Arizona Geological Survey
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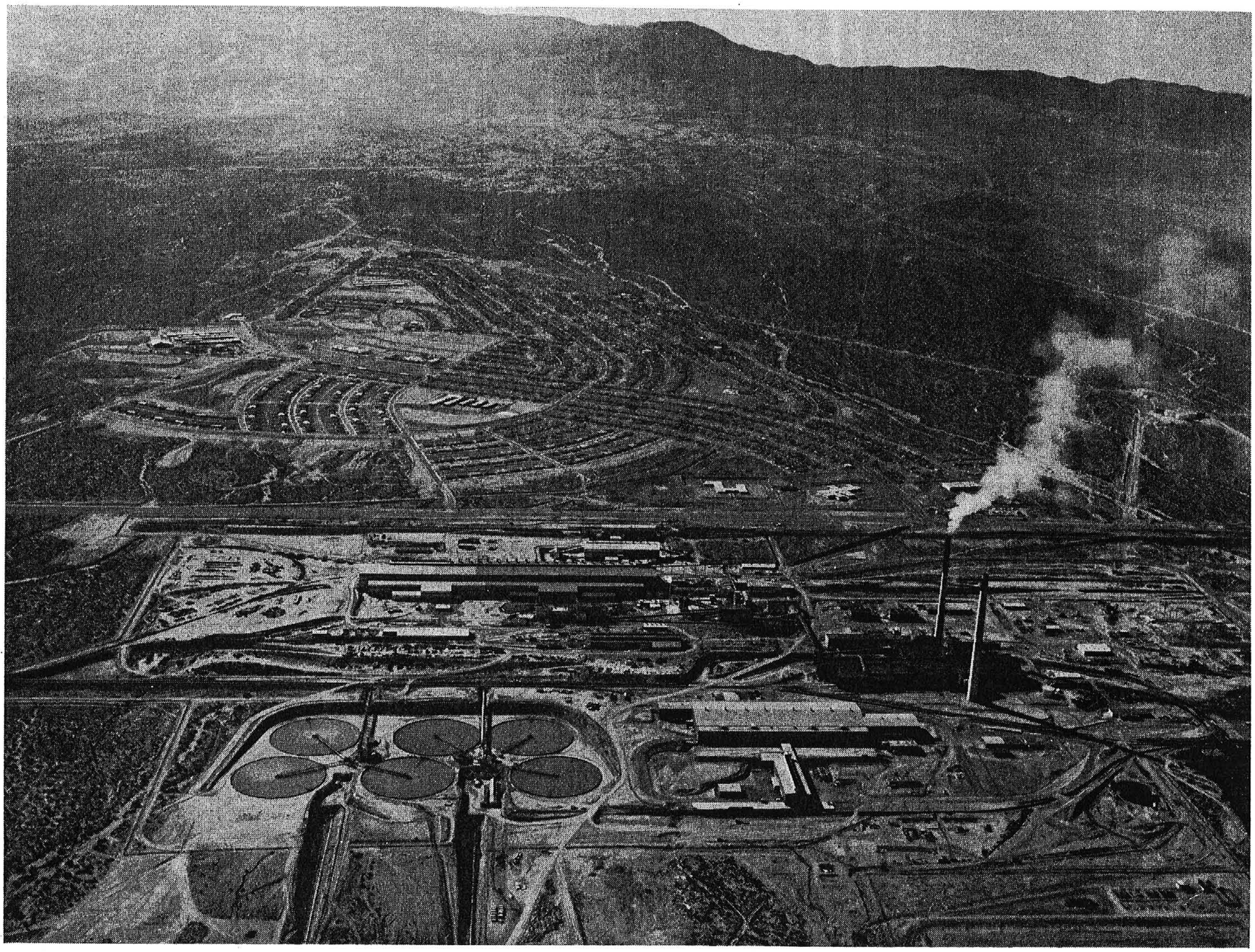
MAGMA

SAN MANUEL DIVISION



GENERAL INFORMATION

MAGMA COPPER COMPANY

A SUBSIDIARY OF NEWMONT MINING CORPORATION

P.O. Box M, San Manuel, Arizona 85631 — Telephone (602) 385-2201

THE HISTORY AND DEVELOPMENT OF THE SAN MANUEL DIVISION MAGMA COPPER COMPANY

Magma Copper Company's San Manuel Division is located in the southeast part of Pinal County, Arizona, about forty-five miles northeast of Tucson. Several headframes and the dome-shaped Red Hill serve as landmarks for the mine area.

The concentrator, smelter, electrolytic refinery, administration building, and other plant facilities are located some seven miles southeast of the mine area adjacent to the town of San Manuel.

The district was prospected prior to the Civil War, but there was little or no ore production until 1881. Until the advent of the San Manuel mine, the chief producers were the Mammoth and Mohawk mines located a mile farther north. Gold, lead, zinc, and some vanadium and molybdenum were the main recoverable metals at these properties. At least two exploratory churn drill holes were drilled in or near the San Manuel ore zone in 1917. The copper content indicated by these holes was not sufficient to encourage further exploration at that time.

In 1942, through the efforts of the property owners, James M. Douglas, R. B. Giffin, Victor Erickson, and Henry W. Nichols, all of Superior, Arizona, the Reconstruction Finance Corporation and War Production Board authorized the United States Geological Survey to investigate the property.

This survey confirmed the owners' original conception of the probable existence of important copper mineralization, and by its recommendation the Bureau of Mines was authorized to put down a limited number of churn drill holes. This test drilling started in November, 1943, and was continued until February, 1945, when seventeen holes had been drilled for a total of 15,844 feet.

Magma Copper Company obtained an option to purchase the property in 1944. In September, 1944, Magma exercised its purchase option, and additional adjoining claims held by the Apex Lead Vanadium Mining Corporation and the Quarelli family were purchased. Additional claims were located and in December of that same year, Magma undertook additional exploration by churn drilling.

The San Manuel Copper Corporation was incorporated in August, 1945, and all of the property acquired by Magma Copper Company in the district was deeded to San Manuel. The corporate structure was changed in 1962 to include the San Manuel property as a Division of Magma Copper Company, rather than a wholly-owned subsidiary corporation. In 1969 Magma was merged with Newmont Mining Corporation and operates today as a wholly owned subsidiary of Newmont.

Exploratory churn drilling was essentially completed in early 1948, and underground exploration and development was started in March of that year.

On July 10, 1952, the Reconstruction Finance Corporation authorized a loan of $94,000,000 to San Manuel for mine development and plant construction.

In early 1953 Utah Construction Company and The Stearns-Roger Manufacturing Company (a Joint Venture) were awarded a contract for the design and construction of the entire surface plant, including the concentrator, smelter, railroads, and auxiliaries. Principal subcontractors were San Xavier Rock and Sand Company, which furnished the concrete; Newbery Electric Corporation, which installed the electric control and transmission system; and Custodis Construction Company, which erected the smelter stack.

The concentrator was completed in September, 1955, and commenced trial runs on stockpiled and mine development ores. Smelter and remaining plant construction was completed in late 1955, except for minor cleanup work. The smelting of copper concentrates was started January 8, 1956. Five shafts had been sunk and over twenty miles of drifting had been completed to prepare the first lift for production. On Jan. 23, 1956, the Mine was in production with the first stope undercut completed.

The 1475, or first level, was mined to completion early in 1965. The 2075, or second level, along with the 1775, or intermediate level, is now being mined.

In 1968, Magma purchased adjacent mining claims to an orebody of similar size and grade to the San Manuel. Top of this second orebody lies 2,500 feet deep and will be opened for exploration on the 2950 level sometime after 1972.

Since production started in 1956, the mine and plant have undergone two expansions. The first in 1965 boosted production from 30,000 to 40,000 tons of ore per day. In 1971, an expansion was completed that increased production to 60,000 tons of ore per day.

THE TOWNSITE

To provide adequate permanent housing facilities for the construction period, as well as the future productive life of the mine, an agreement was made with the Del E. Webb Construction Company and M.O.W. Homes, Inc., under which they were to finance and build a town suitable for the accommodation of San Manuel's employes.

Active construction was started in mid-1953, and by late 1954, the town of San Manuel, consisting of 1,000 homes, shopping facilities, and hospital, was completed. Magma Copper Company acquired the town early in 1955. Additional homes were built in 1957 and 1971 bringing the total to 1,276.

