World Mining

APRIL 1978

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AFTON

Afton, new Canadian copper mine—

The unusual geology of the Afton deposit has resulted in a two product concentrator and the first application in North America of the top blown rotary converter (TBRC™) for copper smelting. The new Canadian mine began stripping waste in February, 1977; the concentrator milled the first ore in December, 1977; and the smelter is scheduled to come on line late this spring. Design mill throughput of 7,000 tons per day has already been exceeded.

The copper ore mining and processing complex, located about 10 miles from downtown Kamloops, British Columbia, is the only major integrated mine through blister copper operation in Canada to come into production in recent years. The last major copper mine in British Columbia was started by Lornex Mining Corporation Ltd. in 1972, 45 miles southwest of Kamloops. The Afton concentrator produces a native copper gravity concentrate and a flotation chalcocite concentrate. The Afton TBRC™ smelter is the only copper smelter in the province.

Teck Corporation has 63 percent interest in Afton Mines Ltd., 50 percent through direct ownership, and an additional 13 percent through Teck's 57 percent owned Iso Mines Ltd., which controls 23 percent of Afton shares. Teck acquired its interest in Afton in 1972.

The new project was managed by Teck and Commonwealth Construction Ltd. was the principal contractor. Wright Engineers Ltd. designed the concentrator and related facilities, while Dravo Corporation designed the smelter complex. Total project cost was $C85,000,000 ($93,500,000).

AFTON PLACEFIX MAP

Senior financing was via loans from the Bank of Montreal and the Canadian Imperial Bank of Commerce. Important lines of credit have also been obtained from U.K. customers (BICC and Delta Metal) who will be buying the output.

Area History

The first indication of mineralization in the new mine area was in 1898 when the 330-foot Pothook shaft was sunk. Two mines in the area, the Iron Mask and the Copper King, were worked to a small degree during the early part of this century.

Axel Bergland, in 1949, staked eight claims in the area which he called Afton. In 1964, Chester Millar became interested in Bergland's claims. Millar convinced Colonial Mines Ltd. to conduct a percussion drilling program. After 11 holes had been drilled, Colonial withdrew from the project. Millar formed a private concern in 1965, staked more claims adjacent to the Trans-Canada Highway, and drilled 30 more percussion drill holes.

An east-west trending zone of copper mineralization was revealed extending to the west and below the drilling area. A consulting geological firm recommended drilling nine diamond drill holes, five of which were completed. One of these intersected 170 feet of altered diorite, grading 0.4 percent copper.

After Duval Corporation refused first rights on the deposit and Quintana Minerals conducted an unsuccessful 17 percussion drill hole program, Millar decided Afton Mines would continue drilling in the area of the diamond drill hole which intersected copper. In 1971, 17 vertical percussion drill holes bottomed in ore.

In 1972 Teck and Iso Mines acquired their interest in Afton. More than 29 miles of drilling was conducted between 1970 and 1973. The decision to go ahead with the project was made in October, 1975.

It is interesting to note that several companies missed the opportunity to become involved with this venture, including New Jersey Zinc Company, Colonial Mines Ltd., Noranda Mines Ltd., Kennecott Copper Corporation, Duval Corporation, Quintana Minerals, and Canex Placer Ltd. Canex had signed an agreement with Afton Mines, previous to Teck involvement which provided for a Canex interest in Afton in exchange for development work support. In an out-of-court settlement, Teck and Iso paid Canex $4,000,000 to purchase its agreement with Afton.

A difficult period for Afton was experienced during the interim between the decision to go ahead with the project and the final project development. Three miles of the Trans-Canada Highway had to be moved, and of course, environmental permits had to be obtained. Canadian environmental groups appealed the issuing of the smelter emission permit. The appeals were dismissed after careful review by the Pollution Control Board. It was determined that the new smelter would not be detrimental to the Kamloops area environment.

Afton Geology

The Afton copper deposit is characterized by two distinct mineralization zones. The first is a deeply penetrating supergene zone which comprises the ore body which will be mined at the Dominion pit and has served as the basis for design of the associated beneficiation plant and smelter. The predominant copper mineralization in the supergene zone is native copper and chalcocite. The second zone is the partly explored hypogene zone, characterized by chalcopyrite and bornite mineralization. The copper grade in the supergene zone is similar to that of the hypogene zone.

