The story of

The CONSOLIDATED MINING & SMELTING COMPANY OF CANADA LIMITED.
The
CONSOLIDATED MINING & SMELTING
COMPANY OF CANADA
LIMITED

PRODUCERS & REFINERS OF
TADANAC BRAND METALS
GOLD
SILVER
LEAD
ZINC
CADMIUM
BISMUTH
ANTIMONY

MANUFACTURERS
OF
SULPHURIC ACID
REFINED SULPHUR
and
"ELEPHANT BRAND"
NITROGEN and
PHOSPHORUS
FERTILIZERS

METALLURGICAL
AND
CHEMICAL PLANTS
TRAIL B.C.

HEAD OFFICE
215 St. James Street, W.
MONTREAL
P.Q.

BRANCH OFFICE
502 Bay Street
TORONTO
ONT.

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5TH Floor Marine Bldg
VANCOUVER
B.C.
The Story of the Consolidated Mining and Smelting Company of Canada, Limited

HISTORY

The Consolidated Mining and Smelting Company of Canada, Limited was formed in 1906 by combining the smelter interests of the Canadian Pacific Railway Company with those of the Centre Star and War Eagle companies of Rossland, and the St. Eugene Company of Moyie, which at that time was the principal lead producer of the district. Since then the development of the huge silver-lead-zinc ore body of the Sullivan Mine, which was taken over by the Company in 1910, has raised the Consolidated Company to the position of the largest producer of non-ferrous metals in the British Empire.

To view the historical background of this industry one must go back almost 50 years to the beginning of the Rossland camp. In 1890, claims were first located on the gold-copper lodes around which the City of Rossland rapidly grew and which brought southern British Columbia into prominence in the mining world. It is interesting to note that during the summer of that year, two men, Bourgeois and Morris, located in one day, the LeRoi (then the Louis claim), Centre Star, War Eagle, Idaho and Virginia claims. During the next few years the young camp developed rapidly, shipping its ore by wagon road to Trail Creek on the Columbia River and then by steamer and rail to Montana for smelting. The year 1895 was one of great activity and marked the construction by Augustus Heinze of Butte, Montana, of a copper smelting plant at Trail. In February 1896 the first furnace was blown in. At this time Heinze also built a railway of three-foot gauge between Trail and Rossland, on which wood-burning locomotives were used. In 1896 the Red Mountain railway connecting Rossland with Northport was completed, giving standard gauge connections with three trans-continental lines at Spokane. At this time Rossland had a population of about six thousand.

View of Red Mountain, Rossland, B. C., 1901, showing the LeRoi, Josie, Number One, War Eagle and Centre Star Mines

One
This was a period of intense competition between the Canadian Pacific and the Great Northern Railways along the border. The completion in 1895 of the Crowfoot branch of the Canadian Pacific built through the coal fields to Kootenay Lake was an important event. In the same year the West Kootenay Power and Light Company completed its power plant at Bonnington Falls, 32 miles distant from Rossland, on the Kootenay River. Coal, coke and electric power were thus made available for the Trail Smelter and the Rossland Mines. In 1898 the Canadian Pacific Railway acquired the Heinze railway interests running out of Trail and in the same year acquired the Smelter. The standard gauge line to Rossland was completed in July 1899.

The Smelter was at this time being operated on gold-copper ores as the Canadian Smelting Works. It was then decided to enter the lead smelting field and a blast furnace was installed in the year 1901. The lead ore of the Kootenays had three possible routes to follow, namely, to United States plants, to the Hall Mines smelter at Nelson and to Trail. The bullion produced at Nelson and Trail was shipped in bond to the Selby Plant on San Francisco Bay for refining.

The refined lead was sold in Eastern Canada and in the Orient and this marked the beginning of the present export from Trail of refined metals which today supply about 11 per cent of the world's requirements of lead and 10 per cent of the zinc, as well as considerable quantities of gold, silver, cadmium and bismuth.

In the year 1902 the company started experimenting with the refining of lead bullion in Trail which soon resulted in a small plant using the Betts electrolytic process. Since then the refinery has been extended until at the present time about 575 tons of refined lead are produced daily.

In 1906 the Canadian Pacific Railway combined its smelter interests with a number of mining companies to form the Canadian Consolidated Mines Limited. A few months later this name was changed to the Consolidated Mining and Smelting Company of Canada, Limited, by which name the company is still known.

In 1909 the production of copper-gold ores from Rossland and of the lead ore from the St. Eugene appeared to be definitely on the decline, so the Consolidated Company was very alert for prospective new mines. It was in this year that the Company took a lease and option on the Sullivan Mine in East Kootenay.
This mine which has now become world famous was discovered in 1892 by Pat Sullivan and three associates who had, a few months earlier, left the Coeur d'Alene country to seek their fortunes in the Kootenay Lake District of British Columbia. From 1896 to 1899 some surface stripping was done and several small shafts sunk. In 1900 the Canadian Pacific Railway completed a branch line of 19 miles from Cranbrook on the Crownest Line to handle the ore from the mines of the Kimberley area. Of these, the North Star was the main producer at that time and in 1900 shipped 16,000 tons averaging 50 to 55 per cent lead and 20 to 25 ounces per ton of silver. In the same year systematic development of the Sullivan Mine was started and during the three following years from four to five thousand tons of 35 to 40 per cent lead ore carrying about 15 ounces of silver, were shipped to the Hall Mines Smelter at Nelson and to the Canadian Smelting Works at Trail.

By this time it was considered that the ore tonnage developed justified the construction of a smelter and in 1903 this was commenced at Marysville, five miles from Kimberley on the St. Mary's river at Mark Creek. Many serious metallurgical difficulties were encountered and overcome during the smelting of some 75,000 tons of ore. Owing to financial difficulties, the smelter and mine were forced to close down late in 1907. The Company was reorganized in 1909 with the Federal Mining and Smelting Company holding control. In December of the same year the Consolidated Company took an option on the property, which option was exercised the following year and much adjoining property acquired. Shipments to Trail of an improved grade of lead ore as a result of hand sorting were then commenced.