The community at San Manuel, Arizona, is a cluster of modern homes and shops, interlaced with surfaced streets, on the sloping west side of the San Pedro Valley. To the east, the Galiuro Mountains offer a spectacular view, while to the west the Santa Catalina Mountains serve as a magnificent backdrop to the residential area.

San Manuel was conceived and built for those who work for Magma Copper Company, as well as for those in related activities -- merchants, police officers, clergymen, and others.

The main shopping center covers 32 landscaped acres off McNab Parkway. The shops located there offer San Manuel a wide variety of merchandise and services. This is supplemented by a second shopping center located in the lower part of the town.

The townsite properties are managed from the San Manuel Townsite Office of the San Manuel Division of Magma Copper Company.

The San Manuel Division Hospital, a half-million dollar institution which maintains the very latest equipment, and a complete medical staff serves the needs of San Manuel and vicinity.

Within the hospital there is a completely equipped surgery, nursery, two obstetrical rooms, emergency room, x-ray room, x-ray developing room, a patients' wing of 30 beds, doctors' offices, laboratories, thereapy rooms, reception room, waiting room, offices, kitchen facilities, and dining rooms.

The hospital is a member of the Southwest Regional Blood Bank of the Red Cross. This is a blood bank system which maintains stocks of blood of all types at all times and blood is available on call. In addition, the hospital maintains a list of blood donors in the townsite, by type, who may be called in emergencies.

Just south of the hospital stands the nurses' home. Facilities exist for accommodating seven nurses in furnished, modern, completely air-conditioned quarters.

In this same area is located the Administration Building which houses the various management, accounting, engineering, exploration, purchasing, and personnel offices.

Four schools serve the educational needs of the elementary and high school students of San Manuel, Mammoth, and vicinity. San Manuel elementary schools and Mammoth elementary school comprise the Mammoth School District Number Eight, and San Manuel High School serves Mammoth High School District, which includes students from San Manuel, Mammoth and vicinity.

The three schools were completed at a cost of $4,500,000 for buildings and equipment. The School Board is elected by the registered electorate without regard to property ownership.

A 10,000-book public library serves the town of San Manuel and supplements the school libraries. The library has gradually expanded from a small one-room area in the Community Center building to its own quarters with over 1,500 square feet of floor space. Parks, playgrounds, community center, and swimming pool facilities are provided by the Townsite for the residents of San Manuel.

THE MINE

The original San Manuel orebody is part of a mass of mineralized rock, chiefly a granitic-appearing monzonite and a similar, though finer-textured, monzonite porphyry. This large zone of mineralization is covered for the most part by unmineralized conglomerate, a younger rock than those comprising the mineralized zone. The orebody, or portion of the general mineralized mass, containing appreciable copper sulfide minerals, in addition to iron sulfides, covers an area over one mile long by one-half mile wide. The known depth of ore extends about 2,600 feet below the surface.

The original orebody in the northerly portion appears to be a tabular mass up to 400 feet thick with its long dimension bearing northeast and lying at an angle of 55° from horizontal to the southeast. This attitude persists down dip for about 2,400 feet where it flattens and then rolls upward to form a cross-sectional fish-hook shape. Within this part of the orebody there is a pronounced thickening, and it is the upper one-third of this southeast portion, starting some 1,100 feet below the surface, that was selected for initial mining operations. Of this 1100-foot thickness from the first mining level to the surface, there is an average of about 430 feet of ore and 670 feet of unmineralized overburden.

The thickness of the overburden and shape and size of the orebody combine to make open pit mining impractical. For these reasons the underground block caving method of mining was selected. The monzonite in which the ore occurs is well fractured, caves readily and crushes to a size that is easy to transport.

Block caving entails the undercutting or removal of a horizontal slice of ore of sufficient area (stope block) so that the unbroken ore above will not support itself, but will cave and slough into the undercut. As the broken ore is drawn, removing support from the ore above, caving extends to the surface, the overburden or waste rock following the ore down. When the waste rock reaches the undercut horizon, drawing is stopped and the stope block is finished.

The caved ore from the undercut horizon is drawn on the grizzly level through a series of closely spaced draw raises. The grizzly level which is the control level, is 15 feet below the undercut. On the grizzly level the ore passes through the grizzlies which consist of rails spaced 14 inches apart over the top of each transfer raise.

Two transfer raises funnel the ore from eight draw raises to one common loading station on the haulage level which is about 60 feet below the grizzly level. A loading station serves two transfer raises, each of which, when full of ore, holds 65 tons. The ore stored in the raises is transported by an underground electric railroad system to the ore hoisting shafts.

Loading operations from the transfer raises to the ore cars are controlled through steel chutes and air-operated chute gates. The ore cars have a capacity of about 12.5 tons, and each train is made up of 15 cars or 185 tons per train, pulled by a 23-ton, 250-horsepower trolley locomotive. One of these trains is dumped every seven minutes. The electrical power system supplying the trolley is 275 volt DC with rectifier stations so situated as to maintain full voltage throughout the haulage system.

The underground track for the haulage system is 36-inch gauge with 70-pound rail through the panels. On the main lines between the mining area and the hoisting shaft, 90-pound rail is used to accommodate the heavy traffic and higher speeds.

At each of the three ore hoisting shafts, 3-A, B and C, the trains pass through a rotary tipple on the haulage level which dumps three cars at a time. The cars, equipped with rotary couplings, do not have to be disconnected as the tipple turns 180° to dump the ore into the 1500-ton pocket or underground storage bin adjacent to each shaft and then rights itself.

The ore is drawn from the bottom of the pocket into a measuring pocket hopper which in turn discharges into skips for hoisting to the surface. The bottom dump ore skips, which hold from 21 to 28 tons of ore, are hoisted to the surface and discharged into three 5,000-ton surface storage bins, which in turn discharge onto pan feeders that carry the ore to the three gyratory crushers located nearby. Discharge from the crushers is moved by conveyor belts to three 10,000-ton surface storage bins awaiting transportation to the Plant.

Two ore hoisting shafts, 3-A and 3-B, are equipped with 6,000-hp hoists with 15-foot diameter drums. These hoists can be manually or automatically controlled. The operating hoisting speed is from 2500 to 3000 feet per minute. The 3-C hoisting shaft is equipped with a 7,000-hp hoist having a 15-ft. diameter drum, hoisting at 2,850 feet per minute. The hoisting cables are 2-1/4 inches in diameter.

Nos. 1 and 2 shafts were sunk early in the program, and from these shafts the first mining lift was developed. No. 1

shaft, steel and reinforced concrete lined, now serves for concrete supply and hoisting of development waste rock and downcast ventilation. No. 2 shaft, sunk for exploration and quick development, has been abandoned.

No. 4 shaft, steel and concrete lined, serves as a downcast ventilation shaft and as a service shaft for men and supplies. Men are lowered and hoisted at the rate of 120 men per trip; and timber, powder, and other supplies necessary for the mining operation are lowered to grizzly and haulage levels through this shaft. The 3-A, 3-B and 3-C shafts, in addition to hoisting of ore, serve for upcast or exhaust ventilation.

Two additional shafts are under construction-one for ore hoisting and one for expanded service of men and supplies.

Other facilities at the mine include mechanical and electrical shops, modern timber framing shed, timber treating plant, warehouse, and change rooms. Mine air compressors provide 48,000 cubic feet per minute of compressed air for rock drills and other air-driven tools underground and on the surface.

Limestone and high grade silica for metallurgical use are mined from a quarry site, 17 miles north of the Plant. These products are hauled by the San Manuel Arizona Railroad to the flux crushing plant in 50 to 70-ton bottom-dump cars.

T H E   C O N C E N T R A T O R

The primary crushing circuit located at the mine site is designed with 3 gyratory crushers. A panel board located for each crusher and an intercommunication system provide control. Iron detectors are installed on conveyors for the removal of tramp iron. The final product of the mine crushing plant is conveyed to three 10,000-ton receiving bins for loading into ore transportation cars.

Ore transportation from the Mine to the Plant is by rail shuttle service in 100-ton capacity bottom-dump railroad cars. The two, 32-car trains are pulled by 1600-horsepower, 125-ton diesel-electric locomotives. The six mile ore transportation track is standard gauge, 132-pound rail and was constructed with liberal curves and no grade.