The Afton deposit is located at the northwest extremity of the Iron Mask batholith, an intrusive comprising an early diorite phase and a later fine-grained microdiorite-micromonzonite phase.

Mineralization occurs in the Sugarloaf and Cherry Creek porphyritic intrusives, associated with the Iron Mask batholith, as veins, stockworks, and disseminations. The Dominion pit appears to be located at the junction of two fault systems. One system is composed of a set of echelon faults, trending east to northeast with a dip of 60 to 70° southwards. This set of faults is postulated to be significant in ore control. The second system runs generally north to south.

The mineralization associated with the fault systems in the supergene zone is unique in this area. The copper containing minerals found in the shattered rock of the faults in order of abundance are native copper, chalcocite, bornite, and chalcopyrite. The following table gives the relative abundance of the principal copper minerals in the uppermost

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on stream

By **Donald A. Pazour**
Assistant Editor

100 meters (325 feet) of the supergene mineralization zone:

Mineral	Weight Percent West	East
Metallic Copper	65	85
Chalcocite	30	10
Chalcopyrite	—	1
Cuprite/Tenorite	5	trace
Other Minerals	trace	1

Metallic copper defines the zone and occurs as fine scales, films, dendrites, and granules, but also in masses as wide as 5 millimeters (1/5 inch). Chalcocite in the deposit is mostly of the sooty supergene variety, with some slightly grey chalcocite (digenite) as well. The chalcocite is both disseminated and in veins up to 25 millimeters (1 inch) wide. In a polished section, chalcocite is seen as replacing both bornite and chalcopyrite which are relics in the zone, as is some pyrite.

Gangue materials are mostly calcite and epidote, with less commonly occurring gypsum, ankerite, specular hematite, quartz, fluorite, and zeolite.

Supergene/Hypogene Zones

The supergene zone is mainly above 500 meters (1,650 feet) elevation in the east part, and 250 meters (825 feet) in the west part. The boundary of the zone is generally sharp and it plunges steeply west about midway along the deposit. The deposit is tabular inside a 0.25 percent cut-off grade and it strikes west-northwest with an average dip of 55° south.

Although the supergene zone of copper mineralization at Afton comprises the immediate orebody and serves as the basis for near future mining, milling, and smelting, a discussion of the hypogene zone is important for a full understanding of the district geology. Furthermore, this zone presents a resource for possible future expansion and development.

The hypogene zone is preserved only in the central and west parts of the present deposit and is found mainly below the 500 meter (1,650 foot) level. The absence of metallic copper defines the zone, which does contain minor amounts of possibly supergene minerals chalcocite and covellite in addition to hypogene sulphides bornite and chalcopyrite. Bornite abundance exceeds that of chalcopyrite near the hanging wall and decreases across the deposit

PHOTOGRAPHS BY BILL HADGKISS

AFTON MINE P&H 1900AL shovel loads one of two Unit Rig 100-ton Lectra-Haul trucks, while Bucyrus Erie 40R drills 9-inch holes in 24 by 24 foot pattern in the background.

SHOVEL LOADING haul truck with native copper-chalcocite ore. Background, left to right: primary crusher, coarse ore stockpile, concentrator, and maintenance building.

CLEAN-UP around the shovels is accomplished using Caterpillar 824 wheel-type dozer. The final 900-foot deep Dominion pit will cover an area 2,700 by 2,800 feet.

until near the foot wall where the ratio is reversed.

The supergene event, which transformed the sulphides in the hypogene zone, consisted of aerated groundwater channeling through the fractured hypogene deposit causing coincident oxidation of magnetite to hematite and reduction of chalcopyrite and bornite to chalcocite and native copper. The metallic copper at Afton is likely to be of the supergene type because of the lack of trace elements which would be found in native copper in a hypogene zone. Excess sulphur and soluble salts were removed by the departing groundwater which flowed to a fault-depressed base level basin to the north. Essential to the formation of this supergene assemblage would be the coexistence of high sulphur copper minerals and magnetite.

The Afton pit will be 900 feet deep with ore reserves of 34,000,000 tons grading 1.0 percent copper, 0.58 grams gold per ton (0.016 ounce per ton), and 4.19 grams silver per ton (0.12 ounce per ton) at a cut-off of 0.25 percent copper. An additional estimated 10,000,000 tons of ore grading 1.6 percent copper may be recoverable through underground mining from the hypogene zone.