Almost immediately an active investigation was started on the problem of separation and treatment of the complex zinc-lead-silver ore. The LeRoy mill at Rossland and the Highland mill at Ainsworth were first used for test work and later the St. Eugene mill was remodelled to accommodate this work, but was destroyed by fire in 1916, and from then on the investigational work was carried on at Trail. During these years ore high in lead and silver and low in zinc was mined and shipped to Trail for smelting. Annual tonnages rose from 23,000 in 1910 to 44,650 in 1915.

In 1914 the Sullivan mine became the largest lead producer in Canada and has retained that distinction up to the present time. During the period of increasing lead shipments, investigations for the extraction of zinc values were being carried on, and during the first year of the Great War an experimental electrolytic zinc plant was started. In 1915 a commercial plant was built and early in 1916 operation was started on crude Sullivan ore running 25 to 35 per cent zinc. This was an economic proposition only because of the high prices of metals at that time.

It then became very evident that cheap power was one of the prime necessities for the prospective electrolytic refineries at Trail and so in 1916 the Consolidated Company obtained control of the West Kootenay Power and Light Company by acquiring all of its common stock and arranged for its expansion. The West Kootenay Power and Light Company has now a total installed generating capacity of 226,000 horse power in its four plants on the Kootenay river.

In 1917 a trial was made of the Horwood process of ore concentration in a 150-ton mill at Trail. This was abandoned on account of high costs and difficult control. Gravity concentration tests using finely ground ore were then tried out but also proved disappointing. Wet magnetic concentration gave some promising results and was operated first at 150 and then at 600 tons per day. Encouraging results with the flotation process led to the decision to parallel the 600-ton magnetic plant with a flotation plant. Operation of this was started in March 1920 and it was soon very apparent that it would render obsolete the magnetic separation method for Sullivan ore. The 600-ton magnetic plant was immediately remodelled to enlarge the flotation operation. In August 1920, the first lead concentrate by differential flotation was made. For the next three years the test mill underwent a long series of changes, both mechanical and metallurgical, with the objects in view of meeting the demands of consuming plants and collecting data for the design of the proposed Sullivan Concentrator at Kimberley. The latter was built and operation commenced in August, 1923, with a capacity of 3000 tons per day. This has since been increased to 6500 tons per day.

The solving of the concentration problem provided high grade concentrates of lead and zinc, facilitating the development of a zinc recovery process which could compete successfully with other methods. This plant, after a number of extensions, now has a capacity of 400 tons of cathode zinc per day.

Apart from improving operations, the developments during recent years have been concerned...
1930 was the beginning of blast slag fuming to increase \( Zn \) \( Pb \) recovery.

Q: Why the need to improve recovery?
A: Because otherwise they would lose that commodity downriver.

Slag composition has changed as ore characteristics and smelting processes have changed. But from 1917 to the Sullivan Mine closed in 2000, it has been the primary feed source for the Trail Smelter. From 1930 until the mid 1990s the smelter process was more or less static except during upset conditions.
ed mainly with the recovery of by-products from the lead and zinc operations. Investigation of the recovery of zinc and lead from lead blast furnace slag by electrothermic and fuming methods led to the selection of the latter process and a plant for this purpose was completed in July 1930.

A concerted effort was also made to recover the sulphur dioxide emitted in low concentrations from the zinc and lead stacks. The degree of success achieved is eminently shown by the existing sulphuric acid and elemental sulphur plants which have an average daily production of 400 tons and 80 tons respectively. In 1930, after several years investigation, the company embarked on an ambitious fertilizer production programme as an outlet for the large quantities of sulphuric acid. These modern plants, constructed at Warfield, about a mile from Trail, produce ammonia, ammonium sulphate and the phosphates of ammonia and lime. These fertilizer products are largely sold in foreign markets.

Other by-products recovered in recent years include refined cadmium and bismuth. In 1938 electrolytic antimony and an arsenic product will be added to the list.

The only major problem that remains, so far as Sullivan ore is concerned, is the utilization of the iron sulphide mill tailing.

The Sullivan Mine has been the Company's principal producer since 1917 and has reserves of ore for many years to come. The Mines Department has for the past several years carried on a very energetic exploration programme throughout the world and particularly throughout the Dominion of Canada. The discoveries indicate substantial progress in many directions.

The tables shown on the pages following give a summary of production to date. Following the tables are given short descriptions of the various operations and of some of the principal services.
The Consolidated Mining and Smelting Company of Canada, Limited

MINE PRODUCTION 1894 TO DATE

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<tr>
<th>Year</th>
<th>Short Tons Ore Keno lard Mines</th>
<th>Short Tons Ore St. Eugene Mine</th>
<th>Short Tons Ore Sullivan Mine</th>
<th>Short Tons of Ore and Customs Concentrates treated at Kimberley and Trail Plants</th>
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The Consolidated Mining and Smelting Company of Canada, Limited

PRODUCTION OF METALS, CHEMICALS AND FERTILIZERS 1894-1937

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<th>Short Tons Zinc</th>
<th>Short Tons Cadmium</th>
<th>Short Tons Bismuth</th>
<th>Short Tons Sulphur</th>
<th>Short Tons Sulphuric Acid</th>
<th>Short Tons Ammonium Sulphate</th>
<th>Short Tons Other Fertilizer</th>
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<td>47</td>
<td>36,170</td>
<td>6,485</td>
<td>18,571</td>
</tr>
<tr>
<td>1921</td>
<td>33,146</td>
<td>5,522,366</td>
<td>384</td>
<td>126,619</td>
<td>65,284</td>
<td>33</td>
<td></td>
<td>73,038</td>
<td>46,721</td>
<td>14,420</td>
</tr>
<tr>
<td>1922</td>
<td>22,393</td>
<td>5,551,349</td>
<td>270</td>
<td>127,319</td>
<td>68,810</td>
<td>123</td>
<td>35</td>
<td>64,219</td>
<td>65,810</td>
<td>3,058</td>
</tr>
<tr>
<td>1923</td>
<td>33,328</td>
<td>7,316,231</td>
<td>784</td>
<td>157,674</td>
<td>110,978</td>
<td>147</td>
<td>123</td>
<td>95,434</td>
<td>55,780</td>
<td>26,717</td>
</tr>
<tr>
<td>1924</td>
<td>65,113</td>
<td>7,594,566</td>
<td>518</td>
<td>164,329</td>
<td>119,840</td>
<td>275</td>
<td>4</td>
<td>120,245</td>
<td>42,949</td>
<td>37,697</td>
</tr>
<tr>
<td>1925</td>
<td>69,330</td>
<td>8,615,795</td>
<td>433</td>
<td>182,541</td>
<td>125,693</td>
<td>263</td>
<td>180</td>
<td>3,464</td>
<td>126,579</td>
<td>71,630</td>
</tr>
<tr>
<td>1926</td>
<td>52,435</td>
<td>9,846,545</td>
<td>2,292</td>
<td>206,579</td>
<td>142,650</td>
<td>218</td>
<td></td>
<td>13,533</td>
<td>112,194</td>
<td>57,818</td>
</tr>
</tbody>
</table>