At the 20,000 ton coarse ore receiving bin at the Plant, the train is run over the bin and four cars are dumped at a time through bottom-dump air operated car gates with compressed air furnished by the locomotive.

From beneath the receiving bins, ore is fed by 48" manganese steel pan feeders and belt conveyors into four seven-ft. standard Symons cone crushers at the rate of 1000 tons per hr. to each crusher. Magnets are suspended at the head of the conveyor to remove tramp iron. Crusher feed passes over double deck grizzly screens where undersize material is bypassed directly to fine ore bins. Screen oversize is conveyed to a series of secondary crushers. The crushed ore from the secondary crushers is conveyed and distributed to seven tertiary seven-ft. Symons cone crushers, each preceded by mechanical screens to bypass the undersize material to fine ore bins.

The crushing plant is designed with all crushers on the same level. A panelboard on the operating floor and an intercommunication system provide complete control from one point. A 30-ton overhead crane with a 5-ton auxiliary hook services the crusher floor.

The final product from the crushing plant, all less than one inch, is delivered by belt conveyor at the rate of 3,500 tons per hour to two 54-inch wide tripper conveyors. The tripper conveyors run over the top of the 70,500-ton capacity fine ore bin in the concentrator building. The trippers travel the length of the bin distributing the ore at an even rate. Seal belts cover the slots through which the ore is discharged, to provide a dust-free atmosphere.

The ore is drawn from the bottom of the fine ore bin by a system of belt conveyors onto gathering conveyors which feed the rod mill sections at the rate of 60,000 tons per day. A weightometer both registers and controls tonnage to each grinding section.

The concentrator is divided into thirteen grinding sections, ten sections each consisting of one 10' x 13' rod mill, and two 10' x 10' ball mills, and three sections each consisting of one 12'6" x 16' rod mill and two 12'6" x 14' ball mills. Ball mills are operated in closed circuit with 20-inch cyclone classifiers. Oversize material from classification is returned to the ball mills for additional grinding.

All grinding sections are operated from a central control room equipped for remote control, also an intercommunication system and a radio circuit help provide control. The grinding bay is serviced by a 175-ton crane and a 275-ton crane which are capable of taking out a fully charged rod or ball mill for repairs. Two 10-ton cranes serve for lighter and faster service.

The classifier overflow goes to distribution boxes where, with reagents added, it is distributed to 40 cubic foot rougher flotation cells, and to 300 cubic foot rougher flotation cells, with a retention time of nine minutes. The copper-molybdenum minerals float to the surface of the pulp in each cell and are gathered in froth launders. The material not floated in these cells is called tailings, and is piped by gravity to the tailings thickeners where approximately 24,000 g.p.m. of reclaimed overflow water is returned to the mill for reuse. The thickened underflow is discharged to the tailings pond where the excess water is decanted and returned to the mill for reuse.

The mineral concentrate is pumped from the rougher flotation cell launders through cone classifiers in closed circuit with eight 8' x 12' regrind ball mills, then distributed to 276 forty cubic foot cleaner flotation cells. The tailings from this flotation are returned to the ball mill circuit or back to the primary cleaner cells. The final copper-molybdenum concentrate is pumped to a thickener. The thickened concentrate going to the molybdenum recovery plant.

Molybdenum sulfide is recovered by flotation in another series of flotation cells, after which the concentrate is filtered, dried, and conveyed to drum storage. Tailings from the molybdenum flotation process is the copper sulfide concentrate. It is thickened, filtered, dried, and conveyed to the concentrate storage bins in the smelter building. Overflow water from the thickeners joins the return water to the mill circuit.

Gold and silver are recovered in the molybdenum circuit by a cyanide precipitation process. The precipitates are fed to the smelter holding furnace and blended into the copper anodes. They are later recovered as slime from electrolytic refining process and sent to precious metals refineries for recovery.

THE SMELTER

Copper concentrate, averaging about 28% copper, is drawn from the storage bins in the smelter building by conveyor belts and is fed to one of two 102-foot long green feed reverberatory furnaces through hoppers located along each sidewall of the furnace. The concentrate is smelted in the furnace at a temperature of approximately 2700°F, using natural gas for fuel. In emergencies the furnace heat is provided by fuel oil.

Gases from the reverberatory furnaces pass through four waste heat boilers which furnish steam at 475psig to the powerhouse. There are two steam turbine generators, one rated 10,000 KW and one 13,600 KW. There are five steam turbine blowers,three rated 30,000 cfm and two 45,000 cfm.

All gases from the reverberatory furnaces and the converters pass through electrostatic precipitators prior to entering the twin stacks. The west stack, 515 feet high, serves the reverberatory furnaces, while the east stack-550 feet high-serves the converters. Practically all solid matter is removed from the smoke. This dust has a high copper content and is returned to the smelting process.

Slag is skimmed into railroad car slag pots of 225 and 380 cubic foot capacity. The slag pots are then hauled to the slag dump. Matte, which is chiefly copper, sulfur, and iron, is tapped into 200 and 300 cubic foot ladles and transferred by crane to Pierce-Smith type converters by three 60-ton overhead cranes. There are five converters; three are 13' x 32.5' and two measure 15' x 35'.

After the matte has been poured into the converters, a flux with a high silica content is added. This flux combines with the iron to form slag which is skimmed and returned to the reverberatory furnace. Further blowing oxidizes the sulfur to sulfur dioxide and converts copper sulfide to metallic copper (blister copper). The molten copper is transferred by ladle to one of three holding furnaces adjacent to the anode casting section of the smelter, which contains two casting wheels.

In the holding furnace, excess oxygen is removed through the injection of reformed gas. The copper is poured into anode molds on two casting wheels. The finished anodes, weighing 785 pounds each, are cooled in water. The anodes are then removed by overhead crane and placed in specially designed racks for transportation to the electrolytic refinery by straddle carrier trucks.

OTHER PLANT FACILITIES

The flux preparation plant is located between the smelter and concentrator buildings and includes receiving bins and crushers for handling limestone and silica flux. A lime kiln for calcining limestone, and a slaker provide metallurgical lime for the concentrator.

Other plant facilities include a machine shop with locomotive service and repair pits, electric shops, carpenter, and truck shops, warehouses, time offices, and change houses.

The San Manuel Arizona Railroad operates on thirty miles of standard gauge railroad from San Manuel to connect with the Southern Pacific Railroad at Hayden, Arizona.

THE ELECTROLYTIC COPPER REFINERY

The San Manuel Refinery with annual capacity of 200,000 tons of electrolytic copper was completed in October, 1971.

The refinery will produce 100,000 tons of continuous cast, 5/16" diameter copper rod per year. The balance of the production will be in the form of cathode copper, either as full plate or sheared to smaller sizes, meeting specific customer requirements. The continuous cast rod will be shipped in coils of from 5,000 lbs. to 16,000 lbs. in gross weight. Cathodes will be shipped in bundles of appropriate size and weight to facilitate materials handling and loading.

General Description of Process and Facilities

Refining takes place in the tankhouse. Smelter anodes are loaded in refining cells with 4" spacing with copper starting sheets suspended between the anodes. Electrolyte containing 45 grams per liter copper and 185 grams per liter sulfuric acid, with solution temperature controlled at 145°F, is circulated through each cell at the rate of 5 gpm.

Electric current is applied in a series-paralleled system to provide 20,000 amperes per cell. The DC voltage per cell is nominally 0.25. This provides a current density of slightly over 20 amperes per square foot of cathode surface. In the electro-refining process, copper ions go into solution at the surface of the anode. At the same time, copper ions are deposited from the electrolyte on the surface of the cathode. As the anode is depleted, the cathode grows in thickness and weight. Anodes are replaced after 28 days in circuit. Each anode charge produces two pulls of cathodes. Under normal operating conditions, an anode weighing 785 pounds produces two cathodes weighing 330 lbs. each. The remaining 125 lbs. of anode after 28 days exposure is washed and returned to the smelter converters for remelting. Cathodes are washed and transferred to the rod casting plant, shear building or shipping docks.