Dominion Pit

The Dominion pit has reached a depth of 120 feet and presently covers an area 1,500 by 2,300 feet. The final 900-foot-deep excavation will cover a 2,700 by 2,800-foot area. Initially, 500,000 tons of glacial till was removed by a contractor. In late February 13,000,000 tons of material had been moved. The initial stripping ratio (during the first five years of operation) will be between 6.0 and 7.0 to 1.0. Over the life of the mining, the stripping ratio will average 4.5 to 1.0.

Two Bucyrus-Erie 40R drills average 630 feet of drilling per shift consisting of 9-inch holes in a 24 x 24-foot pattern. Average powder factor during this mining stage has been 0.26 pounds per ton.

The pit has three P & H 1900AL shovels for loading Lectra Haul, Unit Rig, 100-ton-capacity haul trucks. Two operating 11-cubic-yard bucket shovels, with the third as standby, average 12,500 tons per shovel shift. There are eleven 100-ton haul trucks in Afton's fleet, each powered by a KTA 2300-C Cummins engine with derated horsepower from 1,200 to 1,050. Truck productivity has been approximately 2,800 tons per truck shift. Ore is hauled to the primary crusher, an Allis Chalmers 42 by 65-inch gyratory. Waste rock is piled in 50-foot lifts with berms spaced at 100 feet for reclamation. A small percentage of waste rock is diverted to a $500,000 crushing and screening plant located at the tailings dam. This plant produces material for the tailing dam and road sanding.

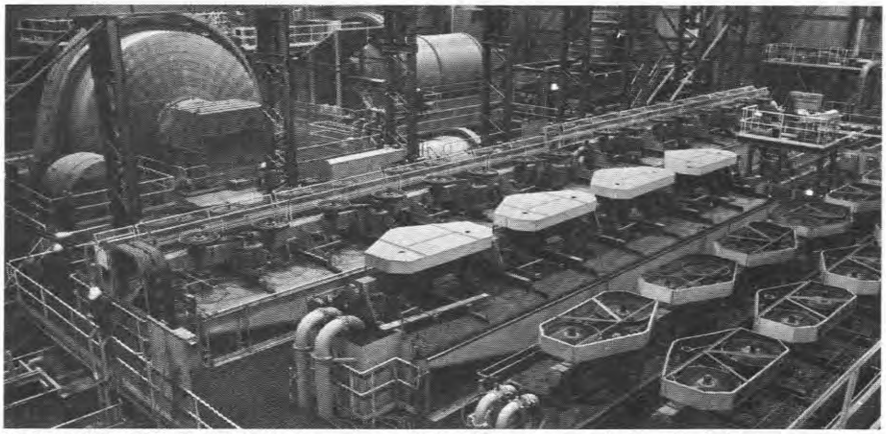
The pit wall slope varies from 35 to 45°. Benches are 30 feet high. Two benches are combined to form 60-foot benches with 38- to 65-foot berms. The haul road grade is 10 percent; haulage roads outside the pit are 100 feet wide, and, right hand traffic is employed.

Ancillary equipment includes one Caterpillar 824 wheel-type tractor, one Caterpillar 14 motor grade, three Cat D8 crawler tractors, and one Cat 769 off-highway truck to be used in the winter for sanding and as a water truck during summer months.

One large building serves as the warehouse, changehouse, equipment shop, and pit maintenance and operations personnel offices.

Two-Product Concentrator

The new Afton concentrator combines gravity separation techniques in the form of jigs and tables, and conventional froth flotation to produce a native copper gravity concentrate and a chalcocite-native copper flotation concentrate.



GRINDING AND FLOTATION sections of the Afton concentrator. Variable speed drive Koppers semi-autogenous mill, top left, secondary and regrind ball mills to the right, and flotation cells below.

Ore from the mine is crushed to minus 8 inches in a 42-inch by 65-inch Allis Chalmers gyratory crusher powered by a 350 horsepower motor at 900 revolutions per minute. The crushed ore is conveyed to a 25,000-ton live storage pile. Two reclaim conveyors, each fed by three Nico 550 H feeders, transport the ore to the primary grinding mill feed conveyor.

