951,015	1912	4,191,723

FOREIGN PRODUCTION.

The following tables relating to the copper industry of the United States are of interest for comparison purposes. Tables XXXII and XXXIII are taken from the advance chapter of the Mineral Resources of the United States, calendar year 1911, the latest available.

TABLE XXXII

Summary of Statistics of the Copper Industry in the United States in 1910 and 1911.

		1910	1911
Production of copper			
Smelter output	pounds	1,080,159,509	1,097,232,749
Mine production	"	1,088,237,532	1,114,761,197
Refinery production of new copper			
Electrolytic..	"	782,171,20[illegible]	823,507,764
Lake...	"	221,162,981	218,185,236
Casting and pig	"	68,260,688	59,577,803
Total domestic	"	1,071,891,876	1,101,270,803
Total domestic and foreign..	"	1,122,039,135	1,133,875,026
Total new and old copper.....	"	1,610,000,000	1,618,000,000
Total ore treated ..	short tons.	28,517,556	29,991,912
Copper ore treated.	"	28,197,123	29,988,235
Average yield of copper	per cent.	1·88	1·825
Imports	pounds	341,435,771	331,607,538
Exports	"	708,316,513	786,553,208
Consumption			
Total new copper	"	732,400,000	681,753,279
Total new and old copper.	"	911,100,000	895,900,000
World's production...	"	1,903,297,003	1,958,201,285
Value of production in the United States..		$137,180,257	$137,151,092

TABLE XXXIII

Production of Copper in the United States in 1910 and 1911.

(Smelter output, in pounds fine).

	1910	1911
Alaska	4,311,026	22,314,889
Arizona	297,250,538	303,202,532
California	15,760,200	35,835,651
Colorado	9,307,497	9,791,861
Georgia	721	....
Idaho	6,877,515	1,511,116
Maryland		23,555
Michigan	221,462,984	218,185,236
Missouri		610,111
Montana	283,078,473	271,814,491
Nevada	61,491,610	65,561,015
New Hampshire	12,409	
New Mexico	3,781,600	2,860,100
North Carolina	181,263	13,699
Oregon	22,[illegible]2	125,913
Pennsylvania	740,626	661,621
Philippine Islands	1,781	9,642
South Dakota	13	4,607
Tennessee	16,694,777	18,965,113
Texas	2,961	105
Utah	125,185,455	112,310,215
Vermont	1,935	......
Virginia	105,313	
Washington	65,021	195,503
Wyoming	217,427	130,199
Undistributed	[1]603,570	11,615
Total	1,080,159,509	1,097,232,749

[1] Includes Missouri

TABLE XXXIV

Production of Copper in 1911, Apportioned to Locality in Which Smelted to Blister, in Pounds.

Locality	Domestic.	Foreign	Total
Arizona	271,000,000	25,600,000	296,600,000
Montana	272,700,000		272,700,000
Utah and Nevada	201,500,000		201,500,000
California and Washington	48,000,000	15,000,000	63,000,000
All others	263,000,000	58,000,000	321,000,000
Total by domestic plants	1,056,200,000	98,600,000	1,154,800,000
Total by foreign plants from domestic ore and matte	11,000,000		
Grand total from domestic ores	1,067,200,000		

TABLE XXXV

Production of Copper in the United States, 1902-1911, by States, in Pounds.

State	1902	1903	1904	1905	1906
Alaska		1,[illegible]	2,013,586	4,900,866	8,685,646
Arizona	119,941,941	147,648,271	191,602,958	226,851,461	262,566,103
California	25,038,721	17,776,756	28,520,023	16,697,189	28,154,202
Colorado	8,122,030	1,158,368	9,506,911	9,101,830	7,127,253
Idaho	227,500	778,906	2,158,858	7,321,585	8,578,046
Michigan	170,609,228	192,100,577	208,309,130	230,287,992	229,695,730
Montana	288,903,820	272,555,851	298,311,801	314,750,582	294,701,252
New Mexico	6,614,961	7,300,832	5,368,666	5,331,192	7,099,842
Nevada	164,301	150,000		113,292	1,090,635
Oregon				846,615	515,859
South Dakota	145,663	173,202	100,000	38	
Utah	23,939,901	38,302,602	17,062,889	51,083,506	50,329,149
Washington	200,297	80,758	663,691	223,328	290,823
Wyoming	889,228	1,023,189	3,565,629	2,530,531	106,177
Eastern states					
Southern states	13,599,017	13,855,612	15,211,086	15,131,960	
Middle states					
Eastern states and unapportioned					18,535,995
Lead desilverizers and unapportioned	[1]500,000	[1]500,000	[1]400,000		. .
Total	659,508,644	698,044,517	812,537,267	888,784,267	917,805,682

State	1907	1908	1909	1910	1911
Alaska	7,031,763	4,438,856	4,057,142	4,311,026	22,314,889
Arizona	256,778,437	289,523,267	291,110,298	297,250,538	303,202,532
California	33,696,602	39,613,835	53,568,708	15,760,200	35,835,[illegible]
Colorado	13,998,496	13,913,878	11,185,631	9,307,497	9,791,861
Idaho	9,707,299	7,256,086	7,096,432	6,877,515	4,511,446
Michigan	219,151,503	222,289,584	227,005,923	221,462,984	218,185,236
Montana	224,263,789	252,503,651	311,858,291	283,078,473	271,814,491
New Mexico	10,440,410	4,991,351	5,031,436	3,784,609	2,860,400
Nevada	4,998,464	12,241,372	53,849,281	64,494,640	65,561,015
Oregon	518,694	274,494	245,403	22,022	125,943
South Dakota		5,471	11,988	13	1,607
Utah	66,448,370	71,376,370	101,241,444	125,485,455	142,310,215
Washington	122,263	162,204	120,644	65,021	195,503
Wyoming	3,026,001	2,116,497	133,672	217,127	130,499
Eastern states and unapportioned	22,164,967	21,513,431	22,806,291	18,[illegible]42,359	20,358,791
Total	[illegible]	942,570,721	1,0[illegible]	1,080,159,509	1,0[illegible]7,232,749

[1] Based partly on estimates.

The exports and imports of copper from or into the United States are shown on Tables XXXVI and XXXVII, taken from Mineral Industry, 1911.

TABLE XXXVI

Exports of Copper from the United States. (a)

Ore, matte, and regulus stated in tons of 2240 lbs., ingots, etc., in pounds.

Country	1906	1907	1908	1909	1910	1911
Ore, matte, and regulus exported to:						
United Kingdom	206	200	168	258		
Germany	59	188	2			
British North America	36,700	82,016	55,367	50,571		
Mexico	10,600	16,737	7,000	8,534		
Other countries	54		552	520		
Total	47,619	99,141	63,149	59,880	43,784	57,915
Ingots and scrap (b) exported to:						
United Kingdom	55,097,670	81,400,141	117,810,314	156,511,113	98,030,213	108,061,603
Belgium	6,175,054	3,822,551	5,500,306	6,046,861	7,176,258	5,125,004
France	80,703,723	93,075,115	115,690,384	99,003,962	116,193,850	135,038,893
Germany	96,629,040	107,607,390	137,453,392	138,213,290	175,861,028	190,428,008
Italy	19,777,296	21,192,908	25,512,267	26,386,069	34,110,237	38,216,773
Netherlands	151,650,293	156,652,270	195,562,619	201,378,211	221,764,806	230,693,649
Russia	9,523,992	4,341,386	1,657,077	3,519,216	6,848,511	15,601,688
Other Europe	25,260,807	26,221,024	39,433,674	11,661,979	42,293,861	9,251,363
British North America	1,476,135	3,747,410	3,977,142	6,790,410	5,628,487	8,931,582
Mexico	263,319	362,111	35,895	46,287		. .
China	1,932,128	10,003,592	13,735,899			
Other countries	262,561	193,873	2,117,101	319,328	499,492	(c) 45,201,645
Total	451,752,018	508,929,401	661,876,127	682,846,726	708,316,513	786,553,208

(a) The exports of ore, matte, and regulus are reported as a gross weight, the copper content not being stated.
(b) Includes bars and plates. (c) Includes Austria-Hungary, 11,200,202 lbs.

TABLE XXXVII

Imports of Copper into the United States. (a)

(In pounds).