Copper starting sheets interspaced between the anodes at the start of the 14-day cathode cycle are produced in the stripper (or starting sheet) section of the tankhouse. In the stripper section, rolled copper blanks with prepared surfaces are interspaced between copper anodes. Electro-deposition occurs in the same manner as the commercial sections. Blanks are pulled after 24 hours deposition and the thin copper deposits are stripped from the blanks. Approximately 5,400 starting sheets weighing approximately 12 pounds each are produced per day. Two loops cut from starting sheet stock are attached to each of the starting sheets and copper suspension bars inserted to complete the starting sheet assembly.

Impurities in anode copper either go into solution in the electrolyte or settle to the bottoms of the electrolytic cells as slime. The slime which contains various impurities including precious metals is washed from the cells at the end of each 28-day anode cycle. It is collected and transferred to an acid leaching, filtering, and drying section. The dry slime is sampled and packaged in plastic lined drums for shipment to a precious metals refinery for recovery of gold, silver, selenium and other economic metals values.

Soluble impurities and copper which tend to concentrate in the electrolyte are controlled within strict concentration limits in the electrolyte purification (Liberator) section. The process of purifying the electrolyte is a modification of the commercial electrolytic refining process. Insoluble lead anodes are used with copper starting sheets as the cathode.

Copper ions in the electrolyte deposit on the cathode, thereby depleting copper in the electrolyte. Impurities settle to the bottom as a sludge or partially plate out in the low quality Liberator Cathode. Impure cathodes and the sludge are returned to the smelter.

Rod Casting

Refined copper, in the form of cathodes, with dimensions approximately 38" x 38" and weighing approximately 330 pounds are transferred to the casting house. Approximately 100,000 tons per year will be melted and cast into 5/16" diameter rod.

Cathode melting takes place in a gas-fired shaft furnace. Molten copper flows through a heated launder system to a 15-ton capacity holding furnace. The holding furnace is equipped with an automatically controlled gas firing system to control pouring temperature of the molten copper.

Molten copper is fed to the rod casting machine at a controlled rate of near 27.5 tons per hour by rotating the holding furnace. The molten copper flows into a casting ladle which directs the flow into the cavity of the casting wheel. The casting wheel is 96" in diameter with a rim cavity specially designed and machined to produce a casting with 5 square inches cross-sectional area. The entire casting assembly is water cooled and lubricated to produce a smooth casting.

The copper casting formed on the casting wheel is continuously withdrawn and fed to a large multiple stand rolling mill which reduces the original casting in 12 step reductions to 5/16" continuous rod. After leaving the rolling mill, the rod is pickled in a dilute sulfuric acid solution and coated enroute to the coiling mechanism. Equipment is provided to coil and package the rod in various weight coils required by the customers. Packaged coils of finished rod are weighed and loaded directly into boxcars for rail shipment or to trucks for truck shipments.

Cathodes can be sheared to various sizes to meet specific customer requirements. Shearing is accomplished in a specially-designed metal shear equipped with conveyors, stacking and banding equipment. The balance of the cathodes are bundled and shipped as full plate cathode copper.

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STATISTICAL DATA

Ore Deposit

Type	Disseminated copper
Gangue rock	Quartz monzonite porphyry
Metallic minerals	Pyrite, chalcopyrite, chalcocite, molybdenite, silver and gold
Copper content	About 0.75%
Molybdenum sulfide content	About 0.025%
Gold and silver contents	Trace amounts

Orebody

Orebody	The control as to size and shape of the orebody is an economic cutoff based on copper content of the mineralized rock. Therefore, that portion considered economically feasible to mine appears in the more northerly portion as a tabular mass up to 400 feet thick with its long dimension bearing northeast and lying at an angle of 55° from horizontal to the southeast. This attitude persists down dip for about 2,400 feet where it flattens and then rolls upward to form a cross-sectional fishhook shape.
Fracture pattern	Intricate, three-dimensional network.
Mineral occurrence	Disseminated through the gangue rock.

Overburden or Capping

Description	Gila conglomerate and weakly mineralized monzonite
Thickness	Averages 670 feet

Mine Openings

Support	All ground requires support, either timber, steel or concrete.
Water	Newly-opened areas may show appreciable flow. Orebody drains rapidly
Temperatures	Moderate

Mine Production

Capacity	60,000 to 62,000 tons daily
Mining method	Block caving
Underground haulage	Electric trolley locomotives; ore car capacity, 12.5 tons; 15 cars per train, 180 trains per day.
Hoisting	Hoisted through three vertical shafts. First hoisting level 1475 feet (now completely mined out) Intermediate hoisting level, 1775 ft. Second hoisting level, 2075 feet. Hoists: 2 - 6000-hp, double-drum 1 - 7000-hp, double-drum Hoisting speed: 2500 to 3000 fpm Capacity of skip: 21 to 28 tons Run-of-mine ore: up to 14 inches

Ore Crushing (Mine)

Bin capacity	Three ore receiving bins hold 5,000 tons each
Primary crushers	Three gyratory crushers
Capacity	1,000 tons per hour each.

Ore Transportation - Mine to Concentrator

Storage	At mine loading point - three 10,000 ton bins.
Ore moved	Shuttle service railroad, 20 round trips daily.
Railway construction	Six mile, standard gauge, 132-pound rail, level, minimum curves with liberal radius.
Type of cars	Bottom-dump, air-operated.
Capacity of car	100 tons or 72 cubic yards.
Cars per train	32
Locomotives	1600hp, 125 ton, Electric-Diesels

Ore Crushing (Plant)

Coarse ore bin	20,000 tons capacity
Secondary crushing	Four 7-foot standard Symons cone crushers, 600 tph each
Tertiary crushing	Seven 7-foot short-head Symons cone crushers, 360 tph each
Fine ore bin	70,500 tons capacity.

Concentration of Ore

Concentrator	60,000 tons per day capacity.
Rod mills	Ten 10' x 13' rod mills and three 12'6" x 16' rod mills; primary grind in open circuit.
Secondary Grind	In closed circuit with 20-inch cyclone classifiers; twenty 10' x 10' and six 12'6" x 14' ball mills with twenty-six sets (122) 20-inch cyclone classifiers.
Flotation	1056-40 C.F. and 63-300 C.F. mechanical cells.
Concentrate regrind	Eight 8' x 12' ball mills.
Cleaner concentrate	1300 to 1500 tons of concentrate to molybdenum plant for recovery of molybdenum.
Molybdenum plant	Products - 92% MoS_2 concentrate ready to market and 28% copper concentrate to smelter storage bins.
Gold plant	Products - Precipitate with gold assay of more than 1000 ounces per ton, and silver assay of more than 1500 ounces per ton; fed to smelter holding furnace, and blended with anode copper.

Smelting of Copper Concentrate

Copper concentrate	28% final copper concentrate to one of two natural-gas fired, side-feed, reverberatory furnaces, 32' x 102' and 34' x 102'.
Reverberatory products	Matte at 32% to 35% copper Slag, to slag dump Waste gases--About 50% of contained heat recovered by two waste-heat boilers each furnace. Flue dust recovered from gases by electrostatic precipitator before entering 20' x 515' and 20' x 550' stacks.
Matte to converters	Three 13' x 32.5' and two 15' x 35' Pierce-Smith type converters
Converter products	Slag, return to reverberatory furnace Waste gases to electrostatic precipitator and stack Blister copper, delivered to 3 anode holding furnaces where it is blown and poled prior to casting into 785 and 760 pound anodes.