* Canadian Smelting Works, 1894 to June 30, 1906.
† C. M. & S. Co. of Canada Ltd., June 30 to Dec. 31, 1906.
six inch by a primary jaw crusher and to three inch by secondary gyratory crushers. The ore is then transported to the concentrator two and three quarter miles away. At present the average daily output is 7500 tons for six days a week.

Men going on shaft, Sullivan Mine, Kimberley, B. C.

SULLIVAN MILL

The intermediate crushing equipment consists of a seven-foot Symons cone crusher and two sets of 72-inch by 26-inch Garfield type rolls, working in parallel, and in closed circuit with hammer screens.

The screen undersize, approximately 10 per cent plus 1 inch, passes through the storage bins—9000 ton capacity—to the three-stage grinding circuit using Hardinge mills, Dorr and Akins classifiers and Willey pumps for circulation. The pulp is delivered to Minerals Separation flotation machines at a consistency of approximately 42 per cent solids.

The heaviest sulphide, galena, with which most of the silver content of the ore is recovered, is floated first. The separation is accomplished through the use of sodium carbonate, sodium ethyl xanthate and creosote oils as activators and sodium cyanide to depress the zinc. The rough concentrate is cleaned twice and shipped to Trail as a 70 per cent lead product containing some 26 ounces of silver per ton.

The dressed pulp passes directly to zinc flotation machines in which a rough zinc concentrate is made using copper sulphate, heat, additional xanthate and oils as activators and lime as an iron depressant. The temperature of all zinc pulps is maintained at 30 C. The rough zinc concentrate is cleaned twice and shipped to Trail as a 53 per cent zinc product. The Sullivan zinc sulphide is in the form of a high iron marmatite containing about 60 per cent zinc and 8 to 9 per cent iron.

Eight
concentrates. American filters for the zinc, and Oliver drum type filters for the lead.

The lead concentrate is conveyed immediately to standard railway cars on track scales, but the zinc concentrate is first dried to about five per cent moisture before loading in a similar manner. These together make up a daily train for Trail of some 800 tons of lead concentrate, and 750 tons of zinc concentrate.

General view of Sullivan Mill, Kimberley, B. C.

A major portion of the feed water is reclaimed for conservation of water, heat and reagents. The iron tailing is impounded in an area below the plant of some 200 acres in extent.

Typical analyses of the mill feed and lead and zinc concentrate are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Au</th>
<th>Ag</th>
<th>Pb</th>
<th>Zn</th>
<th>Cu</th>
<th>S</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill Feed</td>
<td>4.07</td>
<td>10.3</td>
<td>6.45</td>
<td>.07</td>
<td>28.2</td>
<td>36.1</td>
<td></td>
</tr>
<tr>
<td>Lead Conc.</td>
<td>25.7</td>
<td>70.0</td>
<td>5.7</td>
<td>.24</td>
<td>17.3</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Zinc Conc.</td>
<td>2.2</td>
<td>3.5</td>
<td>51.5</td>
<td>14</td>
<td>32.8</td>
<td>11.4</td>
<td></td>
</tr>
</tbody>
</table>

OTHER MILLS

The company has several mills besides the Sullivan in actual operation, or nearing that stage. The new Golden Rose, near Sudbury, Ontario, a 100-ton plant, employs straight cyanidation, and the Big Missouri, near Stewart, B. C., a 750-ton project, employs a combination of flotation and cyanidation.

The Con, on Great Slave Lake, a 100-ton unit, and the Box, on Lake Athabaska, a 1500-ton unit, will both employ straight cyanidation and are expected to go into operation during 1938.

LEAD SMELTER

Sullivan lead concentrate constitutes 60-65 per cent of the total tonnage to the Smelter. Customs lead concentrate and lead and siliceous ores account for 5-10 per cent and the balance is made up of local zinc plant residues and flux.

Smelting operations comprise crushing and sampling, Dwight-Lloyd sintering, blast furnace reduction, drossing, and slag fuming.

For sulphur oxidation, wedge roasters, Godfroy and Huntingdon-Heberlein pots have been used in the past but have been discarded in favour of Dwight-Lloyd sintering machines, of which there are eight 600 inches long and six 264 inches long.

Sintering is carried out at Trail in two stages. The sulphur is reduced in the first pass,
in a bed six inches deep, from 12 - 14 per cent to seven per cent and in the second pass, in a bed
11 inches deep, from seven per cent to 1.5-2 per cent. Besides reducing the sulphur the roasting agglomerates
the charge into a sinters suitable for charging to the blast furnaces. The oxidation of the sulphur
after ignition by an oil flame is sufficiently exothermic to cause the incipient fusion of the mass. The
second sinter is tramned to bins from which it is weighed into the blast furnace charge cars. The
gases, carrying sulphur dioxide in low concentration, pass through flues to the smoke treaters thence
to the sulphur dioxide plant.

Generally the lead blast furnace has not changed radically in all years, but Trail of late
has incorporated such features as: increased length, a width of 60 inches at the tuyeres instead of
48 inches, no bosh, four 2½-inch tuyeres per 38-inch jacket and the Neumith vaporizer system.

There are two furnaces 22½ feet and three 15 feet in length. All are 17 feet from the
tuyeres to the bottom of the feed plates.