The primary mill is a variable speed drive Koppers 28 by 12 foot semi-autogenous mill. The ball charge for the mill is 8 to 10 percent of the mill volume and 4 inch and 5 inch diameter balls are used. The mill is usually run at 72 percent of critical speed, but during start up the mill was run as low as 50 percent of critical speed on soft ore. The variable speed drive has proven to be a useful control tool in grinding, allowing the reduction of mill speed when soft ore is fed to that the balls do not damage the lining.

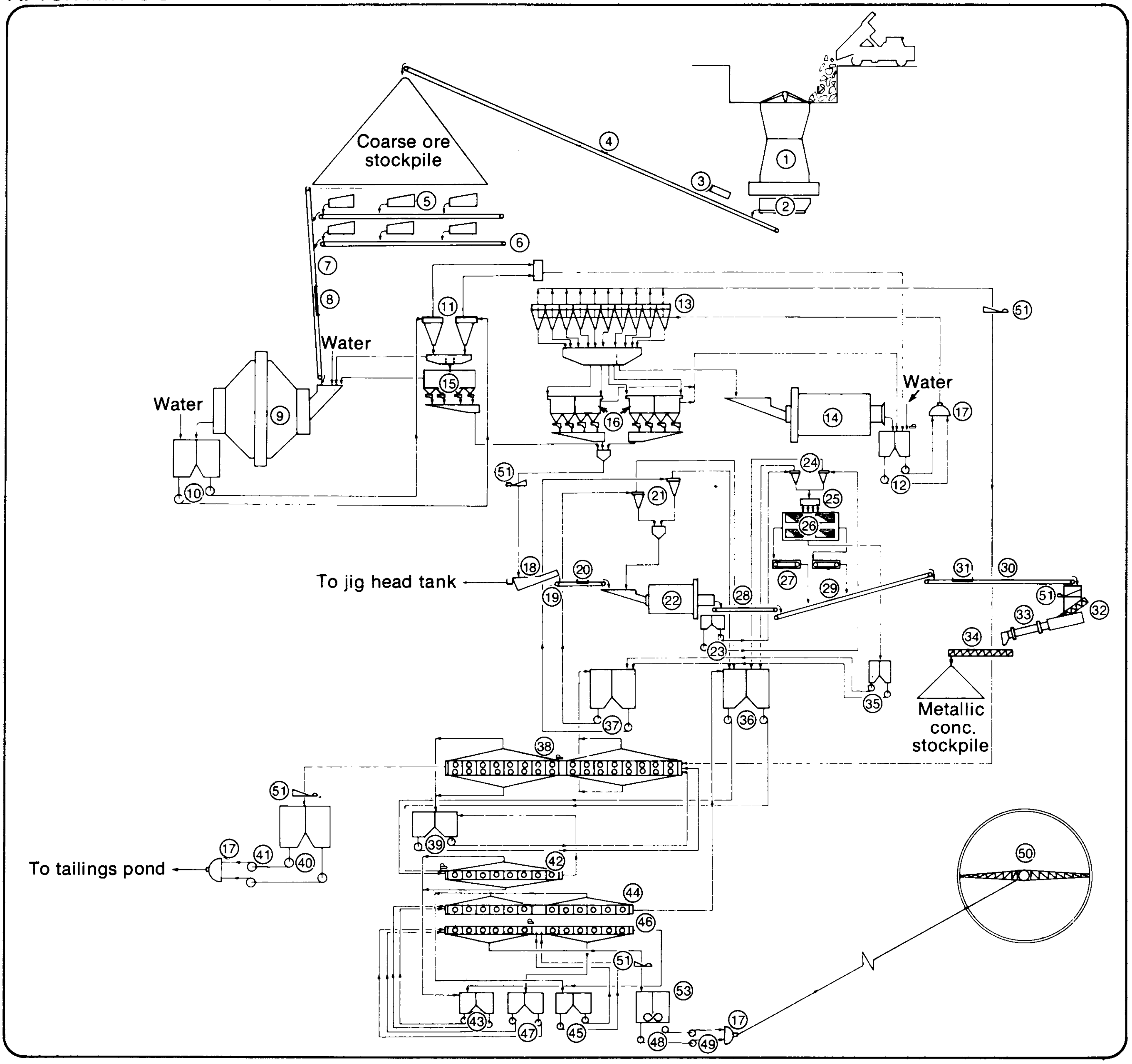
Ore is ground in the primary mill to approximately 80 percent minus 20 mesh. The mill is in closed circuit with two 50-inch-diameter Krebs cyclones with adjustable apexes. A portion of the cyclone underflow can be diverted to two primary 24 x 36 inch Denver mineral jigs, with jig concentrate passing to a screw classifier and then to the regrind mill. Jig tailing is returned with cyclone underflow to the primary mill. These jigs are presently not in use.