Refinery Production (Design Capacity)

Anodes charged per day	795 Tons
Cathodes pulled per day	650 Tons
Anode scrap pulled per day	135 Tons
Average weight -- Anodes	
Commercial sections	785 Pounds
Starting sheet section	760 Pounds
Starting sheets per day	± 5,400
Starting sheet blanks in cells	2,700
Average weight - starting sheets	12 Pounds
Anodes per cell	46
Cathodes per cell	47
Cathodes pulled per day	3,948

Division Power Supply

Outside sources	Arizona Public Service Company--- 115 kv transmission line
Waste heat boilers	One 10,000 kw steam-driven turbo-generator; one 13,600 kw
Supplemental (Emergency Standby)	5,500 kw gas-diesel plant at mine

Approximate Division Employment

Number of Employes	Approximately 3,000
Payroll	Over $20 million annually

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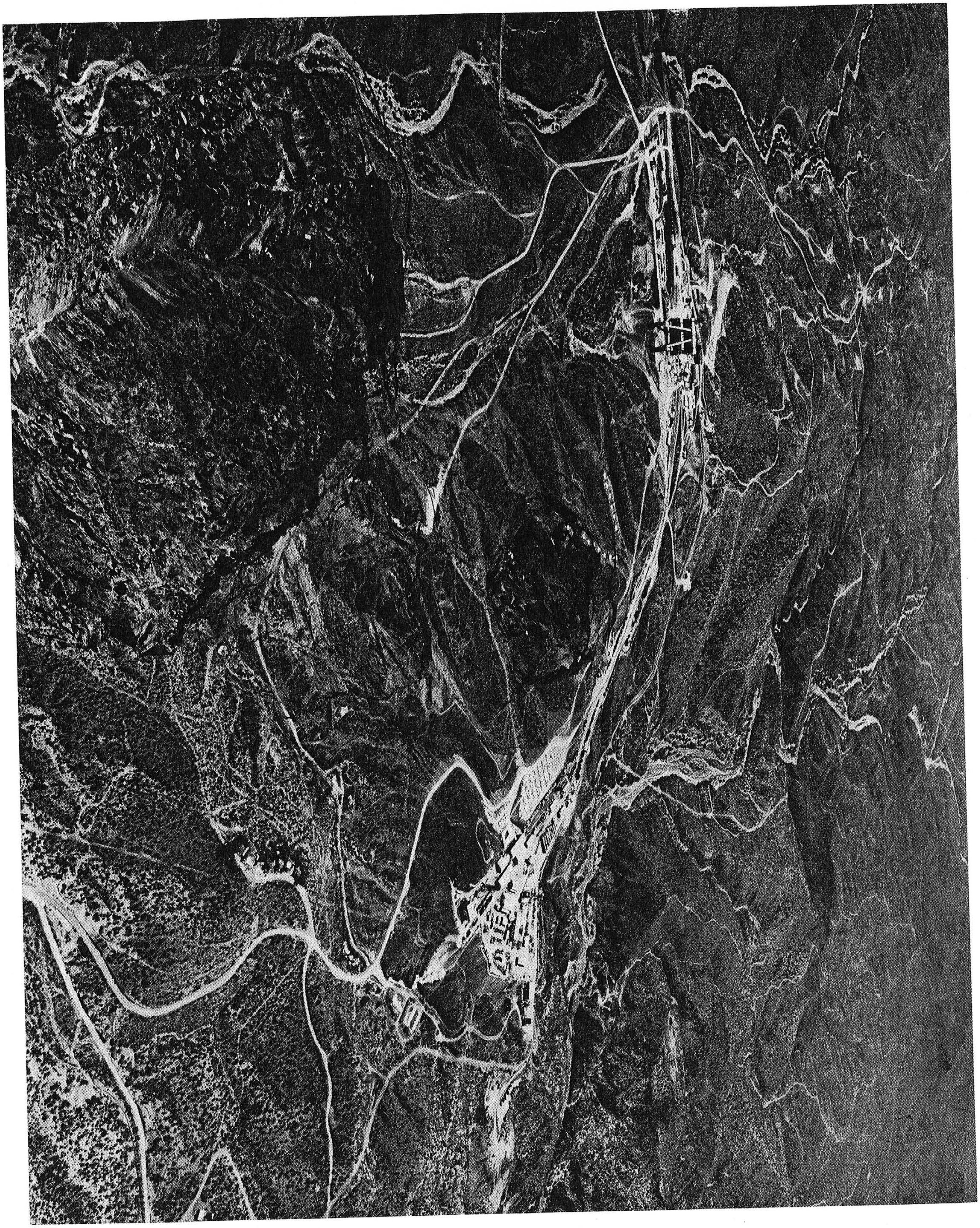


SAN MANUEL FILE

The Plant

GENERAL INFORMATION

MAGMA COPPER COMPANY

A Subsidiary of
Newmont Mining Corporation
San Manuel Division
San Manuel, Arizona 85631

THE HISTORY AND DEVELOPMENT OF THE SAN MANUEL DIVISION MAGMA COPPER COMPANY

Magma Copper Company's San Manuel Division is located in the south-east part of Pinal County, Arizona, about forty-five miles northeast of Tucson. Seven headframes and the dome-shaped Red Hill serve as landmarks for the mine area.

The concentrator, smelter, sulfuric acid plant, electrolytic refinery, administration building, and other plant facilities are located seven miles southeast of the mine area adjacent to the community of San Manuel.

The district was prospected prior to the Civil War, but there was little or no ore production until 1881. The chief producers were the Mammoth and Mohawk mines. Gold, lead, zinc, and some vanadium and molybdenum were the main recoverable metals at these properties. At least two exploratory churn drill holes were drilled in or near the San Manuel ore zone in 1917. The copper content indicated by these holes was not sufficient to encourage further exploration at that time.

In 1942, through the efforts of the property owners, James M. Douglas, R. B. Giffin, Victor Erickson, and Henry W. Nichols, all of Superior, Arizona, the Reconstruction Finance Corporation and War Production Board authorized the United States Geological Survey to investigate the property.

The survey confirmed the owners' original conception of the probable existence of important copper mineralization and, by its recommendation, the Bureau of Mines was authorized to put down a limited number of churn drill holes. This test drilling started in November, 1943, and was continued until February, 1945, when seventeen holes had been drilled for a total of 15,844 feet.

Magma Copper Company obtained an option to purchase the property in 1944. In September, 1944, Magma exercised its purchase option. Adjoining claims held by the Apex Lead Vanadium Mining Corporation and the Quarelli family were purchased. Additional claims were located and in December of that same year, Magma undertook exploration by churn drilling.

The San Manuel Copper Corporation was incorporated in August, 1945, and all of the property acquired by Magma Copper Company in the district was deeded to San Manuel. The corporate structure was changed in 1962 to include the San Manuel property as a Division of Magma Copper Company, rather than a wholly-owned subsidiary corporation. In 1969 Magma was merged with Newmont Mining Corporation and operates today as a wholly owned subsidiary of Newmont.

Exploratory churn drilling essentially was completed in early 1948, and underground exploration and development was started in March of that year.

On July 10, 1952, the Reconstruction Finance Corporation authorized a loan of $94,000,000 to San Manuel for mine development and plant construction.

TIGER MINE IN THE 1940'S

In early 1953 Utah Construction Company and the Stearns-Roger Manufacturing Company, a Joint Venture, was awarded a contract for the design and construction of the entire surface plant, including the concentrator, smelter, and railroads.

The concentrator was completed in September, 1955, and began trial runs on stockpiled and mine development ores. Smelter and remaining plant construction was completed in late 1955, except for minor cleanup work. The smelting of copper concentrates was started January 8, 1956. Five shafts had been sunk and over twenty miles of drifting had been completed to prepare the first lift for production. On January 23, 1956, the Mine was in production with the first stope undercut completed. Ore was first hoisted on November 21, 1955.