The bullion, which is 98.8 per cent lead and carries gold, silver and impurities, mainly anti-
mony, copper and arsenic, flows from the lead wells to a receiver, thence to a five-ton transfer pot
for delivery by crane to the Drossing Plant. A typical slag contains 3.5 per cent lead, 18.0 per
cent zinc, 19.0 per cent silica, 30.0 per cent iron and 7.0 per cent lime. The slag is tapped intermit-
tently through a settler into a holding furnace, fired with powdered coal, where it is stored till charged
to the slag fuming furnace.

In the two 100-ton drossing furnaces the bullion is kept at 1000°F. After skimming off
a dross containing most of the copper, the bullion is tapped to cooling pots from which it is cast,
at 650 to 700°F., into 75-pound anodes which are loaded into special cars for delivery to the refinery.
The dross is treated to give a copper-lead matte.

View of Lead Smelter and Slag Fuming Plant, Trail, B. C.

The slag fuming plant for the recovery of the zinc and lead from the blast furnace slag
consists of a furnace, a waste heat boiler, an economizer and a highhouse. The furnace is 10 feet
wide, 24 feet long and 10 feet high and is completely water jacketed. Slag is poured into it from pots holding nine tons, a complete charge being about 60 tons. Powdered coal, at the rate of six tons per hour, and air are blown into the charge through tuyeres on each side of the furnace. The charge cycle is 135 minutes. Slag as tapped from this furnace contains .03 per cent lead, 3.0 per cent zinc, 17 per cent iron, 26 per cent silica and 9 per cent lime.

The gases from the furnace, carrying zinc and lead as fume, pass through the boiler and the economiser to the baghouse. A typical analysis of the baghouse dust is as follows: .5 ounces silver, 59.5 per cent zinc, 14.9 per cent lead, .02 per cent copper, 1.1 per cent sulphur and 1.2 per cent iron. The baghouse contains 1,080 flannel bags, 8 inches in diameter and 9 feet 8 inches long. Fume from the flues, baghouse and boilers, totalling about 140 tons per day, is sent to the zinc plant for recovery of the zinc content, the lead being returned as a residue to the smelter.

View of One Section of Lead Refinery Cell Room, Trail, B. C.

REFINERIES

LEAD

This plant is the world’s pioneer electrolytic lead refinery. Operations were inaugurated in 1901. By 1922 a capacity of 100 tons per day was attained. Plant additions between 1922 and 1926 brought the capacity of the plant up to 395 tons per day. Subsequent improvements in metallurgical practice have made possible a daily output of 575 tons.

Two buildings, measuring 856 feet by 61 feet and 583 feet by 73 feet, house all operations pertaining to the production of refined lead. These buildings are constructed of steel, gunite and transite. All basement footings and floors, storage tanks and electrolytic cells are of reinforced con-
crete construction. Where exposed to the electrolyte, the concrete is protected with a covering of asphalt. Cell supports are of timber.

The electrolyte used is a solution of lead silico-fluoride and hydrofluosilicic acid, a representative analysis being as follows:

<table>
<thead>
<tr>
<th>Grams Per Litre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp. Gr.</td>
</tr>
<tr>
<td>1.210</td>
</tr>
</tbody>
</table>

The electrolyte is circulated through the cells at three to four gallons per minute. The circulation is maintained by centrifugal pumps of monel metal construction. Main distribution lines are of rubber lined iron pipe. Rubber headers serve the various sections. Both inlet and outlet connections to the cells are of hard rubber.

A representative sample of Tadanac bullion is as follows:

<table>
<thead>
<tr>
<th>Ounces/Tons</th>
<th>Au</th>
<th>Ag</th>
<th>Cu</th>
<th>Pb</th>
<th>Sb</th>
<th>As</th>
<th>Sn</th>
<th>Bi</th>
</tr>
</thead>
<tbody>
<tr>
<td>.42</td>
<td>49.9</td>
<td>.035</td>
<td>98.77</td>
<td>.6</td>
<td>.1</td>
<td>.038</td>
<td>.02</td>
<td></td>
</tr>
</tbody>
</table>

The bullion as delivered to the refinery is unloaded direct to the cells.

The stirring sheers or cathodes, are cast from refined lead by pouring the molten metal over inclined cast iron plates. They are prepared for the cells by straightening on a table after which they are hung on 1-inch by ½-inch copper bars.

The anodes are electrolyzed for six days. Two crops of cathodes are removed. When operating at peak production or when special grades of lead are required, the anode mud is washed from the anodes at the end of the third day. The mud is removed by means of motor driven brushes and is washed free of electrolyte in 48-inch vertical shaft centrifugals. The anode scrap is melted and recast into anodes at the refinery.

The cathode lead is melted in 235-ton welded steel kettles which are fired with pulverized coal. It is heated to 950°F and blown with air for the removal of the small percentages of tin, arsenic and antimony present. The lead is then cooled to 780-800°F, and cast into pigs for market.

A representative analysis of the refined lead is as follows:

<table>
<thead>
<tr>
<th>Ounces/Ton</th>
<th>Ag</th>
<th>Cu</th>
<th>Pb</th>
<th>Sb</th>
<th>As</th>
<th>Bi</th>
</tr>
</thead>
<tbody>
<tr>
<td>.08</td>
<td>.0006</td>
<td>99.998</td>
<td>.0005</td>
<td>Tr.</td>
<td>.0002</td>
<td></td>
</tr>
</tbody>
</table>

**SILVER**

The anode mud from the lead refining operation is treated for the recovery of gold, silver, bismuth and antimony. These operations are housed in separate buildings of brick construction. They are primarily furnace treatments, the more important steps of which are as follows:

1. Melting of the anode mud to metal and some slag.
2. Elimination of the arsenic and antimony as fume by oxidation.
3. Cupellation of the metal from Step 2 to Dore metal.
4. Reduction of the cupellation slags to a lead-bismuth metal plus some slag.

Slags from Steps 1 and 4 are returned to the lead smelter.

The Dore metal from Step 3 is parted by the sulphuric acid process. The silver for market assays 999.3 fine. The gold, approximately 975 fine, is shipped to the Canadian Mint.

**BISMUTH**

The lead bismuth metal from Step 4 above is first dressed for the removal of copper. The contained precious metals are removed by the Parkes process. The residual metal is then refined electrolytically by the Beres process. The anode mud from this operation is then melted and refined to market bismuth of a high degree of purity. Most of the bismuth of commerce is used in the making of low melting point alloys and in the manufacture of pharmaceutical products.