The cyclone overflow, or the 80 percent minus 20 mesh material, is fed to ten D20 20-inch Krebs cyclones in closed circuit with the secondary Koppers 16-foot, 6-inch by 29-foot ball mill which grinds the ore to about 70 percent minus 200 mesh. The mill is powered by a synchronous drive 4,600 horsepower motor. Ball charge is approximately 35 percent of mill volume and 2-inch balls are used. Pulp density in the mill is 70 to 72 percent solids.

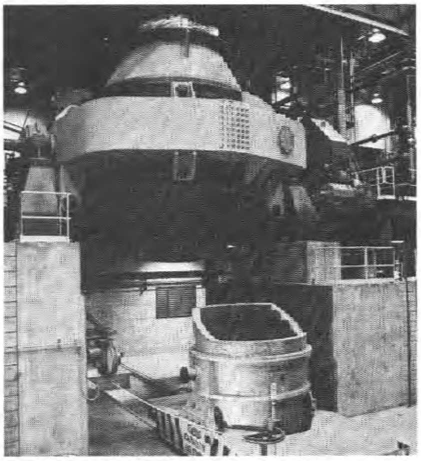
From 5 to 20 percent of the secondary cyclone underflow is diverted to four 24 by 36-inch Denver mineral jigs. Jig concentrate flows by gravity to the screw classifier mentioned earlier. Classifier sands are fed to the regrind mill, and tailings from the jigs are returned to the secondary mill with the rest of the cyclone underflow. The classifier overflow is used for makeup water in the grinding circuit.

The cyclone overflow, 70 percent minus 200 mesh is feed for the rougher flotation section. Rougher flotation tailing is pumped directly to the tailing

AFTON MINES LIMITED CONCENTRATOR FLOWSHEET



1. Allis Chalmers gyratory crusher, 42"x65"
2. Nico TR 1100 hydrastroke feeder
3. Asea metal detector
4. Conveyor system, 48"
5. Nico 550 H hydrastroke feeders
6. Conveyor systems, 42"
7. Conveyor system, 42"
8. Merrick 440 DS-I weightometer
9. Koppers primary semi-autogenous mill, variable speed drive, 28'x12'
10. Georgia Ironworks primary mill discharge pumps
11. Kreps D50 Cyclones, adjustable apexes
12. Allis Chalmers SRL-C pumps
13. Krebs D20 LB cyclones, pneumatic inlet valves and adjustable apexes
14. Koppers secondary ball mill, 16'6"x29'
15. Denver primary mineral jigs, 24"x26"
16. Denver secondary mill jigs, 24"x36"
17. Tech-Taylor valves
18. Triple pitch Wemco classifier, 30"x20'3"
19. Conveyor system, two speed drive, 18"
20. Merrick 440 DS-I weightometer
21. Krebs D15 cyclones
22. Koppers regrind mill, 9'6"x12'
23. Allis Chalmers SRL-C pumps
24. Krebs D10 cyclones
25. Deister 12-way distributor
26. Concenco 999 triple deck concentrating tables
27. Straight Line metallic concencrate filters
28. Conveyor system, 18"
29. Conveyor system, 18"
30. Conveyor system, two speed, 18"
31. Merrick 440 DS-I weightometer
32. Dryer feed screw conveyor, 8"x14'6"
33. Lockhead Haggerty rotary dryer with fans and scrubber, 3'x24'
34. Dryer discharge screw conveyor, 9"x25'9"
35. Allis Chalmers SRL-C table tailing pumps
36. Allis Chalmers SRL-C regrind cyclone overflow pumps
37. Allis Chalmers SRL-C regrind mill cyclone feed pumps
38. Denver 600H rougher and scavenger flotation cells
39. Allis Chalmers SRL-C scavenger concentrate pumps
40. Allis Chalmers SRL-C flotation tailing pumps
41. Allis Chalmers SRL-C variable speed flotation tailing pumps
42. Denver 300V cleaner flotation cells
43. Allis Chalmers SRL first cleaner concentrate pumps
44. Denver 30DR cleaner flotation cells
45. Allis Chalmers SRL second cleaner concentrate pumps
46. Denver 30DR cleaner flotation cells
47. Allis Chalmers SRL third cleaner concentrate pumps
48. Allis Chalmers SRL-C final concentrate pumps
49. Allis Chalmers SRL-C variable speed final concentrate pumps
50. Flotation concentrate thickener, 50' diameter
51. Denver automatic samplers
52. Clarkson reagent feeders
53. Final concentrate conditioner tank