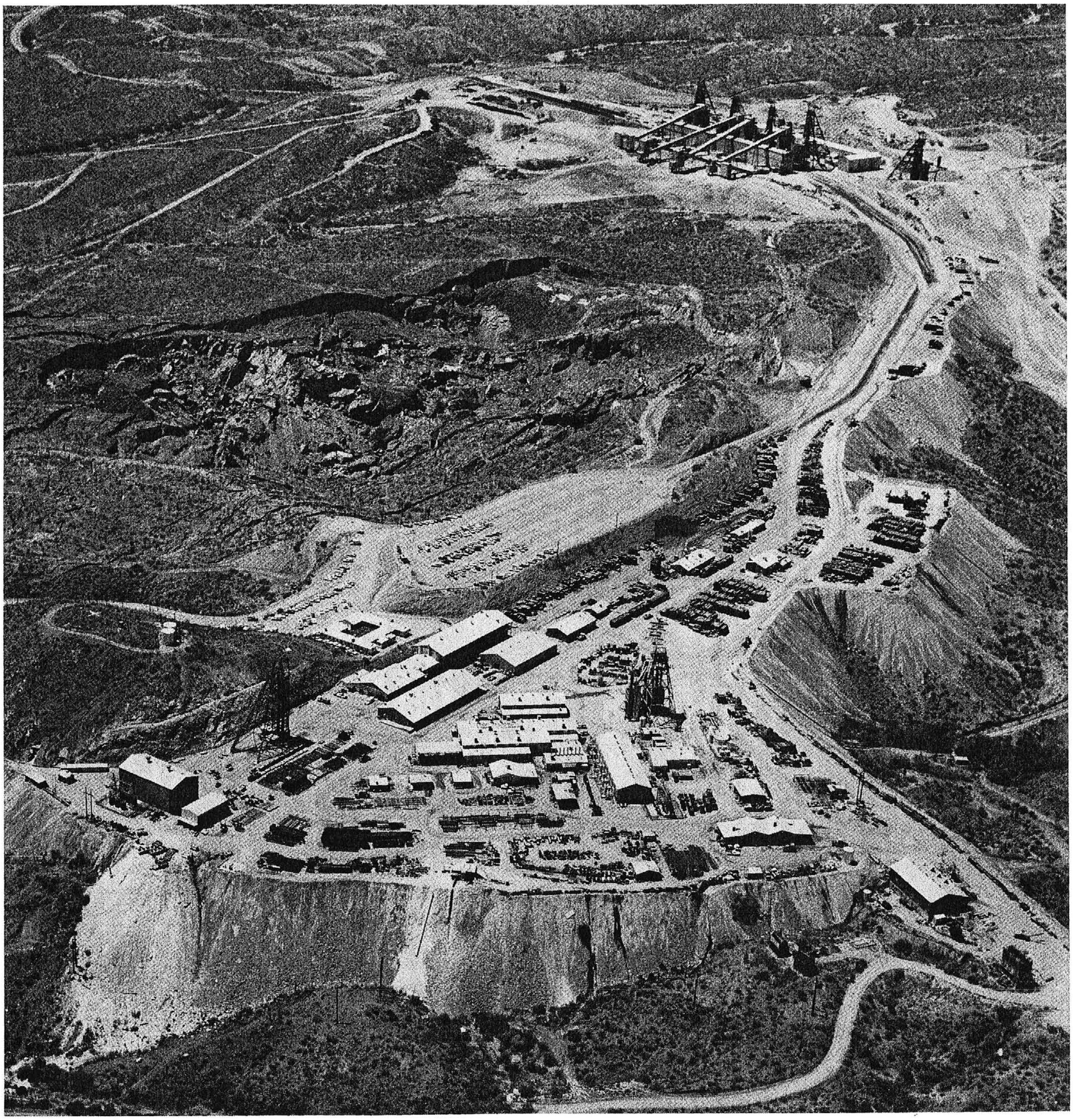
The 1475', or first level, was mined to completion early in 1965. The 2075', or second level, along with the 2375' or intermediate level, and the 2675', or third level are now being mined.

In 1968, Magma purchased nearby mining claims to an orebody of similar size and grade to San Manuel. The top of this second orebody lies 2,500 feet deep and mining will start on the 2950 level.

Since production started in 1956, the mine and plant have undergone two expansions. The first in 1965 boosted production from 30,000 to 40,000 tons of ore per day. In 1971, an expansion was completed that increased production to 62,500 tons of ore per day.

THE SAN MANUEL MINE

The San Manuel orebody is the recumbent lower half of an ore shell which was originally an elliptical (in cross-section) cylinder some 8000 feet long, and with major and minor axes of 5000 and 2500 feet. In its present location, its curved limbs lie 700 feet below the surface and its keel some 3000 feet deep. The economic ore shell occupies the regional contact zone between a central plug of intrusive granodiorite porphyry rock of laramide age and the intruded porphyritic quartz monzonite of pre cambrian age. The granodiorite porphyry core within the ore shell is marginally mineralized and the quartz monzonite surrounding the shell is strongly pyritized but with very low copper content. Post-ore faulting concealed most of the original San Manuel orebody under a wedge-shaped sequence of tertiary conglomerate.



1975 AERIAL VIEW OF SAN MANUEL MINE

The 700' thickness of the overburden and shape and size of the orebody combine to make open pit mining impractical. For these reasons the underground block caving method of mining was selected. The host rocks in which the ore occurs are well fractured, cave readily and crush to a size that is easy to transport.

Block caving entails the undercutting or removal of a horizontal slice of ore of sufficient area (stope block) so that the unbroken ore above will not support itself, but will cave and slough into the undercut. As the broken ore is drawn, removing support from the ore above, caving extends to the surface with the overburden or waste rock following the ore down. When the waste rock reaches the undercut horizon, drawing is stopped and the block is finished.

The caved ore from the undercut horizon is drawn on the grizzly level through a series of closely spaced draw raises. The grizzly level which is the control level, is 15 feet below the undercut. On the grizzly level the ore passes through the grizzlies which consist of rails spaced 14 inches apart over the top of each transfer raise.

Two transfer raises funnel the ore from eight draw raises to one common loading station on the haulage level which is about 60 feet below the grizzly level. A loading station serves two transfer raises, each of which, when full of ore, holds 55 tons. The ore stored in the raises is transported by an underground electric railroad system to the ore hoisting shafts.

Loading operations from the transfer raises to the ore cars are controlled through steel chutes and air operated chute gates. Two types of ore cars are used. One is a 12.3 ton rotary dump car which is used in a 15-car train with a total haulage capacity of 185 tons. The second type of ore car is a bottom dump, 15.5 ton capacity car which is used in a 10-car train with a total haulage capacity of 170 tons. In both cases ore trains are pulled by a 23-ton, 250 horsepower trolley locomotive. The trolley power system is 275 volt DC with rectifier stations situated to maintain full voltage throughout the haulage routes.

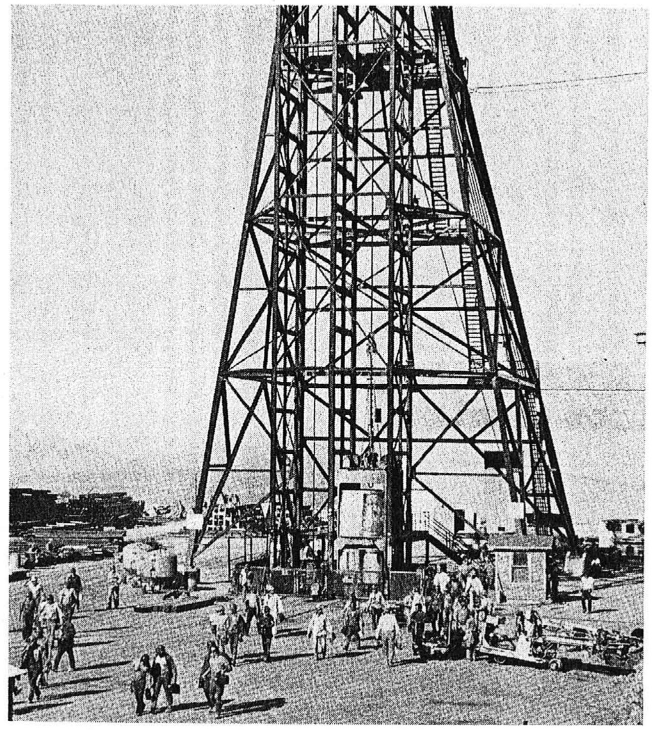
The underground track for the haulage system is 36-inch gauge with 70-pound rail through the panels. On the main lines between the mining area and the hoisting shaft, 90-pound rail is used to accommodate the heavy traffic and higher speeds.

Three of the four ore hoisting shafts, 3-A, B, & D, accommodate rotary dump type ore cars, the trains of which pass through a rotary tipple on the haulage level and dump three cars at a time. The cars are equipped with rotary couplings and are not disconnected as they are turned 180° to dump the ore into a 1500 ton underground storage bin adjacent to each hoist.

The 3-C shaft accommodates the bottom dump type ore car which passes over the ore dump on a rail while a mechanism opens the car bottom for dumping while the train is in motion.