 Twelve
ANTIMONY

The fume produced in Step 2 above will be the source of antimony for a plant which will go into operation early in 1938. The production of insecticides from the arsenic content of this fume is now under consideration. Antimony finds industrial application in hard lead alloys used mainly for battery plates, in bearing and babbitt metals, in rubber goods and in paints.

ELECTROLYTIC ZINC

THE Consolidated Company at Trail and the Anaconda Copper Mining Company, at Great Falls, Montana, pioneered the production of electrolytic zinc on this continent.

The rated capacity of the Trail plant in 1916 was 60 tons of cathodes per day. This has been gradually increased to 400 tons per day, making it the largest single producer of electrolytic zinc in the world. The total production of hot zinc at Trail, up to the close of 1937 has amounted to 1,336,178 tons.

While there is considerable variation in details of operation in electrolytic zinc plants, fundamentally they all produce zinc from a solution of zinc sulphate by electrolysis. This entails the five steps of roasting, leaching, purification of solution, electrolysis and melting.

ROASTING

This converts the zinc sulphide of the concentrate into zinc oxide in which form it is readily soluble in dilute sulphuric acid. The iron is converted to the insoluble ferric oxide, and the sulphur is discharged as sulphur dioxide gas at a concentration suitable for the manufacture of sulphuric acid.

The roasting equipment a few years ago consisted of 25 standard Wedge roasters, which had a daily capacity of 35 tons each, consuming fuel to maintain the requisite temperature.

A new method of “suspension roasting” has recently been developed at Trail, which is similar in principle to the burning of coal in powdered form. The plant requirements are now supplied by eight converted roasters, which will operate at any rate of feed between 40 and 120 tons per day. No fuel is required and by-product steam is recovered from the gases, equivalent to approximately one pound of steam per pound of concentrate roasted. A materially higher zinc solubility of the calcine is also obtained from this type of roaster. The average analysis of the roasted product or calcine is as follows:

<table>
<thead>
<tr>
<th>% Ph</th>
<th>% Zn</th>
<th>% Fe</th>
<th>% Total S</th>
<th>% Sulphate S</th>
<th>% Zn Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7</td>
<td>57.5</td>
<td>12.8</td>
<td>2.3</td>
<td>1.7</td>
<td>87.5</td>
</tr>
</tbody>
</table>

LEACHING AND PURIFICATION

The roasted concentrate or calcine is delivered continuously to the leaching plant. Here it is treated with sulphuric acid of suitable strength for the extraction of the zinc, producing an impure zinc sulphate solution containing cadmium and copper and various other minor impurities originally present in the concentrate. This impure solution is subjected to suitable purification methods, which produce a pure zinc sulphate solution for electrolysis and separate valuable impurities, such as cadmium and copper, in a form suitable for ultimate recovery in marketable form. Iron and other impurities, together with any insoluble zinc, remain as a residue which contains the gold, silver and lead originally present in the concentrate. This is sent to the smelter for recovery of the values. The zinc in the residue is recovered by the smelter as zinc oxide and is returned to the zinc plant.

The main items of the leaching and purification plant equipment comprise Pachuca agitating tanks, Dore thickeners, American filters, Mothe type filters and Kelly and Shriner filter presses.

ELECTROLYSIS

The purified zinc sulphate solution is delivered to the electrolytic tank rooms containing 65 electrolytic units, each of which consists of 36 cells in four cascades of 9 cells each. Cells are of acid proof construction, either of concrete with rubber lining, or of unlined tanks of “Proborite” which is a bituminous concrete. This latter type was developed at Trail and promises to be the most suitable yet developed for this very exacting service.

Thirteen
The installed electrical capacity totals 54,550 K.W., made up of 13 motor generator sets, each consisting of two 4000-amp., 125-volt generators; ten 4500-amp., 350-volt rotary converters and three 10,000-amp., 560-volt mercury arc rectifiers.

Pure lead anodes are used and the zinc is deposited on aluminum cathodes. The zinc cathode sheets are stripped every 24 hours. Electrolysis regenerates sulphuric acid equivalent to the zinc deposited, and the plant is practically self-sustaining in its acid requirements.

MELTING

Zinc cathodes are melted in coal fired reverberatory furnaces. Zinc is ladled from the furnaces and cast into bars averaging 56 pounds in weight.

Three standard grades of zinc are produced—"A" grade, "Prime Western", and "Die Casting", with analyses as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Pb</th>
<th>Cd</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn by Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot; Grade</td>
<td>.015</td>
<td>.003</td>
<td>.0018</td>
<td>.001</td>
<td>99.979</td>
</tr>
<tr>
<td>Prime Western</td>
<td>.930</td>
<td>.006</td>
<td>.007</td>
<td>.002</td>
<td>99.955</td>
</tr>
<tr>
<td>Die Casting</td>
<td>.0031</td>
<td>.0017</td>
<td>.001</td>
<td>.0007</td>
<td>99.993</td>
</tr>
</tbody>
</table>

Various modifications of these grades are regularly supplied to suit special requirements.

View of Zinc Electrolytic Cell Room, Trail B. C.

CADMIUM

Most zinc ores contain some cadmium, the amount present varying up to a maximum of about one per cent.

In the standard retort process cadmium present contaminates the zinc. It is possible to recover some cadmium by this process, but a relatively impure metal results and the recovery is very poor.

In the electrolytic zinc process, however, cadmium is precipitated in the purification cycle and later recovered by an electrolytic process similar to that used for recovering zinc.

The uses for cadmium have expanded rapidly since a supply of pure metal became available. Plating for rust protection, anti-friction bearing metals and high grade pigments are some of the present uses.
The market farmers produce at peak of their harvest; Modern extraction methods are now replacing casting for pebbles and bars.