Country	1906	1907	1908	1909	1910	1911
Ore and matte imported from						
British North America	10,329,955	12,803,069	11,187,297	9,689,829	10,034,806	12,949,614
Mexico	31,690,058	32,467,418	15,903,692	23,914,040	22,731,184	46,[illegible]81,071
South America	4,140,589	8,790,621	13,025,614	20,987,197	19,125,233	15,305,335
Other countries	2,874,289	5,657,679	16,365,340	26,496,327	33,033,752	23,717,628
Total	49,034,891	59,718,787	56,484,943	81,087,393	8[illegible]24,975	68,626,7[illegible]
Pig and scrap (b) imported from						
United Kingdom	22,549,324	25,706,852	5,434,435	26,527,574	48,649,727	9,004,461
France	3,202,168	606,662	468,506	490,291		....
Germany	5,503,712	6,814,338	1,454,370	4,045,647		
Other Europe	5,649,689	5,646,261	13,359,147	27,379,475	25,414,393	28,042,257
British North America	30,398,369	30,902,596	30,895,737	29,496,351	29,016,785	22,442,335
Mexico	85,595,359	76,744,532	43,742,993	76,419,724	84,008,907	97,115,574
Cuba	513,240	767,184	349,560	104,182	....	..
West Indies (c)	399,569	401,585	484,490	223,408	......	
Japan	6,752,186	9,809,569	8,329,896	25,830,440	18,482,989	20,030,447
Other countries	46,194,477	35,534,688	58,308,040	55,797,329	83,640,995	89,345,686
Total . . .	176,558,390	192,901,267	162,224,444	240,743,721	259,210,796	265,984,760

(a) The imports reported are the copper contents of ore matte and regulus. (b) Includes also bars, ingots, and plates. (c) Includes Bermuda.

The copper consumption of the United States as estimated by "Mineral Industry" is shown in Table XXXVIII, and the world's production and consumption, as determined by the same authority, are shown in Table XXXIX.

TABLE XXXVIII.

Consumption of Copper in the United States. (a)

Year.	Production.	Stock Jan. 1	Imports.	Supply.	Exports.	Stock Dec. 31	Consumption.
1902	636,796,381	209,587,698	161,551,010	1,007,935,119	376,298,726	162,935,439	468,700,951
1903	708,375,228	162,935,439	167,461,720	1,038,472,387	312,822,627	230,111,792	495,537,968
1904	817,715,005	230,111,792	182,292,205	1,230,119,002	555,638,552	208,376,672	466,103,778
1905	875,241,744	208,376,672	210,724,685	1,294,343,098	548,772,103	132,587,496	612,983,499
1906	917,620,000	132,587,496	227,593,281	1,275,800,777	467,839,041	139,385,400	668,576,336
1907	1,152,747,890	9,000,000	5,000,000	1,166,747,890	508,929,104	120,000,000	537,818,489
1908	1,152,895,019	120,000,000	....	1,272,895,019	661,876,127	122,357,266	488,661,623
1909	1,405,403,056	122,357,266	.. ..	1,527,760,322	682,846,726	111,766,111	703,117,185
1910	1,152,122,120	111,766,111	..	1,593,888,231	708,316,513	122,030,195	763,541,195
1911	1,431,938,338	122,030,195	..	1,533,968,533	786,553,208	89,154,695	677,960,630

(a) The statistics in the above table up to 1906 inclusive are computed in the old way, namely, on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in "Eng. and Min. Jour." July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form, and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those of 1906.

TABLE XXXIX.

World's Production and Consumption of Copper.

(In tons of 2204·6 lb.)

Year.	Production.	Consumption	Price.[1]
			cts.
1899	478,200	467,700	16·67
1900	499,200	512,700	16·19
1901	534,800	491,200	16·11
1902	553,300	582,500	11·63
1903	591,300	586,700	13·21
1904	617,900	662,100	12·82
1905	693,900	727,400	15·59
1906	712,900	727,600	19·28
1907	703,000	657,300	20·00
1908	714,600	698,300	13·21
1909	854,100	782,800	12·98
1910	866,610	861,000	12·74
1911	869,370	986,300	12.38
Totals	8,719,240	8,716,900	

[1] Quotational averages, cents per pound at New York.

The world's production of copper as determined by "Mineral Industry" is shown in Tables XL and XLI.

TABLE XL.

The World's Copper Production.

(In metric tons).

Country.		1902	1903	1904	1905	1906	1907	1908	1909	1910 (b)	1911 (b)
Africa	Cape Co.	2,794	1,701	5,563	5,105	4,003	4,298	[illegible]550	4,720	7,016	17,252
	Namaqua	1,727	610	2,337	2,337	2,612	2,510	10	2,337		
(a)	Other	.....	.....	.....	.....	.....	.....	....	8,128	8,433	...
Argentina (a)		211	137	157	157	107	22[illegible]	[illegible]26	610	305	1,036
Australasia (a)		29,098	29,461	31,706	31,483	36,830	41,9[illegible]	[illegible],123	31,952	40,962	42,512
Austria-Hungary (a)		1,626	1,107	1,473	1,316	1,458	1,0[illegible]	3,877	6,218	2,276	2,566
Bolivia (a)		2,032	2,032	2,032	2,032	2,540	21,03[illegible]	2,510	2,032	2,540	1,829
Canada (d)		17,765	19,637	19,190	21,595	19,110	2,510	21,376	21,626	23,810	25,570
Chile (d)		27,066	29,923	31,025	29,126	25,839	28,863	42,097	42,726	38,346	33,088
Cuba (d)		.....	.....	.....	.....	1,381	1,388	2,966	3,006	3,538	3,753
Germany total (a)		21,951	32,211	30,262	22,492	20,665	20,818	20,523	32,815	25,105	22,363
(Mansfield) (a)		(19,050)	(19,810)	(19,578)	(19,878)	(18,085)	(17,343)	(18,000)	(19,015)	(20,275)	......
Italy (a)		3,121	3,150	3,388	2,997	2,911	3,353	3,022	2,769	3,272	2,612
Japan		29,034	31,861	33,187	35,911	36,963	40,183	11,399	12,987	50,703	52,303
Mexico total (d)		36,357	46,010	51,759	65,[illegible]9	61,615	57,491	38,190	57,230	62,510	61,884
(Boleo) (a)		(10,958)	(10,480)	(11,120)	(10,3[illegible])	(11,002)	(11,506)	(12,600)	(12,126)	(13,003)	....
Newfoundland (a)		2,906	2,753	2,235	2,316	2,332	1,758	1,153	1,402	1,097	1,174
Norway (a)		1,638	6,010	5,502	6,106	6,218	7,122	9,337	9,226	10,592	9,576
Peru (c)		7,701	9,497	9,501	12,213	13,171	20,681	15,210	16,257	27,375	28,500
Russia (e)		8,817	9,232	9,835	9,515	9,296	15,930	17,718	18,035	22,670	25,980

TABLE XL. *Continued.*

The World's Copper Production—*Continued.*

Country	1902.	1903	1904	1905.	1906.	1907	1908	1909	1910 (*h*)	(1911) (*h*)
Spain-Portugal (*a*)	50,587	50,536	47,788	45,527	50,409	50,470	53,125	53,023	51,080	52,880
Rio Tinto (*a*)	35,032	36,382	31,016	32,795	31,642	32,833	35,517	35,938	(34,111)	(35,100)
Tharsis (*a*)	6,817	6,421	5,710	4,415	4,876	4,206	4,500	4,425	(3,551)	(3,450)
Mason and Barry (*a*)	3,383	2,469	2,997	2,764	2,504	2,662	2,804	2,403	(3,003)	(2,972)
Sevilla (*a*)	1,570	1,123	1,351	1,300	2,073	2,337	2,196	1,849	(1,656)	(1,558)
Sweden (*e*)	178	776	533	1,385	1,209	1,577	2,808	2,032	2,032	2,032
Turkey (*a*)	1,118	1,422	965	741	432	1,270	1,068	813	610	1,016
United Kingdom (*g*)	490	545	501	727	762	677	588	442	508	508
United States (*d*)	293,053	312,631	400,998	397,069	416,343	398,930	430,399	501,372	492,720	491,634
Total	542,606	630,590	693,240	698,931	715,510	721,120	758,065	854,758	877,494	880,098

(*a*) As reported by Henry R. Merton & Co., Ltd., of London. (*b*) As reported by Henry R. Merton & Co., previous to 1905, subsequently as reported by the "Eng. and Min. Journ." (*c*) As officially reported except for 1909, for which year the figure of Henry R. Merton & Co. is used. (*d*) As reported by the "Eng. and Min. Journ." (*e*) As reported by Henry R. Merton & Co. for 1900-1902, as officially reported 1903-1907, as per Henry R. Merton & Co. for 1908 and 1909. (*f*) As officially reported. (*g*) As officially reported, 1900-1905, subsequently as per Henry R. Merton & Co. (*h*) Henry R. Merton & Co., through "Eng. and Min. Journ."