The ore is drawn from the bottom of the pocket into a measuring pocket hopper which in turn discharges into skips for hoisting to the surface. The bottom dump ore skips, which hold from 21 to 28 tons of ore, are hoisted to the surface and discharged into four 5,000-ton surface storage bins, which in turn discharge onto pan feeders that carry the ore to the four gyratory crushers located nearby. Discharge from the crushers is moved by conveyor belts to four 10,000-ton surface storage bins awaiting transportation to the Plant.

Two ore hoisting shafts, 3-A and 3-B, are equipped with 6,000-hp hoists with 15-foot diameter drums. These



SHIFT CHANGE AT #4 SHAFT

hoists can be manually or automatically controlled. The operating hoisting speed is from 2500 to 3000 feet per minute. The 3-C and 3-D hoisting shafts are equipped with 7,000-hp hoists having 15-ft. diameter drums, hoisting at 2,850 feet per minute. The hoisting cables are 2-¼ inches in diameter. The hoisting shafts also serve for ventilation up-cast.

Nos. 1 and 2 shafts were sunk early in the program, and from these shafts the first mining lift was developed. No. 1 shaft, steel and reinforced concrete lined, now serves for concrete supply and hoisting of development waste rock and downcast ventilation. No. 2 shaft, sunk for exploration and quick development, has been abandoned.

No. 4 shaft, steel and concrete lined, serves as a downcast ventilation shaft and as a service shaft for men and supplies. Men are lowered and hoisted at the rate of 100 men per trip; and timber, powder, and other supplies necessary for the mining operation are lowered to grizzly and haulage levels through this shaft.

No. 5 shaft is equipped for service and development hoisting. The double drum service and supply hoist is powered by two 1000-hp DC motors and is capable of carrying 100 men per trip in its double deck cages. The double drum rock hoist is powered by one 1000-hp DC motor with power supplied through a 1000 KW static Thrystor. The rock skip capacity is 5.5 tons. It is a downcast ventilation shaft.

Other facilities at the mine include mechanical and electrical shops, modern timber framing shed, timber treating plant, warehouse, and change rooms. Mine air compressors provide 55,000 cubic feet per minute of compressed air for rock drills and other air-driven tools underground and on the surface.

Limestone and high grade silica for metallurgical use is mined from two separate quarries. Limestone is mined from a quarry site 6 miles south of the plant and hauled by truck. Silica is mined at a site 17 miles north of the plant and is hauled by the San Manuel Arizona Railroad to the flux crushing plant.

THE CONCENTRATOR

The primary crushing circuit located at the mine site is equipped with 4 gyratory crushers. A panel board located for each crusher and an intercommunication system provide control. Iron detectors are installed on conveyors for the removal of tramp iron. The final product of the mine crushing plant is conveyed to four 10,000-ton receiving bins for loading into ore transportation cars.

Ore transportation from the Mine to the Plant is by rail shuttle service in 100-ton capacity bottom-dump railroad cars. The two, 36-car trains are pulled by 1600-horsepower, 125-ton diesel-electric locomotives. The six mile ore transportation track is standard gauge, 132-pound rail and was constructed with liberal curves and no grade.

At the 20,000 ton coarse ore receiving bin at the Plant, the train pulls over the bin and four cars are dumped at a time through bottom-dump air-operated gates with compressed air furnished by the locomotive.

From beneath the receiving bins, ore is fed by 48" manganese steel pan feeders and belt conveyors into four, seven-ft. standard cone crushers at the rate of 1000 tons per hr. to each crusher. Magnets are suspended at the head of the conveyor to remove tramp iron. Crusher feed passes over double deck grizzly screens where undersize material is bypassed directly to fine ore bins. Screen oversize is conveyed to a series of secondary crushers. The crushed ore from the secondary crushers is conveyed and distributed to seven tertiary seven-ft. cone crushers, each preceded by mechanical screens to bypass the undersize material to fine ore bins.

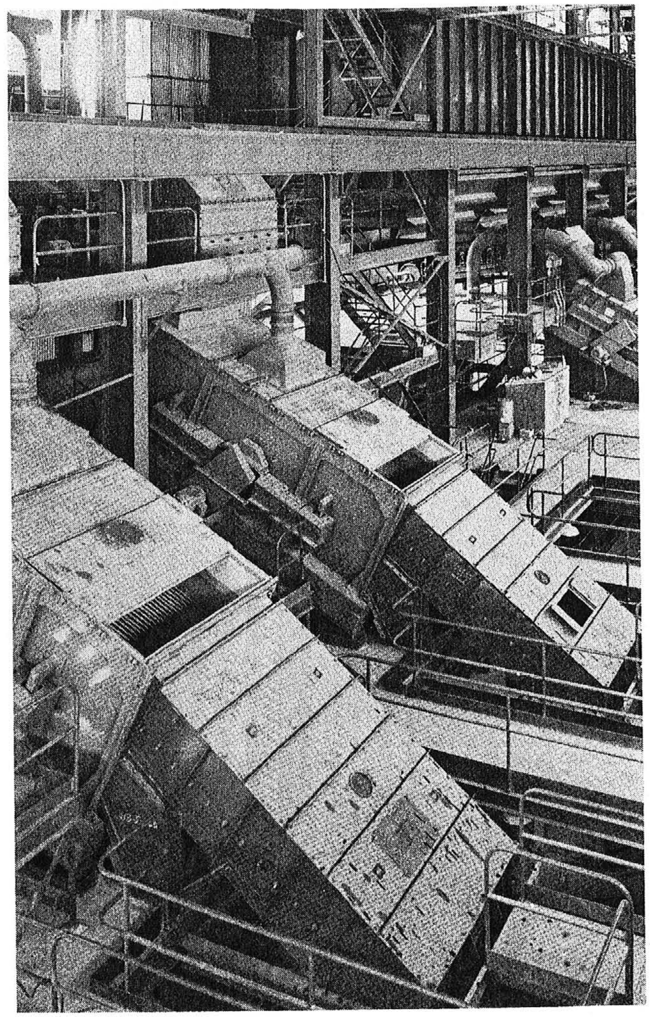
The crushing plant is designed with all crushers on the same level. A panelboard on the operating floor and an intercommunication system provide complete control from one point. A 30-ton overhead crane with a 5-ton auxiliary hook services the crusher floor.

The final product from the crushing plant, all less than one inch, is delivered by belt conveyor at the rate of 3,500 tons per hour to two 54-inch wide tripper conveyors. The tripper conveyors run across the top of the 70,500-ton capacity fine ore bin in the concentrator building and travel the length of the bin distributing the ore at an even rate. Seal belts cover the slots through which the ore is discharged and provide dust control.

The ore is drawn from the bottom of the fine ore bin by a system of belt conveyors onto gathering conveyors which feed the rod mill sections at the rate of 60,000 tons per day. A weightometer both registers and controls tonnage to each grinding section.

The concentrator is divided into thirteen grinding sections, ten sections each consisting of one 10' x 13' rod mill, and two 10' x 10' ball mills, and three sections each consisting of one 12'6" x 16' rod mill and two 12'6" x 14' ball mills. Ball mills are operated in closed circuit with 20-inch cyclone classifiers. Oversize material from classification is returned to the ball mills for additional grinding.

All grinding sections are operated from a central control room equipped for remote control and an intercommunication system and radio circuit help provide control. The grinding bay is serviced by a 175-ton crane and a 275-ton crane which are capable of taking out a fully charged rod or ball mill for repairs. Two 10-ton cranes serve for lighter and faster service.