COPPER SMELTER, first top blown rotary converter for copper in North America.

pond, rougher concentrate is fed to the regrind cyclone, and the middling product is recycled through the rougher flotation cells. Regrind cyclone underflow is fed, along with classifier sands, to the regrind mill, a Koppers 9-foot, 6-inch by 12-foot ball mill driven by a 500 horsepower motor. This mill is charged with 2-inch balls to approximately 28 percent of the volume, and the pulp density is 60 to 65 percent solids.

Regrind cyclone underflow moves to four Concenco triple-deck concentrating tables. Table concentrate is the final gravity native copper concentrate and to date has averaged from 78 percent copper assay. It is hoped to eventually obtain a 90 percent copper concentrate from the table operation. This concentrate is dewatered on a belt filter and then dried in a 3-foot-diameter by 24-foot-long Lockhead Haggerty rotary dryer. The dried concentrate is trucked to the TBRC™ smelter and stockpiled. The table tailing is recycled to the regrind cyclones.

Regrind cyclone overflow is pumped to eight Denver 300V cleaner flotation cells, the first of four stages of flotation cleaning cells. Tailing from the first cleaner bank is returned to rougher flotation. The following three cleaning stages utilize a total of 24 Denver DR 30 flotation cells. Final flotation concentrate is pumped to a thickener adjacent to the smelter, filtered, dried, and stockpiled. To date, flotation concentrate has averaged 47 to 53 percent copper. This is very close to the target assay of "in excess of 50 percent".

Flotation reagents are collector, potassium/sodium amyl xanthate; and frother, cresylic acid/MIBC at a ratio of one to four by volume. Flotation is carried out at a natural pH of 9.5.

The mill, designed for 7,000 tons of ore per day, in February averaged 7,800 tons per day. Ore treated to date has been primarily from the top benches of the open pit which contained lower (0.91 percent copper) than average grade, oxidized copper, and mud. Recovery to date has been 81%, with February recovery achieving the feasibility rate of 87%. As mining goes deeper, recoveries should improve. On one day early this year, recovery, in fact, averaged 92 percent.

Afton has incorporated very little automatic control in this very simple mill. This was done in order that reliable actual plant data may be monitored manually to determine which, if any, parameters in this mill warrant automatic control.

Water and Tailing Disposal

The tailing impoundment area is about 10,000 feet from the concentrator in the valley of Hughes Lake. The dam was geotechnically designed. The impoundment area required two dams, one on the east end and one on the west end. Ultimate crest elevation for the dams will be 2,400 feet maximum. Final rise above the valley floor will be 300 feet, and the starter dams rise 100 feet above the floor.

The dams will be constructed from waste rock and till from the open pit. A gravel plant at the dam will crush and size material both for use at the dam and for use in sanding the pit roads during the winter. Both dams will have rock core and an impervious blanket on the upstream side. They will be free standing with benched downstream faces with slopes of 2.0 to one. The upstream slopes will be two to one. The impoundment area has been designed to hold 95,000,000 cubic yards of tailing and will require 20,000,000 cubic yards of waste rock for construction.

Because of the relatively low settle ability of the slimes in the tailings, initially no effort will be made to reclaim water. Water for the mill and mine will be supplied at a rate of 4,400 gallons per minute from Kamloops Lake. Research is being conducted with the goal of eventually flocculating the tailing in order to reclaim water.