TABLE XLI.

World's Production of Copper. (a)

Year.	Metric tons.	Short tons.	Year.	Metric tons.	Short tons.
1881	166,065	183,093	1897	412,818	455,147
1882	181,620	203,550	1898	441,282	486,529
1883	202,697	223,481	1899	476,194	525,021
1884	223,881	246,840	1900	494,435	511,564
1885	229,315	252,828	1901	529,708	583,517
1886	220,669	243,295	1902	542,606	597,951
1887	226,492	249,716	1903	630,590	691,910
1888	262,285	281,179	1904	693,210	764,758
1889	265,516	292,741	1905	698,931	770,221
1890	274,055	302,166	1906	715,510	788,492
1891	280,438	308,862	1907	724,120	798,205
1892	309,113	340,808	1908	758,065	835,623
1893	310,704	342,562	1909	854,758	942,408
1894	330,075	363,920	1910	877,494 (b)	966,998
1895	339,994	371,856	1911	880,098	970,308
1896	384,493	423,917			

(a) The statistics for 1881-91 are as reported by Henry R. Merton & Co.; 1892-1910 as per The "Mineral Industry." (b) Henry R. Merton & Co.

An interesting table, compiled by James Douglas, was published by the Mining and Scientific Press in 1910, showing the relative position of the principal copper producing countries of the world in 1850 and in 1909. This table is republished as Table XLII.[1] It will be noted that in 1850 Great Britain produced 26·8% of the world's supply of copper, while the United States and Canada together produced only 1·2%. In 1909 Great Britain produced only 0·06%; the United States production was 56·75%; and Canada stood seventh with a production of 2·72% of the total. Japan, Mexico, and Newfoundland were not producers in 1850. It is probable that Japan at that time was included with Asia, since some Japanese copper mines have been in operation for more than a century. In 1910 the United States again stood first with a production of 56·75% of the total world's production and Canada stood seventh with 2·97% of the total.

[1] From Mineral Industry, 1910

TABLE XLII.

World's Production of Copper in 1850 and 1909 Compared. (a)

	1850		1909.	
	Pounds.	Per cent	Pounds.	Per cent.
Great Britain	29,648,000	26·8	1,120,000	0·06
Chile	25,060,000	22·9	84,000,000	4·54
Russia	12,900,000	11·8	50,400,000	2·66
Austrian Empire	6,660,000	6·0	2,800,000	1·14
Cuba...	6,800,000	6·3	...	....
Australasia	7,000,000	6·4	98,560,000	5·22
Asia.	6,000,000	5·4	......	...
Scandinavia	4,000,000	3·7	25,760,000	1·35
Germany	2,800,000	2·6	44,800,000	2·37
Turkey	2,000,000	1·8	2,240,000	0·11
Rest of Europe	2,000,000	1·8	124,544,000	6·58
South America (except Chile	2,400,000	2·2	52,080,000	2·75
Africa.	1,200,000	1·1	15,904,000	0·84
Japan	...	...	115,280,000	5·56
Mexico	...	...	125,440,000	6·64
Newfoundland	.	....	4,480,000	0·23
Canada	1,300,000	1·2	51,520,000	2·72
United States			1,099,840,000	58·23
	109,708,000	100·0	1,888,768,000	100·0

(a) Compiled by James Douglas, Min. and Sci. Press, May 21, 1910.

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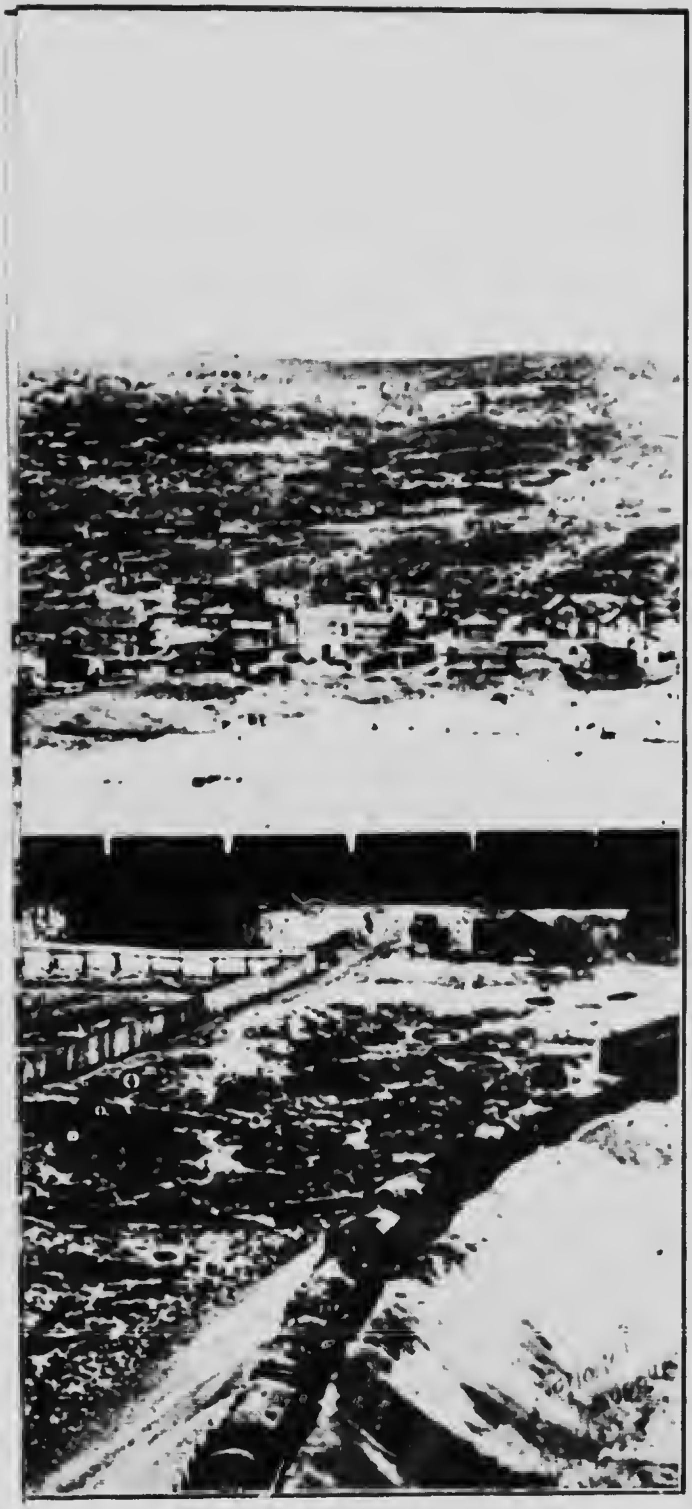
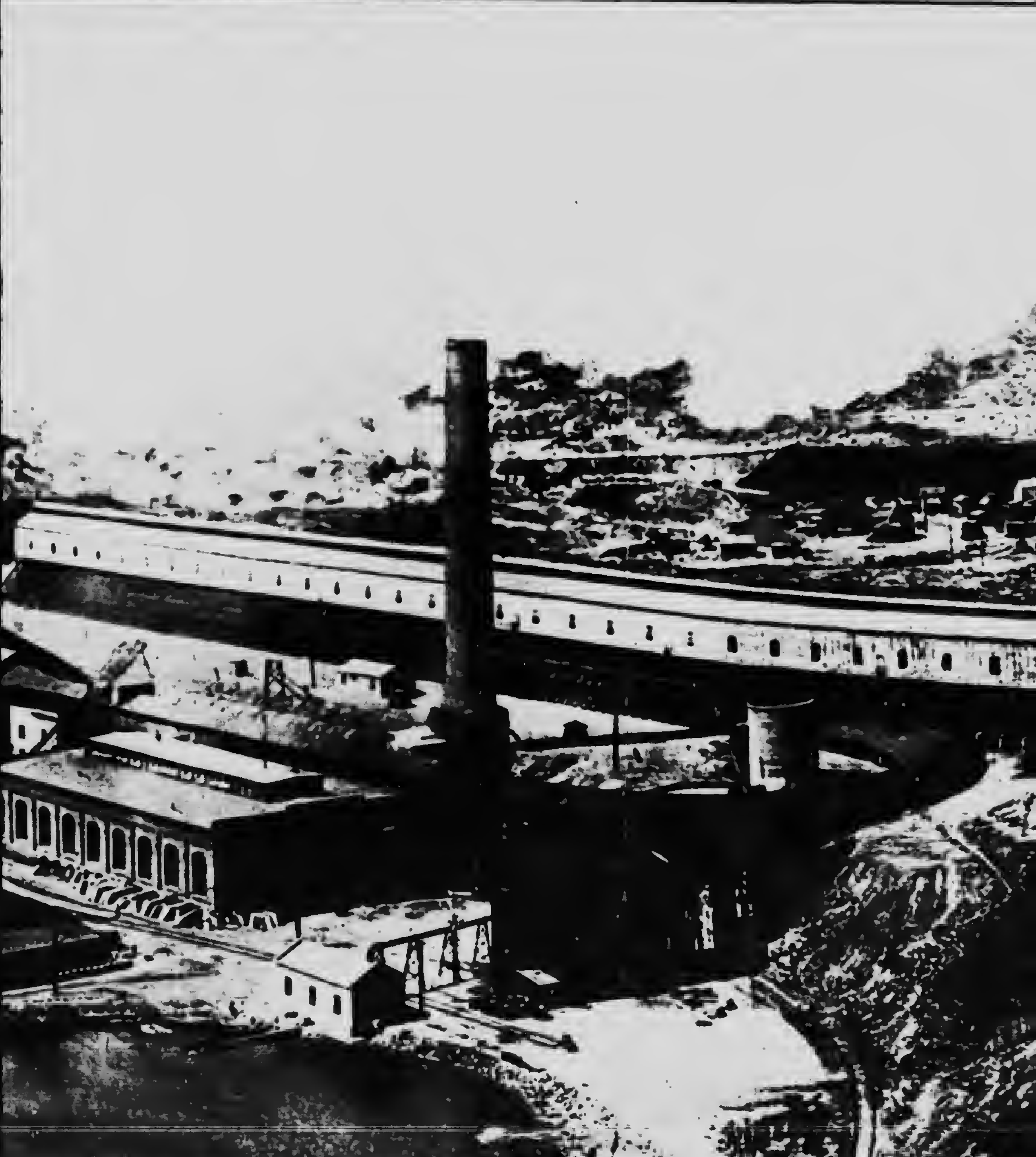
PLATE II.