An average analysis is as follows:

\[
\begin{array}{cccc}
\text{Ca} & \text{Fe} & \text{Zn} & \text{Tr} \\
\text{wt} & \text{wt} & \text{wt} & \text{wt} \\
1.5 & 0.12 & 0.047 & \text{Cal by Difference} \\
\text{Tr} & 99.968
\end{array}
\]

Metal of very high purity is also available, assaying as follows:

\[
\begin{array}{cccc}
\text{Cu} & \text{Fe} & \text{Zn} & \text{Tr} \\
\text{wt} & \text{wt} & \text{wt} & \text{wt} \\
0.001 & 0.001 & 0.001 & \text{Tr} \\
\end{array}
\]

SMOKE CONTROL

The amount of solids in the form of dust and fumes allowed to get into the atmosphere, either from stacks or from foundry furnaces, blast and smoke cleaning plants, is reduced to a minimum. Continuous testing and accurate records are necessary to this. The recovery of these solids may be either a very profitable operation or may only be for the elimination of a nuisance.

Each metallurgical operation presents a special problem and the most efficient type of cleaning for each is installed. Waste heat boilers and economizers are used for cooling the hotter gases and the soot is collected either by simple settling, spraying with water, cyclones, baghouses, electric precipitation or by some combination of these.

CHEMICALS AND FERTILIZERS

The existence of the Chemical and Fertilizer Department depends to a large extent on the fact that the lead and zinc are in the Sullivan ore as sulphides. The first step in the process of producing the pure metals from the lead and zinc concentrates is the elimination of the sulphur and sulphur oxides. The recovery of this sulphur and the development of processes and erection of plants with the object in view was started in 1930. By the end of 1937 approximately $15,000,000 had been spent to this end.

The operations fall into five groups:

1. The Sulphur and Sulphuric Acid Plants
2. The Ammonia Plant
3. The Phosphate Plant
4. The Ammonium Sulphate Plant
5. The Storage and Shipping Plant

General view of Fertilizer Plants, Trail, B.C.
SULPHURIC ACID AND SULPHUR

The sulphur dioxide contained in the roaster gases is fixed either as sulphuric acid, ammonium sulphate or elemental sulphur. The gas, containing 6 to 7 per cent sulphur dioxide is first cleaned of dust by Cottrell electrostatic precipitation, followed by water washing after which it passes to either the sulphuric acid plant or the ammonia absorption plant. In the latter it is absorbed to give an ammonium sulphate solution which, when treated with sulphuric acid, is converted to ammonium sulphate with liberation of 100 per cent sulphur dioxide. This concentrated gas provides the feed for the 80-ton elemental sulphur unit. The ammonium sulphate solution is pumped to a separate plant for crystallization.

The sulphuric acid plants consist of one 40-ton and three 120-ton units. The process is standard, consisting of sulphuric acid drying of the clean gas, oxidation of the dioxide to the trioxide using a vanadium oxide catalyst, and absorption of the sulphur trioxide in 98.5 per cent sulphuric acid. The acid consumed is largely 93 per cent sulphuric, obtained by dilution of the absorption acid. One unit is also equipped to produce oleum of any required strength.

Elemental sulphur is produced by passing the 100 per cent sulphur dioxide together with a small proportion of by-product oxygen through a bed of incandescent coke in a furnace similar to an ordinary gas producer. The furnace gases are cooled in waste heat boilers where the sulphur is condensed as liquid and mist, the last traces of mist being removed in Cottrell electrostatic treaters. The liquid sulphur is finally filtered to give a 99.9 per cent pure product, which is pumped to storage.

AMMONIA

The ammonia synthesis plant, using electrolytic hydrogen and air nitrogen, is one of Fauser design, and has a daily capacity of 105 tons anhydrous ammonia.

The hydrogen is produced by the electrolysis of water in 1944 tank type cells. D.C. power is obtained by means of three 10,000-amp, 670-volt and three 10,000-amp, 830-volt mercury arc rectifiers. The electrolyte is an 18 per cent caustic soda or a 25 per cent caustic potash solution. Nitrogen is produced in two standard Claude liquid air units, each having a daily capacity of 46 tons of nitrogen. Both hydrogen and nitrogen have the high purity of 99.9 per cent.
In the ammonia plant proper the hydrogen and nitrogen gases are mixed in the proportion of three to one by volume and then compressed to about 250 atmospheres in six-stage compressors, after which the mixture is circulated through four synthesis columns containing an iron base catalyst maintained at a temperature of 400-450°C. In one circulation through a column, about 15 per cent of the gas mixture is converted to ammonia. The ammonia formed is condensed in the cooling system, one for each synthesis column, the residual gas being re-circulated and fresh gas added continuously.

Prior to its use in the consuming plants the liquid ammonia is vaporized and a part used in this form for the production of ammonium phosphate fertilizers. The remainder is dissolved in water to a concentrated aqua ammonia which is used in the sulphur dioxide recovery plant and finally appears as ammonium sulphate.

![Exterior view of Ammonia Plant, Trail, B. C.](image)

**PHOSPHATE**

Phosphate rock is the usual source of phosphorus contained in fertilizers. If concentrated fertilizers are required, phosphoric acid must first be made from the rock. This is accomplished at Trail in a plant consisting of three units, having a total capacity of 450 tons phosphate rock per day. The process is continuous and consists of the reaction of ground rock with sulphuric acid in a series of mechanical agitators followed by counter-current, triple-stage filtration of the phosphoric acid-gypsum slurry. The fluorine evolved is recovered in a small plant and is used locally in the lead refining process. The acid produced contains 32 to 33 per cent P₂O₅.

The phosphate fertilizer plant consists of three units having a total capacity of 300 to 450 tons of finished product per day. These can be used interchangeably for production of the different phosphate fertilizers which are:

(a) Ammonium phosphate containing 11 per cent nitrogen, 48 per cent phosphoric acid and produced by partial neutralization of phosphoric acid with ammonia gas.
(b) Ammonium phosphate-sulphate containing 16 per cent nitrogen, 20 per cent phosphoric acid and produced by partial neutralization of a phosphoric acid-ammonium sulphate solution with ammonia gas.
(c) Triple superphosphate, 45 per cent available phosphoric acid, made by interaction of phosphoric acid and phosphate rock.
The main items of equipment of each unit are mechanical agitators, blunger, drier, elevator, screens and pulverizer.