New Smelting Technology

Afton is the first copper smelter in the Western Hemisphere to use the top blown rotary converter (TBRC™), applying the technology recently developed by the International Nickel Company for treating nickel concentrates. The smelter was built under license from Inco and Dravo Corporation. The single TBRC™ is 14 feet in diameter by 21 feet long and is expected to produce 28,000 tons of blister copper annually as 1,200 pound billets. (See box describing TBRC™ in detail, page 47.)

The TBRC™ process was chosen by Afton over other alternatives for several reasons. It was chosen over an electric furnace because of a lower capital cost and greater flexibility for processing varying grades of concentrates. Hydrometallurgical methods were ruled out because they offered no way of recovering the precious metal values from the concentrates of ore.

The smelter will treat two heats a day, each producing approximately 50 tons of blister copper. Once the working lining refractory has worn to 4-6 inches remaining, the vessel must be relined.

Dried gravity concentrate from the mill is trucked to the smelter and flotation concentrate is pumped to a thickener, filtered, dried, and placed in a storage bin. The average grade of combined concentrate is 65 percent copper.

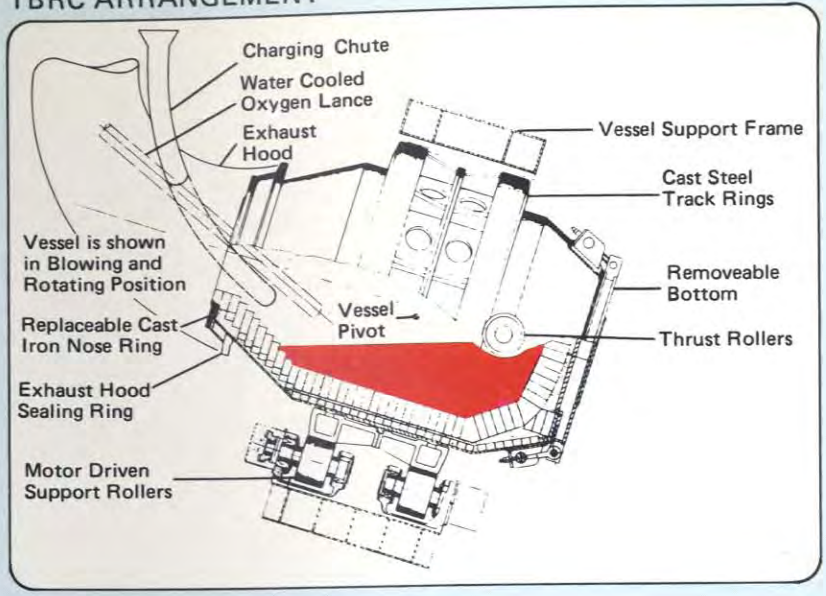
The flotation concentrate along with fluxing agents is fed to the furnace and melted with an oxygen-natural gas flame from the lance. When the concentrate is melted, the natural gas is shut off and oxygen, air or a combination, is injected through the lance to sustain the exothermic oxidation of sulphur with the corresponding production of copper. Charging of the flotation concentrate continues and the molten bath is slagged. After the low sulphur flotation concentrate has been charged and the bath has been slagged, the gravity concentrate is charged to the furnace. If slag must be removed after charging of the gravity concentrate, this is done. Any high copper slag that requires cleaning is held in refractory-lined ladles.

Blister copper is transferred via a refractory-lined ladle to the casting operation and cast into billets. Any slag that requires cleaning is returned to the TBRC™ for reprocessing. The cleaned slag is removed, and the metal recovered.

The process off-gases from the smelter have a wide variance in composition and are cooled to 650° F.

Dust is removed by an electrostatic precipitator and is briquetted and returned to the furnace for smelting. The dust-free gas is scrubbed in a dual-alkali scrubber to remove SO_2. The gas is then cooled in packed towers, using 3,000 gallons per minute of cold water, to condense mercury which is collected in a mist eliminator and stored in plastic-lined drums for future sale. The cooled process off-gas from the packed towers is reheated and discharged to the at-

TBRC ARRANGEMENT



The top blown rotary converter TBRC™ process combines a fully operational vessel with the new process technology to offer an alternative to conventional smelting processes. R. A. Daniele and L. H. Jaquay of Dravo Corporation summarized the history and technology of the TBRC™ as follows in a paper to the 1972 AIME Meeting in San Francisco, California, United States. The first application of the vessel (Kaldo Process) was in Sweden in 1957 by Stora Kopparbergs for producing steel from high phosphorous iron ore. Since that time, the process has been successfully employed in eight steel plants.