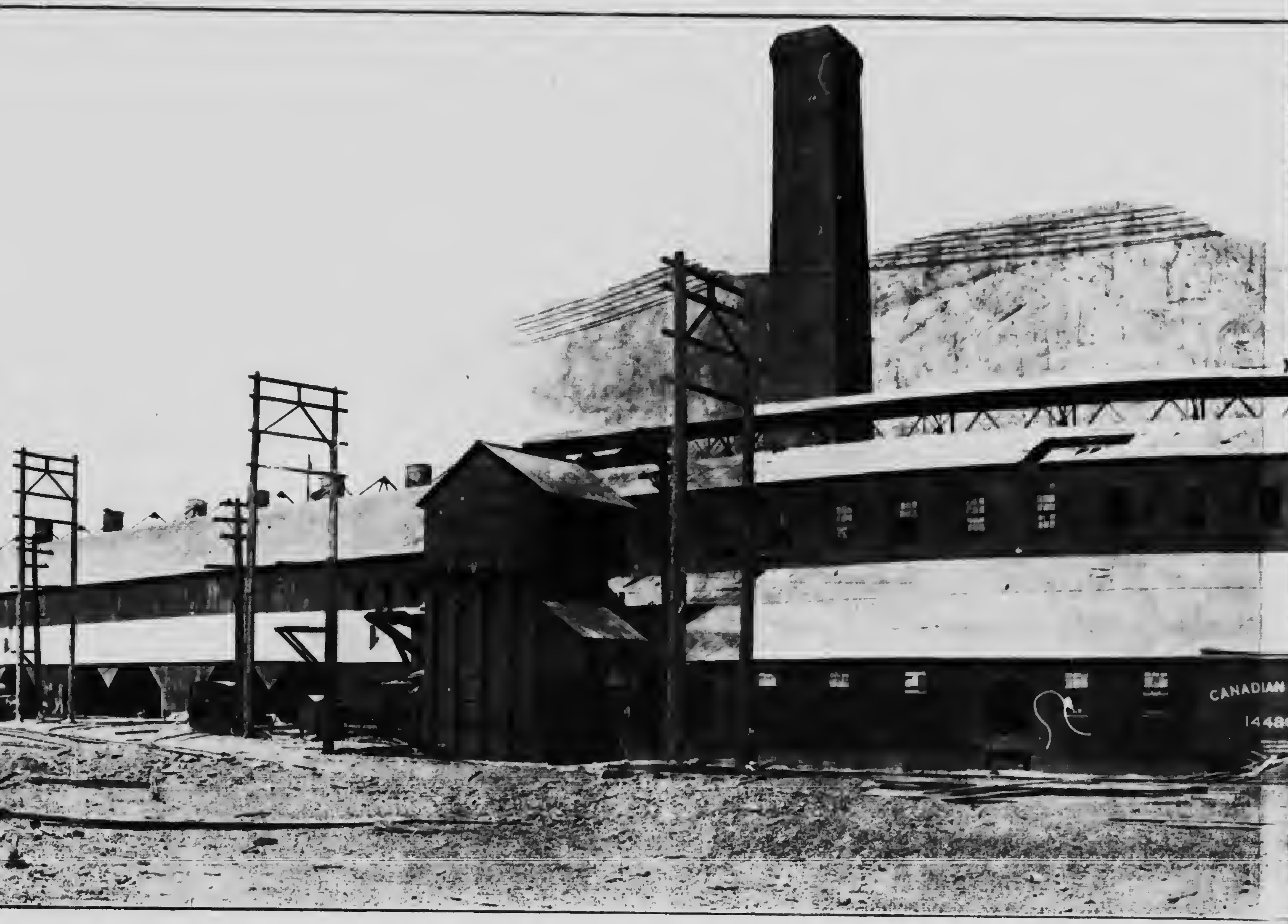
Birds-eye view of the works of the Canadian Copper Company, Copper Cliff, Ont.