AMMONIUM SULPHATE

In the process at present being used the practically saturated ammonium sulphate solution from the sulphur plant is evaporated and crystallized in a battery of four Oslo crystallizer units, each having a capacity of 100 tons per day. The practically pure salt is recovered from the Oslo concentrated slurry by centrifuging, washing and drying, the mother liquor being returned to the system.

The plant also has three saturator units capable of producing, by direct neutralization of sulphuric acid, 250 tons ammonium sulphate per day. This process and equipment is, however, little used at the present time on account of the necessity of using all the ammonia available for sulphur recovery.

STORAGE AND SHIPPING

Because of the seasonal demand for fertilizers, large storages are necessary. The Storage Plant provided at Trail has a total capacity of approximately 100,000 tons. To serve this there are provided shipping mills suitably equipped with disintegrators, screens, sacking hoppers, scales and sewing machines, to load as much as 1,500 tons daily.

The free-running, non-caking, granular nature of the Trail fertilizer products is of particular interest especially where fertilizers have to be distributed through drills, as is the case on the Canadian Prairies.
ENGINEERING AND CONSTRUCTION

All plant repairs and maintenance as well as the design and construction of new plants are handled by the Engineering and Construction Department. This service covers not only the Smelting, Chemical and Fertilizer Plants at Trail, but also the Sullivan Mine and Mill at Kimberley and the numerous other operations of the Company in various parts of Canada.

The extensive plant improvements and new construction of the past 10 to 15 years together with the fact that our operations in the Trail-Kimberley area are a considerable distance from large manufacturing centres has justified the erection and equipping of much larger and better shops than would be required for maintenance work alone. The Trail shops now construct the greater part of any new equipment required.

The number of men employed for these services is 1,200 and the facilities comprise an iron, steel and brass foundry, also machine, electric, carpentry, rubber, lead burning, welding and boiler shops as well as equipment for rolling lead and extruding lead pipe.

To offset the tendency of a large construction program to sidetrack adequate maintenance and to enable the operators to exercise a close control over routine maintenance, the various production departments have small individual shops where facilities are adequate to handle minor break-downs and maintain spare parts. Each of these production plant shops has its own foreman in the various trades, who is responsible for the work of his trade in the individual plant to his chief, as well as to the plant superintendent.

Large jobs go to the main shops which have built under license such machines as 102-inch diameter American filters, 60-inch diameter by 24-inch crushing rolls, 10-foot Hardinge mills, 12-ton electric locomotives and narrow gauge rolling stock, Dwight-Lloyd sintering machines, Cottrell smoke treaters, electrolytic hydrogen cells and 25-foot diameter Wedge roasters. They are equipped to

Nineteen
handle wide variations in work such as the complete rebuilding of aeroplanes, rubber vulcanizing, the cutting of herringbone pinions, the casing of steel or iron sheg pots, the lead burning of tanks and other equipment, complete building of blast furnaces, rebuilding of motors, stainless steel casting and the making of fine furniture and fancy wrought iron articles. Such a list might continue indefinitely, but will suffice to indicate the extent of the possibilities and demands.

The design and detailing of machinery or complete plants is handled by a well-staffed draughting office working under the direction of the Chief Engineer and in conjunction with the operators of the departments being served. A fair proportion of the tradesmen have been apprenticed in the shops where they are now employed.

FUEL

The Company's fuel requirements at Trail are important from the standpoint of utility as well as expense. Coal, coke, cordwood and fuel oil to a total value of one and a quarter million dollars are used annually.

Coal consumption amounts to 100,000 tons a year, of which 75 per cent is burned in powdered form either as metallurgical fuel or for steam raising. This coal, a high carbon bituminous grade, originates in the Crowsnest Pass district in the southeastern corner of the province and is hauled by rail 280 miles to the Smelter.

Eighty-five thousand tons of coke are used annually and of this 83 per cent is used as lead blast furnace fuel.

Fuel oil commands a very high price in the district and consequently its use is restricted. Powdered coal has replaced oil at every possible point with a very material saving in fuel costs. The oil in use at present is diesel oil. It is received in tank cars and no difficulty is experienced in handling it in zero weather and in preheating is required. About 1,000,000 gallons are burned annually at various points in the plant where powdered coal, for one reason or another, cannot be used.

ELECTRIC POWER

Power is supplied by the West Kootenay Power and Light Company, Limited, from four hydro-electric plants on the Kootenay River, about 27 miles away, and is transmitted at 60,000 volts, 3-phase, 60 cycles. The Power Company built its first plant on the Kootenay River in 1898, which consisted of two 1,184-H.P. hydro-electric units. A third unit of the same size was added in 1899. With the increase in demand for power, other stations were added and the original station dismantled in 1925, to be replaced with a larger plant. The total installed capacity of the four existing plants now in operation is 226,000 H.P.

Operations at Trail are on a 24-hour basis and have a full capacity load of 181,000 H.P. The 24-hour load factor is 95 per cent and the power factor is about 95 per cent.

From a central switching station the power is distributed to nine high tension step-down stations located at various parts of the plant where it is stepped down to the voltage required. Central power in the plant is used at 2200 and 550 volts, except for rotary converters and mercury arc rectifiers. Eight sub-stations step the power down from 2200 to 600 volts in different parts of the plant as required.

Seventy-five per cent of the power is used for electrolytic work in the production of metals and hydrogen gas. The installed capacity of D. C. conversion equipment is 104,800 K.W.—140,500 H.P.—of which 14,250 K. W. is converted by motor generator sets, 24,750 K. W. by rotary converters and 61,800 K. W. by mercury arc rectifiers. The first mercury arc rectifier installation was put into operation in 1922 and consisted of three 5,600 K. W. units in the Zinc plant. At that time it was one of the largest mercury arc rectifier installations for electrolytic work in the world. In the refinery, motor generator sets are used to convert the D. C. power required. In the Chemical and Fertilizer Plants, 50 per cent of the power is used in the production of hydrogen.

Twenty
In the hydrogen plant, mercury arc rectifiers are used as conversion equipment. There be six units, three of which are 6,700 K. W. and three 8,300 K. W.

The above covers the large users of electric power, but a number of other applications maybe mentioned, such as Cottrell treaters for the precipitation of metallic dust from flue gases, electric evaporators, boilers and furnaces, as well as pumping stations and the traction system.