It was not until 1959 that the TBRC™ process was adapted for the treatment of non-ferrous concentrates such as those of nickel, copper, and lead. At that time, the first commercial facility was constructed by Dravo Corporation for the International Nickel Company for producing nickel at Copper Cliff, Ontario, Canada. At this facility, two 14-foot-diameter vessels with one operating full time and the other part time, 276 tons per day of metallics from nickel sulphide concentrate, copper-nickel metallics, anode residue, and TBRC™ system dusts can be produced.

The basic vessel used for producing steel is also used for processing non-ferrous materials. The figure above shows the thrust rollers which secure the vessel longitudinally in the frame and the motor driven support rollers which both support the vessel within the frame via two cast steel track rings and rotate it at speeds up to 40 revolutions per minute. This arrangement permits the vessel to rotate freely inside the support frame.

Trunions support the furnace so that it can be tilted through 360° for filling, blowing, and pouring.

The mouth has an exhaust hood sealing ring which provides a bearing surface for a tight hood and minimizes in-leakage of ambient air to the exhaust hood. A water-cooled oxygen lance and charging chute are mounted on the exhaust hood. The charging chute is used when feeding concentrate, or additives.

The TBRC™ process for primary smelting of copper claims to offer several advantages over conventional smelting processes. Proponents of the process also claim significant savings in capital and operating costs can be attained by using the TBRC™ process.

The water-cooled lance which is inserted through the exhaust hood can be used to control the smelting atmosphere by injecting different combinations of fuel, oxygen, and air to obtain neutral, reducing, or oxidizing conditions. The lance can also be adjusted for depth and angle in the furnace. When commercially pure oxygen is used instead of air, converting rates can be increased, sulphur dioxide concentrations in exhaust gases can be maintained as high as 50 percent, and slag fluidity can be increased. The high sulphur dioxide concentrations are obtained by eliminating the nitrogen dilution obtained when air is used.

Adjustment of the rotational speed of the furnace and adjustment of the lance angle help to maintain high oxygen efficiency. Inco's testwork at its Port Colborne Research Center indicated that oxygen efficiency with the TBRC™ process could be maintained above 95 percent.

The total dust loading of the exhaust gas is reduced in the TBRC™ because of the double passing of the process gases over the bath surface and the rotation of the vessel. The molten material wets the refractory surface and tends to absorb dust.

Thermal efficiency is usually superior with the TBRC™ than with conventional smelting. The option to use fuel with oxygen allows running the bath at higher temperatures. Even without the aid of fuel for heat input, a higher temperature is maintained because of the absence of nitrogen contained in air which normally consumes heat to reach operating temperature, and rotation allows heat transfer from the refractory walls to the molten metal. Thermal gradients are diminished because of the good mixing imparted by the rotational action.

A cost comparison between the TBRC™ process and conventional smelting methods made by Afton indicated this process to have considerable capital cost savings. The Afton smelter will cost less than $1,000 per annual ton of copper.

The application of the TBRC™ process above serves as a single vessel smelter, performing as a reverberatory melting furnace by injecting an oxy-fuel mixture through the lance and as smelting proceeds, the vessel becomes simply a converter, with only oxygen and/or air being injected and heat being supplied by the exothermic sulphur oxidation reaction.

The TBRC™ process can be applied to copper smelting in other ways than as an autogenous smelter. It may be used to smelt scrap, cement copper, white metal, or matte from a separate reverberatory furnace.

mosphere from a 300-foot stack, 1,500 feet above the city of Kamloops.

Afton has established an ambient air monitoring system with data telemetered back to the smelter. The maximum permitted emissions are as follows:

Contaminant	*Permitted Concentration*
Lead	0.003 grains per cubic foot
Zinc	0.003 grains per cubic foot
Cadmium	0.003 grains per cubic foot
Mercury	4.0 pounds per day
Sulphur Dioxide	90% removal

When operational, Afton's top blown rotary converter will be the cleanest smelter in North America. Expected recovery for the plant is 99 percent and blister grade should exceed 99 percent copper. END.