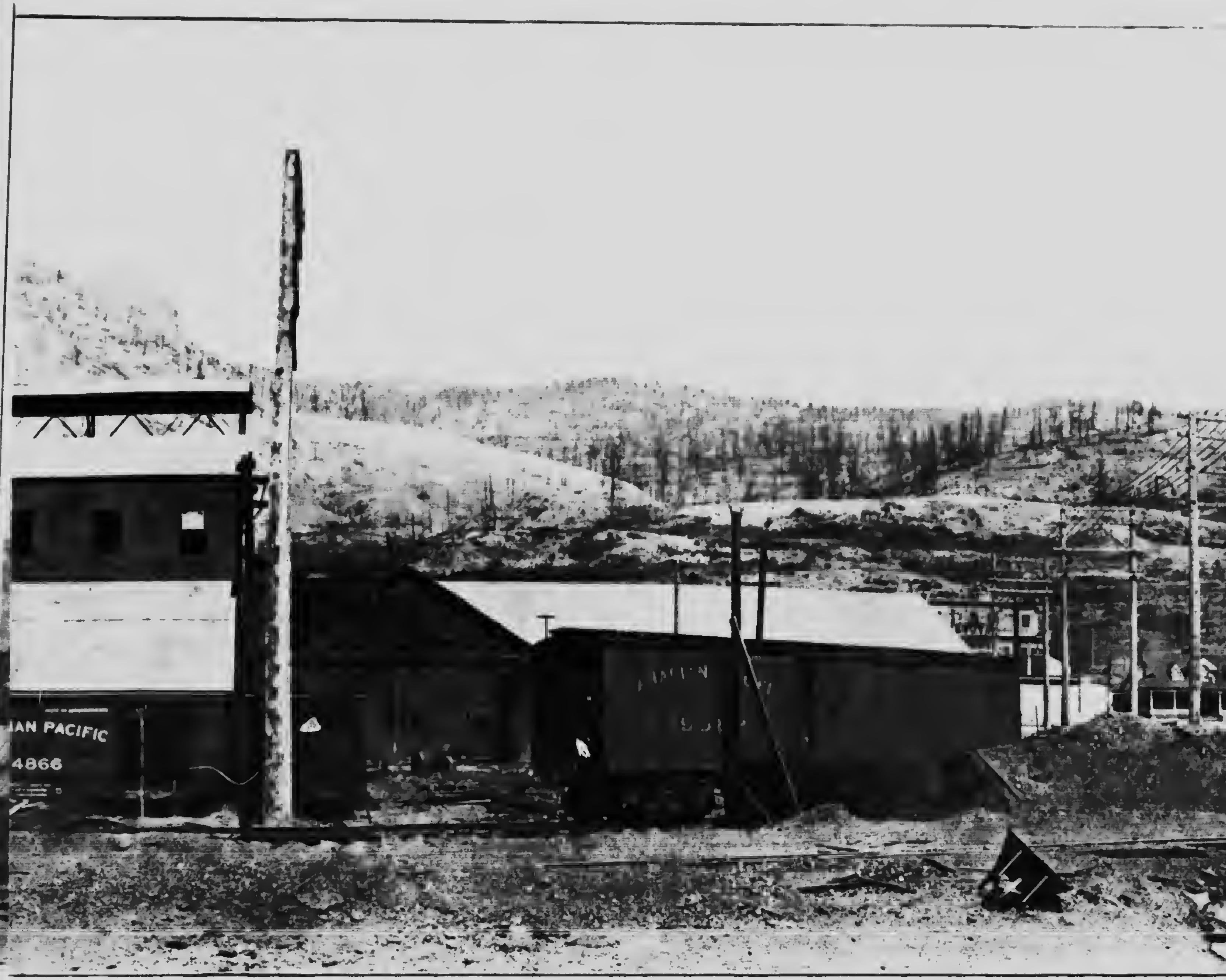
e Canadian Copper Company, Copper Cliff, Ont.

Trail Smelter

… Smelter and Refinery.



Granby Smelter, Grand Forks, B.C.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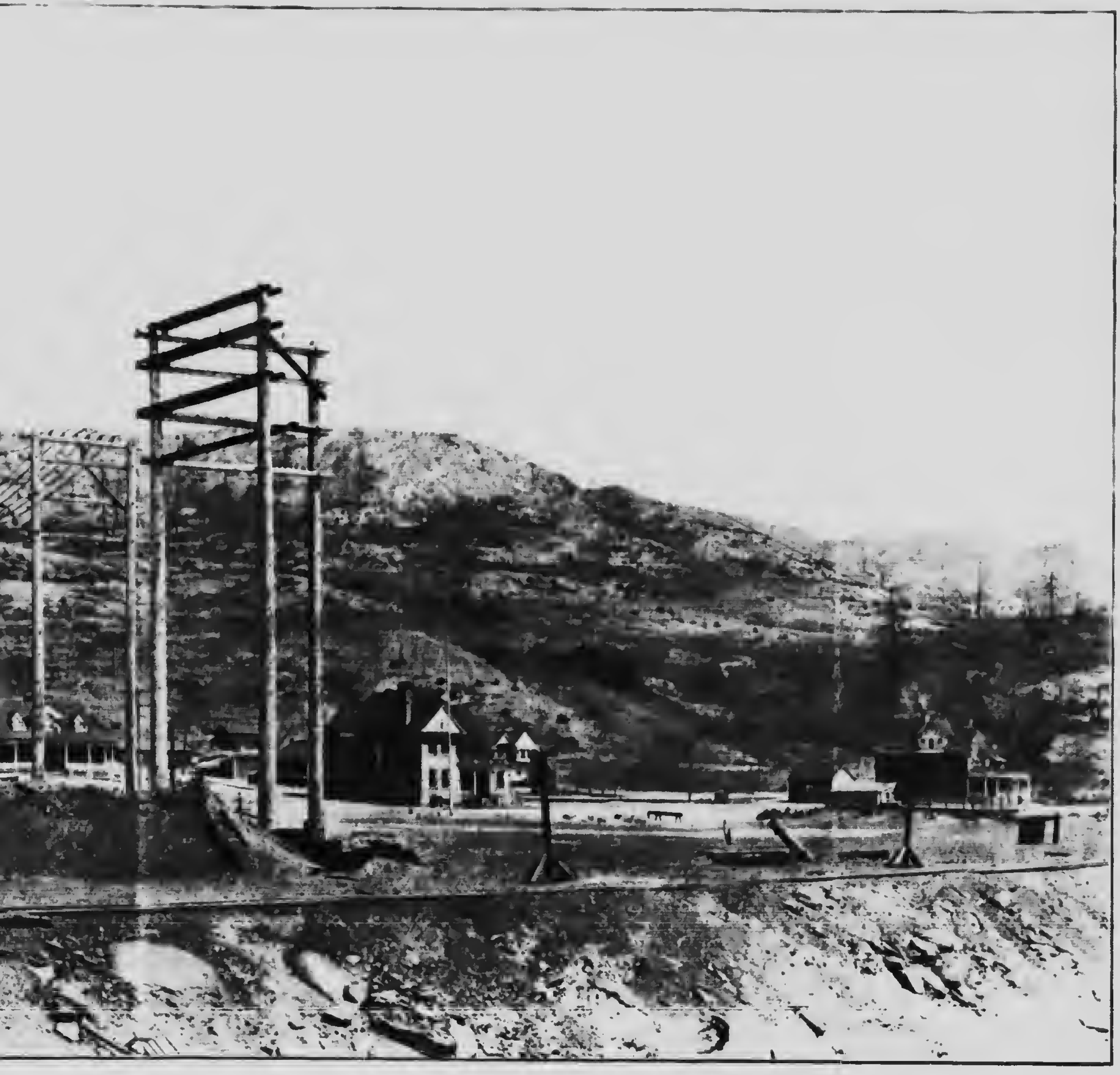

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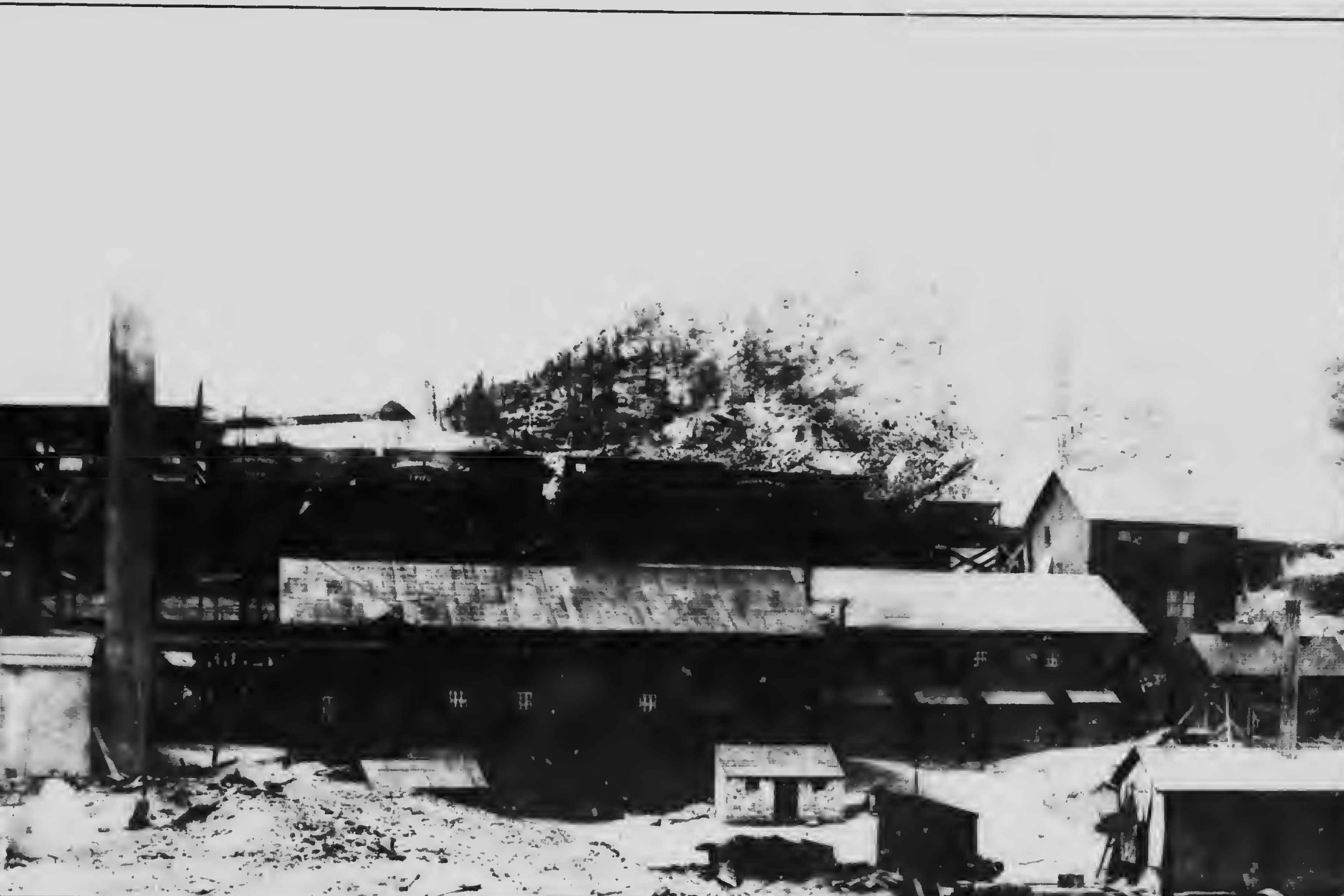