View of No. 1 Plant of The West Kootenay Power and Light Company, Ltd., on Kootenay River near Nelson, B. C.
INDUSTRIAL RELATIONS

HAND in hand with the industrial expansion of the Trail reduction plants and the Sullivan mine there has been, during the past 20 years, marked progress in sound and harmonious employer-employee relationships. The Industrial Relations program of the Company covers the hiring, placing, training, promotion, transfer and discharge of employees; wages, salaries, bonuses and profit sharing; hours and conditions of labour; apprentice training; safety and first aid promotion; employees' housing and recreation; group assurance, health insurance and pensions.

WORKMEN'S CO-OPERATIVE COMMITTEES

A vital factor in the successful administration of the Company's Industrial Relations plan has been the Workmen's Co-operative Committee system, which has been in operation for many years at the Trail and Kimberley plants. Each committee consists of members elected by their fellow workmen, each member representing one of the various departments for a term of 12 months, 50 per cent of the membership coming up for election by secret ballot every six months. The General Manager is a permanent member of these Committees and attends meetings either at his request or at the request of the Committee.

The function of the Workmen's Co-operative Committee is to assist the management to run the plants of the Company safely and fairly, also to interpret correctly ideas of the management to the men and those of the men to the management. By co-operation and fair play through the Workmen's Co-operative Committees, cordial relations have been maintained between the employer and employee. Evidence of results is to be found in improved living and working conditions, also in the fact that there have been no serious labor troubles or strikes of any kind since the inauguration of the committee system in 1917.

HIRING

All applicants for employment are interviewed privately at the employment office located outside the plant boundaries. In the selection of applicants, all other qualifications being equal, preference is given to sons of employees and to those of Canadian birth. A preference is shown also to those who are considered to be of benefit to the community in welfare, artistic, athletic and social activities.

Careful selection under these conditions has had the dual effect of building up an efficient body of men for work and a contented community capable of providing a great deal of its own entertainment.

OPEN TRANSFER SYSTEM

Once established with the Company the employee's position is made as secure as possible. To avoid his being unjustly discharged and to assure him a square deal, the open transfer system has been evolved.

If the workman fails to give satisfaction, the usual practice of the foreman is to give him an open transfer, making a written statement of the reasons thereof. Except in the case of a very serious offence or unpardonable conduct, the employee's open transfer is recorded by the Industrial Relations Department and he is put back to work with another foreman. If unsatisfactory to a second department, he is given yet another chance. On being turned in as unsuitable for a third time he is automatically discharged. By this system a good man is fairly well assured of permanent employment with the Company.

A workman may appeal his dismissal through the Workmen's Co-operative Committee which reviews his case through an appointed tribunal of his fellow workmen. The Committee may or may not see fit to appeal the decision.

Twenty-Two
WAGES, BONUSES, ETC.

It has been the policy to give the employee some financial interest in the Company. His wage consists of a base rate of pay, sufficient to take care of his cost of living. In addition to this he participates in profits in the nature of bonuses based on plant efficiency and metal prices. On completion of each two years' service the employee is given a bonus of one share of Company stock.

WORKING TIME

Since 1932 a five-day week or its equivalent has been in effect. Shift men, comprising those who work in departments of the plant where operations are continuous, work 15 days and then lay off five days. Most of the shop crews and those working on construction, work five days and lay off two days.

Employees wishing to take a vacation or requesting leave of absence, may, when convenient to the company, take time off equivalent to 10 per cent of their total period of service with the Company, with no loss of service privileges.

GROUP ASSURANCE

Three months after entering the service of the Company, each employee is covered by group insurance to the extent of $500.00. This amount increases $100.00 for each additional six months' service until the maximum of $1,500.00 is reached. The cost of this insurance is borne by the Company.

Under the same group policy, employees subscribe to an additional $1,000.00 coverage at the same low premium rate.

A valuable feature of both of these plans is the Total and Permanent Disability clause.

HEALTH INSURANCE

All employees and their dependents receive practically complete medical attention and hospitalization. This service costs the employee $2.50 per month, the Company contributing, directly and indirectly, approximately 90 cents per man per month. Both occupational and non-occupational sickness is covered under this plan.

NON-OCCUPATIONAL SICKNESS ALLOWANCE

The Consolidated Employees' Benevolent Society, formed and administered by the employees, assists those who are forced to lay off work due to non-occupational sickness or accident. The employee contributes $1.00 per month and is entitled to receive benefits of $1.50 per day for a period of six months in any one year.

PENSIONS

A pension scheme financed entirely by the Company provides retirement payments at the age of 60 years after 15 years of service or at the age of 55 years after 25 years of service. Based on the average earnings for the ten years immediately preceding retirement, a pension is granted of one per cent for every year of service with a minimum payment of $240.00 per year.

APPRENTICE TRAINING

In the interest of youth and to ensure to some extent against a future shortage of skilled tradesmen, the Company offers opportunities to sons of employees to learn one of twelve mechanical and building trades. Under a progressive apprentice training plan the boys are given four hours each week in the Apprentice School under competent technical supervision, together with four and a half years practical training under qualified tradesmen. On completion of this period of apprenticeship it has been the Company's practice to absorb the apprentices into their own trades if possible. However, when this is not possible they are offered other work until such time as a vacancy occurs in the chosen trade.

Twenty-Three
SAFETY FIRST

A vigorous campaign of accident prevention is maintained and a systematic attack on the accident problem is promoted by free safety and first aid instruction to all employees. The following figures for the Trail plant illustrate the fact that such a policy has been amply justified:

<table>
<thead>
<tr>
<th>Year</th>
<th>Shifts lost per 1,000 worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>21.0</td>
</tr>
<tr>
<td>1927</td>
<td>10.5</td>
</tr>
<tr>
<td>1937</td>
<td>4.3</td>
</tr>
</tbody>
</table>

HOUSING

Employees are encouraged to own their own homes. To this end the Company advances building loans to employees at five per cent interest. Monthly payroll deductions are arranged for repayment of principal and interest, usually spread over a period of eight to ten years. A building inspector is employed by the Company who supervises construction of all houses and sees that they are up to specifications. The Company has also made building sites available to employees for summer camps at one of the nearby lakes.

General view of Trail, B. C., 1937