British Columbia Copper Co. Smelter, Gree

per Co. Smelter, Greenwood, B.C.

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REPORTS.

1. Mining Conditions in the Klondike, Yukon. Report on—by Eugene Haanel, Ph.D., 1902.

†2. Great Landslide at Frank, Alta. Report on—by R. G. McConnell and R. W. Brock, M.A., 1903.

†3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Dr. Haanel, 1904.

†4. Rapport de la Commission nommée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe—by Dr. Haanel. (French Edition), 1905.

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†8. Clays and Shales of Manitoba: Their Industrial Value. Preliminary Report on—by J. W. Wells, 1905.

†9. Hydraulic Cements (Raw Materials) in Manitoba: Manufacture and Uses of. Preliminary Report on—by J. W. Wells, 1905.

†10. Mica: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (See No. 118.)

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†16. *Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final Report on—by Dr. Haanel, 1907.

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†19. Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nystrom, M.E., 1908.

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* A few copies of the Preliminary Report, 1906, are still available.
†Publications marked thus † are out of print.

†21. Summary Report of Mines Branch, 1907-8.

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24. General Report on the Mining and Metallurgical Industries of Canada, 1907-8.

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26. The Mineral Production of Canada, 1906. Annual Report on—by John McLeish, B.A.

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†27a. The Mineral Production of Canada, 1908. Preliminary Report on—by John McLeish.

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†28a. French translation: Summary Report of Mines Branch, 1908.

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47. Iron Ore Deposits of Vancouver and Texada islands. Report on—by Einar Lindeman, M.E.

†55. Report on the Bituminous, or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale industry of Scotland—by Dr. R. W. Ells.

58. The Mineral Production of Canada, 1907 and 1908. Annual Report on—by John McLeish.

Note.—*The following preliminary bulletins were published prior to the issuance of the Annual Report for 1907-8.*

†31. Production of Cement in Canada, 1908.

42. Production of Iron and Steel in Canada during the Calendar Years 1907 and 1908

43. Production of Chromite in Canada during the Calendar Years 1907 and 1908.

44. Production of Asbestos in Canada during the Calendar Years 1907 and 1908.

†45. Production of Coal, Coke, and Peat in Canada during the Calendar Years 1907 and 1908.

46. Production of Natural Gas and Petroleum in Canada during the Calendar Years 1907 and 1908.

59. Chemical Analyses of Special Economic Importance made in the Laboratories of the Department of Mines 1906-7-8. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the Commercial Methods and Apparatus for the Analysis of Oil-shales—by H. A. Leverin, Ch. E.).

Schedule of Charges for Chemical Analyses and Assays.

†62. Mineral Production of Canada, 1909. Preliminary Report on—by John McLeish.

63. Summary Report of Mines Branch, 1909.

67. Iron Ore Deposits of the Bristol Mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman and Geo. C. Mackenzie, B.Sc.

†68. Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Dr. Haanel.

69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel. (Second Edition, enlarged.)

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†Publications marked thus † are out of print

†71. Investigation of the Peat Bogs and Peat Industry of Canada, 1908-9, to which is appended Mr. Alf Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. v. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem,' 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. v. Anrep. (Second Edition, enlarged.)

81. French Translation: Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel.

82. Magnetic Concentration Experiments. Bulletin No. 5—by Geo. C. Mackenzie.

83. An investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others.
   Vol. I—Coal Washing and Coking Tests.
   Vol. II—Boiler and Gas Producer Tests.
   Vol. III—
      Appendix I
         Coal Washing Tests and Diagrams.
   Vol. IV—
      Appendix II
         Boiler Tests and Diagrams.
   Vol. V—
      Appendix III
         Producer Tests and Diagrams.
   Vol. VI—
      Appendix IV
         Coking Tests.
      Appendix V
         Chemical Tests.

†84. Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen Islands. Report on—by W. F. Jennison, M.E. (See No. 245.)

88. The Mineral Production of Canada, 1909. Annual Report on—by John McLeish.

   Note.—*The following preliminary bulletins were published prior to the issuance of the Annual Report for 1909.*

   †79. Production of Iron and Steel in Canada during the Calendar Year 1909.

   †80. Production of Coal and Coke in Canada during the Calendar Year 1909.

   85. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials during the Calendar Year 1909.

89. Reprint of Presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Dr. Haanel.

90. Proceedings of Conference on Explosives.

92. Investigation of the Explosives Industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Second Edition.)

93. Molybdenum Ores of Canada. Report on—by Professor T. L. Walker, Ph.D.

100. The Building and Ornamental Stones of Canada, Vol. I. Report on—by Professor W. A. Parks, Ph. D.

100a. French translation: The Building and Ornamental Stones of Canada, Vol. I. Report on—by W. A. Parks.

102. Mineral Production of Canada, 1910. Preliminary Report on—by John McLeish.

†103. Summary Report of Mines Branch, 1910.

104. Catalogue of Publications of Mines Branch, from 1902 to 1911, containing Tables of Contents and List of Maps, etc.

105. Austin Brook Iron-bearing District. Report on—by E. Lindeman.

110. Western Portion of Torbrook Iron Ore Deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Fréchette, M.Sc.

111. Diamond Drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph. D.

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†Publications marked thus † are out of print.

118. Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid, M.E.

142. Summary Report of Mines Branch, 1911.

143. The Mineral Production of Canada, 1910. Annual Report on—by John McLeish.

Note.—*The following preliminary Bulletins were published prior to the issuance of the Annual Report for 1910.*

†114. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, 1910.

†115. Production of Iron and Steel in Canada during the Calendar Year 1910.

†116. Production of Coal and Coke in Canada during the Calendar Year 1910.

†117. General Summary of the Mineral Production of Canada during the Calendar Year 1910.

145. Magnetic Iron Sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie.

†150. The Mineral Production of Canada, 1911. Preliminary Report on—by John McLeish.

151. Investigation of the Peat Bogs and Peat Industry of Canada, 1910-11. Bulletin No. 8—by A. v. Anrep.

154. The Utilization of Peat Fuel for the Production of Power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-11. Report on—by B. F. Haanel, B.Sc.

155. French translation: The Utilization of Peat Fuel for the Production of Power, being a Record of Experiments conducted at the Fuel Testing Station, Ottawa, 1910-11. Report on—by B. F. Haanel.

156. French translation: The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.

167. Pyrites in Canada. Its Occurrence, Exploitation, Dressing, and Uses. Report on—by A. W. G. Wilson.

170. The Nickel Industry: with Special Reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.

184. Magnetite Occurrences along the Central Ontario Railway. Report on—by E. Lindeman.

196. French translation: Investigation of the Peat Bogs and Peat Industry of Canada, 1909-10, to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenburg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. v. Anrep; also a translation of Lieut. Ekelund's Pamphlet entitled "A Solution of the Peat Problem," 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch. E. Bulletin No. 4—by A. v. Anrep. (Second Edition, enlarged.)

197. French translation: Molybdenum Ores of Canada. Report on—by Dr. T. L. Walker.

198. French translation: Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nystrom, M.E., 1908.

201. The Mineral Production of Canada during the Calendar Year 1911. Annual Report on—by John McLeish.

Note.—*The following preliminary Bulletins were published prior to the issuance of the Annual Report for 1911.*

181. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada during the Calendar Year 1911. Bulletin on—by John McLeish.

†182. Production of Iron and Steel in Canada during the Calendar Year 1911. Bulletin on—by John McLeish.

183. General Summary of the Mineral Production in Canada during the Calendar Year 1911. Bulletin on—by John McLeish.

199. Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals of Canada, during the Calendar Year 1911. Bulletin on—by John McLeish.

200. The Production of Coal and Coke in Canada during the Calendar Year 1911. Bulletin on—by John McLeish.

†Publications marked thus † are out of print.

202. French translation: Graphite: Its Properties, Occurrence, Refining and Uses, by Fritz Cirkel, 1907.

216. Mineral Production of Canada, 1912. Preliminary Report on, by John McLeish.

221. Summary Report of the Mines Branch, 1912.

226. French translation: Chrome Iron Ore Deposits of the Eastern Townships. Monograph on, by Fritz Cirkel. (Supplementary Section: Experiments with Chromite at McGill University, by Dr. J. B. Porter.)

Sections of the Sydney Coal Fields, by J. G. S. Hudson.

†229. Summary Report of the Petroleum and Natural Gas Resources of Canada, 1912, by F. G. Clapp. (See No. 224.)

230. Economic Minerals and the Mining Industry of Canada.

231. French translation: Economic Minerals and the Mining Industry of Canada.

233. French translation: Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen Islands. Report on—by W. F. Jennison.

NOTE.—*The following preliminary Bulletins were published prior to the issuance of the Annual Report for 1912.*

238. General Summary of the Mineral Production of Canada, during the Calendar Year 1912. Bulletin on—by John McLeish.

247. Production of Iron and Steel in Canada during the Calendar Year 1912. Bulletin on—by John McLeish.

256. Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals of Canada, during the Calendar Year 1912—by C. T. Cartwright, B.Sc.

257. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials during the Calendar Year 1912. Report on—by John McLeish.

258. Production of Coal and Coke in Canada, during the Calendar Year 1912. Bulletin on—by John McLeish.

NOTE.—*Lists of manufacturers of clay products, stone quarry operators, [illegible] lime kilns, are prepared annually by the Division of Mineral Resources [illegible] may be had on application.*

IN THE PRESS

56. French translation: Bituminous or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale Industry of Scotland—by R. W. Ells.

149. French translation: Magnetic Iron Sands of Natashkwan, [illegible]. Report on—by Geo. C. Mackenzie.

180. French translation: Investigation of the Peat Bogs and Peat Industry of Canada, 1910-11. Bulletin No. 8—by A. v. Anrep.

209. The Copper Smelting Industry of Canada. Report on—by A. W. G. Wilson.

Lode Mining in Yukon: An Investigation of [illegible] Deposits of the [illegible]. Report on—by T. A. MacLean, B.A.Sc.

245. Gypsum in Canada: Its Occurrence, Exploitation, and Technology. Report on—by L. H. Cole.

254. Calabogie Iron-Bearing District. Report on—by E. Lindeman.

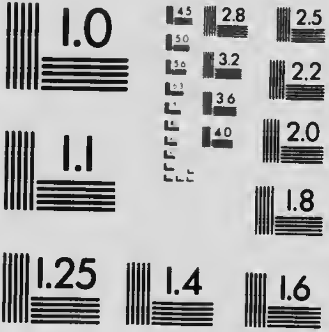
259. Preparation of Metallic Cobalt by Reduction of the Oxide. Report on—by H. T. Kalmus, B.Sc., Ph.D.

262. The Mineral Production of Canada during the Calendar Year [illegible]—by John McLeish.

† Publications marked thus † are out of print.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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263. French translation. Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Dr Haanel.

264. French translation: Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid.

265. French translation: Annual Mineral Production of Canada, 1911. Report on—by John McLeish.

MAPS

†6. Magnetometric Survey, Vertical Intensity: Calabogie Mine, Bagot township, Renfrew county, Ontario—by E. Nystrom, 1904. Scale 60 feet = 1 inch. Summary report, 1905. (See Map No. 249.)

†13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905. Scale 60 feet = 1 inch. Summary report, 1905. (See Map No. 186.)

†14. Magnetometric Survey of the Wilbur Mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905. Scale 60 feet = 1 inch. Summary report, 1905.

†33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet = 1 inch.

†34. Magnetometric Survey, Vertical Intensity: Lots 2 and 3, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet = 1 inch.

†35. Magnetometric Survey, Vertical Intensity: Lots 10, 11, and 12, Concession IX, and Lots 11 and 12, Concession VIII, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet = 1 inch.

*36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nystrom, and A. v. Anrep. (Accompanying report No. 30.)

*37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nystrom, and A. v. Anrep. (Accompanying report No. 30.)

*38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*39. Survey of Newington Peat Bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario —by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*48. Magnetometric Survey of Iron Crown claim at Klaanch river, Vancouver island, B.C.—by E. Lindeman. Scale 60 feet = 1 inch. (Accompanying report No. 47.)

*49. Magnetometric Survey of Western Steel Iron claim, at Sechart, Vancouver island, B.C.—by E. Lindeman. Scale 60 feet = 1 inch. (Accompanying report No. 47.)

*53. Iron Ore Occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White and Fritz Cirkel. (Accompanying report No. 23.)

*54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel. (Accompanying report No. 23).

†57. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel. (Accompanying report No. 29.)

†60. Magnetometric Survey of the Bristol Mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet = 1 inch. (Accompanying report No. 67.)

*61. Topographical Map of Bristol Mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet = 1 inch. (Accompanying report No. 67.)

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison.
†65. Index Map of New Brunswick: Gypsum—by W. F. Jennison. (Accompanying report No. 84.)
†66. Map of Magdalen Islands: Gypsum—by W. F. Jennison.

†70. Magnetometric Survey of Northeast Arm Iron Range, Lake Timagami, Nipissing District, Ontario—by E. Lindeman. Scale 200 feet = 1 inch. (Accompanying report No. 63.)

†72. Brunner Peat Bog, Ontario—by A. v. Anrep.
†73. Komoka Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No. 71.)
†74. Brockville Peat Bog, Ontario—by A. v. Anrep.

†75. Rondeau Peat Bog, Ontario—by A. v. Anrep.
†76. Alfred Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No. 71.)
†77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. v. Anrep.

†78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel. Scale 1 mile = 1 inch. (Accompanying report No. 69.)

†94. Map showing Cobalt, Gowganda, Shiningtree, and Porcupine districts—by L. H. Cole, B.Sc. (Accompanying Summary report, 1910.)

*95. General Map of Canada, showing Coal Fields. (Accompanying report No. 83—by Dr. J. B. Porter.)

*96. General Map of Coal Fields of Nova Scotia and New Brunswick. (Accompanying report No. 83—by Dr. J. B. Porter.)

*97. General Map showing Coal Fields in Alberta, Saskatchewan, and Manitoba. (Accompanying report No. 83—by Dr. J. B. Porter.)

*98. General Map of Coal Fields in British Columbia. (Accompanying report No. 83—by Dr. J. B. Porter.)

*99. General Map of Coal Field in Yukon Territory. (Accompanying report No. 83—by Dr. J. B. Porter.)

†106. Geological Map of Austin Brook Iron Bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman. Scale 400 feet = 1 inch. (Accompanying report No. 105.)

†107. Magnetometric Survey, Vertical Intensity: Austin Brook Iron Bearing District—by E. Lindeman. Scale 400 feet = 1 inch. (Accompanying report No. 105.)

*108. Index Map showing Iron Bearing Area at Austin Brook—by E. Lindeman. (Accompanying report No. 105.)

*112. Sketch plan showing Geology of Point Mamainse, Ont.—by Professor A. C. Lane. Scale, 4,000 feet = 1 inch. (Accompanying report No. 111.)

†113. Holland Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No. 151.)

*119-137. Mica: Township maps, Ontario and Quebec—by Hugh S. de Schmid. (Accompanying report No. 118.)

†138. Mica: Showing Location of Principal Mines and Occurrences in the Quebec Mica Area—by Hugh S. de Schmid. Scale 3·95 miles = 1 inch. (Accompanying report No. 118.)

†139. Mica: Showing Location of Principal Mines and Occurrences in the Ontario Mica Area—by Hugh S. de Schmid. Scale 3·95 miles = 1 inch. (Accompanying report No. 118.)

†140. Mica: Showing Distribution of the Principal Mica Occurrences in the Dominion of Canada—by Hugh S. de Schmid. Scale 3·95 miles = 1 inch. (Accompanying report No. 118.)

†141. Torbrook Iron Bearing District, Annapolis county, N.S.—by Howells Fréchette. Scale 400 feet = 1 inch. (Accompanying report No. 110.)

†146. Distribution of Iron Ore Sands of the Iron Ore Deposits on the North Shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie. Scale 100 miles = 1 inch. (Accompanying report No. 145.)

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†147. Magnetic Iron Sand Deposits in Relation to Natashkwan harbour and Great Natashkwan river, Que. (Index Map)—by Geo. C. Mackenzie. Scale 40 chains = 1 inch. (Accompanying report No. 145.)

†148. Natashkwan Magnetic Iron Sand Deposits, Saguenay county, Que.—by Geo. C. Mackenzie. Scale 1,000 feet = 1 inch. (Accompanying report No. 145.)

†152. Map showing the Location of Peat Bogs investigated in Ontario—by A. v. Anrep.

†153. Map Showing the Location of Peat Bogs investigated in Manitoba—by A. v. Anrep.

†157. Lac du Bonnet Peat Bog, Manitoba—by A. v. Anrep.

†158. Transmission Peat Bog, Manitoba—by A. v. Anrep.

†159. Corduroy Peat Bog, Manitoba—by A. v. Anrep.

†160. Boggy Creek Peat Bog, Manitoba—by A. v. Anrep.

†161. Rice Lake Peat Bog, Manitoba—by A. v. Anrep.

†162. Mud Lake Peat Bog, Manitoba—by A. v. Anrep.

†163. Litter Peat Bog, Manitoba—by A. v. Anrep.

†164. Julius Peat Litter Bog, Manitoba—by A. v. Anrep.

(Accompanying report No 151.)

†165. Fort Francis Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No. 151.)

*166. Magnetometric Map of No. 3 Mine, Lot 7, Concessions V and VI, McKim township, Sudbury district, Ont.—by E. Lindeman. (Accompanying Summary report, 1911.)

†168. Map showing Pyrites Mines and Prospects in Eastern Canada, and Their Relation to the United States Market—by A. W. G. Wilson. Scale 125 miles = 1 inch. (Accompanying report No. 167.)

†171. Geological Map of Sudbury Nickel region, Ont.—by Prof. A. P. Coleman. Scale 1 mile = 1 inch. (Accompanying report No. 170.)

†172. Geological Map of Victoria Mine—by Prof. A. P. Coleman.

†173. " " Crean Hill Mine—by Prof. A. P. Coleman.

†174. " " Creighton Mine—by Prof. A. P. Coleman.

(Accompanying report No. 170.)

†175. " " showing Contact of Norite and Laurentian in vicinity of Creighton mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†176. " " of Copper Cliff offset—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†177. " " No. 3 Mine—by Prof. A. P. Coleman. (Accompanying report No. 170).

†178. " " showing vicinity of Stobie and No. 3 mines—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†185. Magnetometric Survey, Vertical Intensity: Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†185a. Geological Map, Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†186. Magnetometric Survey, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†186a. Geological Map, Belmont iron mine, Belmont township, Peterborough county, Ont.—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

†187. Magnetometric Survey, Vertical Intensity: St. Charles [illegible] Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†187a. Geological Map, St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†188. Magnetometric Survey, Vertical Intensity: Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†188a. Geological Map, Baker Mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†189. Magnetometric Survey, Vertical Intensity: Ridge iron ore deposits, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†190. Magnetometric Survey, Vertical Intensity: Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†190a. Geological Map, Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†191. Magnetometric Survey, Vertical Intensity: Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†191a. Geological Map, Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†192. Magnetometric Survey, Vertical Intensity: Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†192a. Geological Map, Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†193. Magnetometric Survey, Vertical Intensity: Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†193a. Geological Map, Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†194. Magnetometric Survey, Vertical Intensity: Bow Lake iron ore occurrences, Faraday township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet = 1 inch. (Accompanying report No. 184.)

†201. Index Map, Magnetite occurrences along the Central Ontario Railway—by E. Lindeman, 1911. (Accompanying report No. 184.)

205. Magnetometric Map, Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman, 1912. (Accompanying report No. 266.)

205a. Geological Map, Moose Mountain iron-bearing district, Sudbury district, Ontario. Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman. (Accompanying report No. 266.)

*206. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario. Northern part of Deposit No. 2—by E. Lindeman, 1912. Scale, 200 feet = 1 inch. (Accompanying report No. 266.)

*207. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: D[illegible] Nos. 8, 9, and 9A—by E. Lindeman, 1912. Scale 200 feet = 1 inch. (Accompanying r[illegible]o. 266.)

*208. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposit No. 10—by E. Lindeman, 1912. Scale 200 feet = 1 inch. (Accompanying report No. 266.)

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

*208a. Magnetometric Survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: Eastern portion of Deposit No. 11—by E. Lindeman, 1912. Scale, 200 feet = 1 inch. (Accompanying report No. 266.)

*208b. Magnetometric Survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: Western portion of Deposit No. 11—by E. Lindeman, 1912. Scale, 200 feet = 1 inch. (Accompanying report No. 266.)

*208c. General Geological Map, Moose Mountain iron-bearing district, Sudbury district, Ontario—by E. Lindeman, 1912. Scale, 800 feet = 1 inch. (Accompanying report No. 266.)

*210 Location of Copper Smelters in Canada—by A. W. G. Wilson, Ph.D. Scale, 197·3 miles = 1 inch. (Accompanying report No. 209.)

*220. Mining Districts, Yukon—by T. A. MacLean. Scale 35 miles = 1 inch. (Accompanying report No. 222.)

*221. Dawson Mining District, Yukon—by T. A. MacLean. Scale 2 miles = 1 inch. (Accompanying report No. 222.)

*232. Mineral Map of Canada. Scale 100 miles = 1 inch. (Accompanying report No. 230.)

*249. Magnetometric Survey, Caldwell and Campbell mines, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale, 200 feet = 1 inch. (Accompanying report No. 254.)

*250. Magnetometric Survey, Black Bay or Williams Mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale, 200 feet = 1 inch. (Accompanying report No. 254.)

*251. Magnetometric Survey, Bluff Point iron mine, Calabogie district, Renfrew county, Ontario —by E. Lindeman, 1911. Scale, 200 feet = 1 inch. (Accompanying report No. 254.)

*252. Magnetometric Survey, Culhane mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale, 200 feet = 1 inch. (Accompanying report No. 254.)

*253. Magnetometric Survey, Martel or Wilson iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale, 200 feet = 1 inch. (Accompanying report No. 254.)

*261. Magnetometric Survey, Northeast Arm iron range, Lot 339 E.T.W. Lake Timagami, Nipissing district, Ontario—by E. Nystrom, 1903. Scale, 200 feet = 1 inch.

IN THE PRESS.

268. Map of Peat Bogs Investigated in Quebec—by A. v. Anrep, 1912.

269. Large Tea Field Peat Bog, Quebec " "

270. Small Tea Field Peat Bog, Quebec " "

271. Lanorie Peat Bog, Quebec " "

272. St. Hyacinthe Peat Bog, Quebec " "

273. Rivière du Loup Peat Bog " "

274. Cacouna Peat Bog " "

275. Le Parc Peat Bog, Quebec " "

276. St. Denis Peat Bog, Quebec " "

277. Rivière Ouelle Peat Bog, Quebec " "

278. Moose Mountain Peat Bog, Quebec

Address all communications to—

DIRECTOR MINES BRANCH,
DEPARTMENT OF MINES,
SUSSEX STREET, OTTAWA

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

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