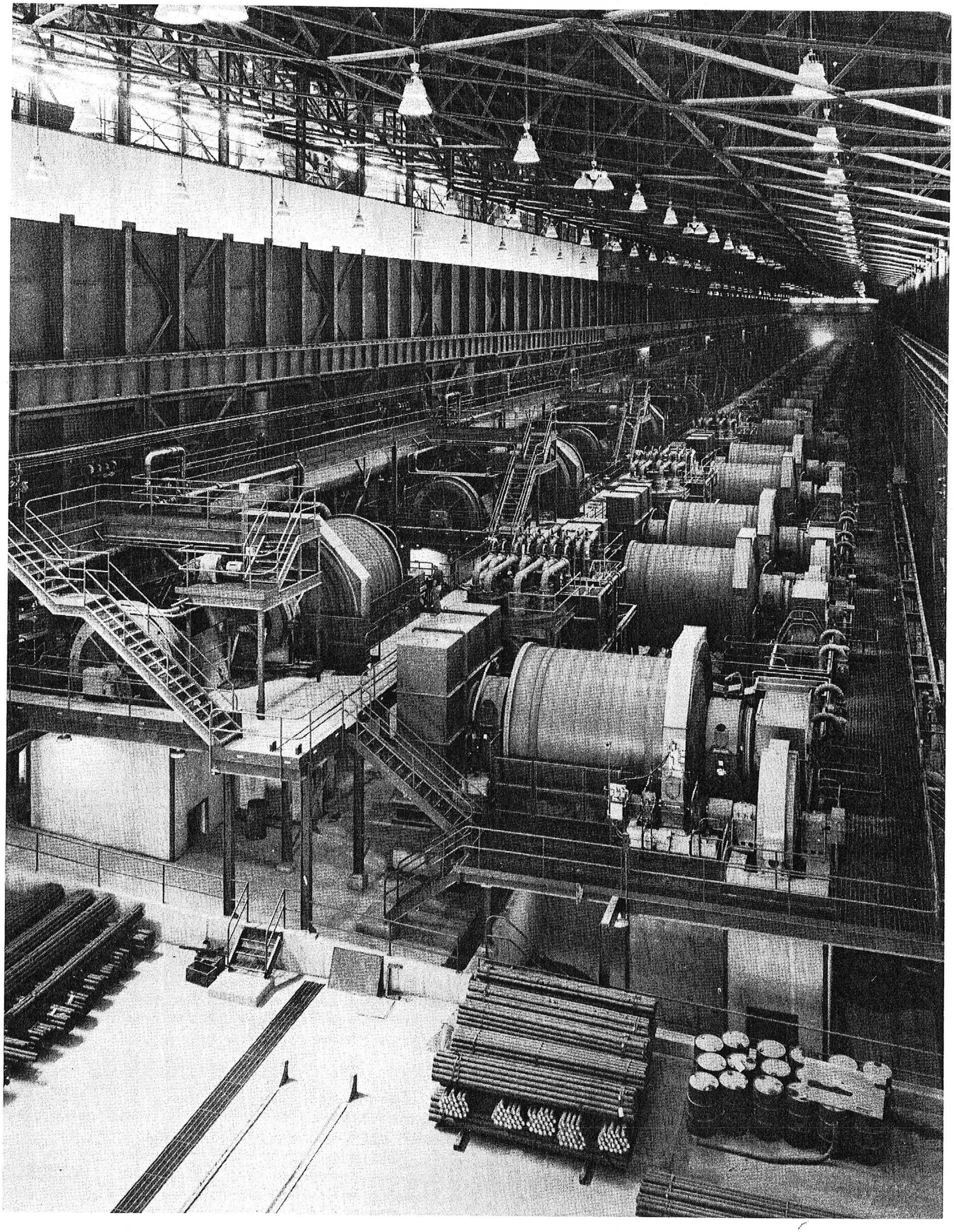


SECONDARY CRUSHING PLANT AT SAN MANUEL

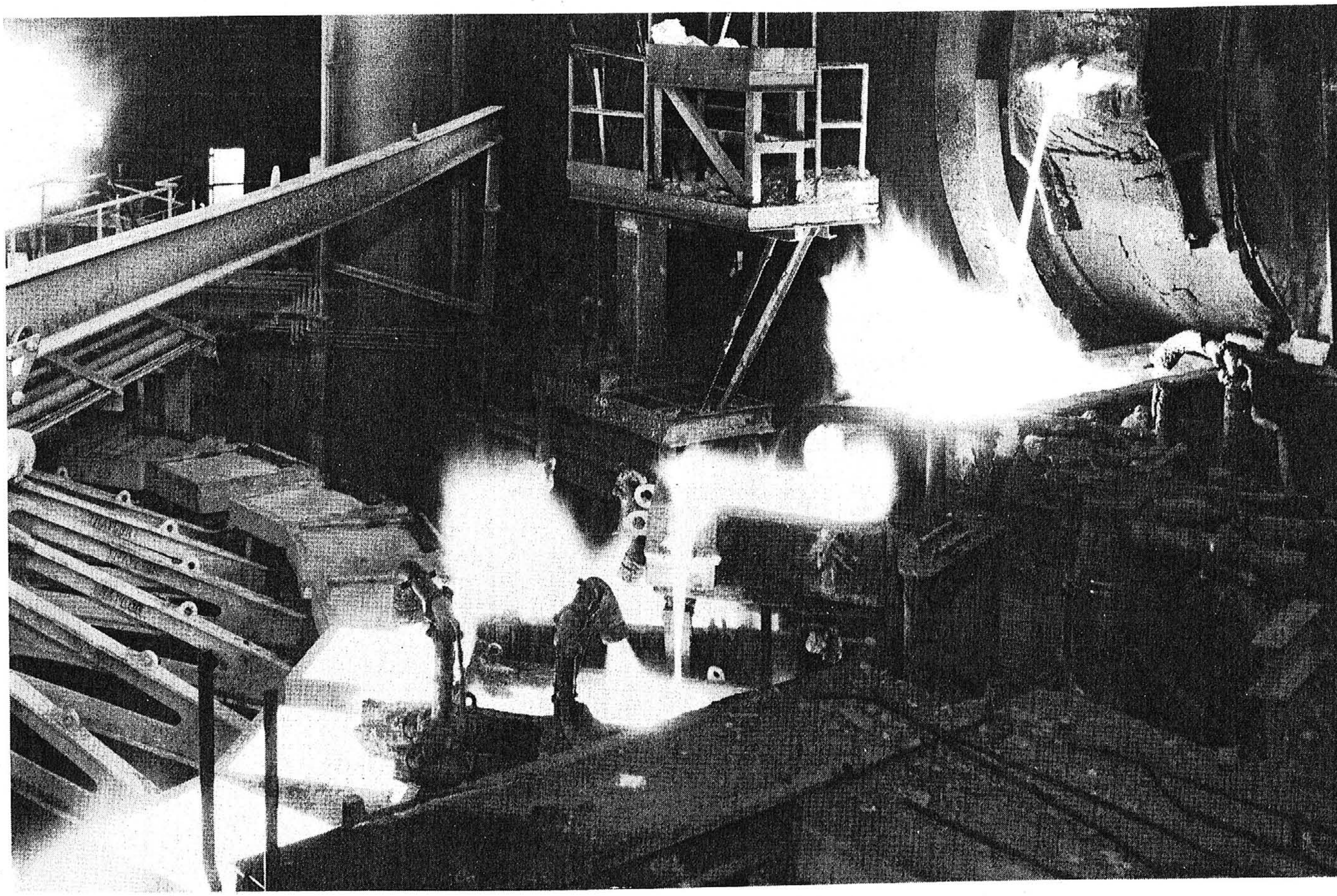
The classifier overflow goes to distribution boxes where, with reagents added, it is distributed to 40 cubic foot rougher flotation cells, and to 300 cubic foot rougher flotation cells, with a retention time of nine minutes. The copper-molybdenum minerals float to the surface of the pulp in each cell and are gathered in froth launders. The material not floated in these cells is called tailings, and is piped by gravity to the tailings thickeners where approximately 24,000 g.p.m. of reclaimed overflow water is returned to the mill for reuse. The thickened underflow is discharged to the tailings pond where the excess water is decanted and returned to the mill for reuse.

The mineral concentrate is pumped from the rougher flotation cell launders through cyclone classifiers in closed circuit with eight 8' x 12' regrind ball mills, then distributed to 276 forty cubic foot cleaner flotation cells. The tailings from this flotation are returned to the ball mill circuit or back to the primary cleaner cells. The final copper-molybdenum concentrate is pumped to a thickener. The thickened concentrate goes to the molybdenum recovery plant.

Molybdenum sulfide is recovered by flotation in another series of flotation cells, after which the concentrate is filtered, dried, and conveyed to drum storage. Tailings from the Molybdenum flotation process is the copper sulfide concentrate. It is thickened, filtered, dried, and conveyed to the concentrate storage bins at the smelter. Overflow water from the thickeners joins the recycled water to the mill circuit.



GRINDING MILLS AT SAN MANUEL CONCENTRATOR



PRECISION ANODE CASTING AT SAN MANUEL SMELTER

THE SMELTER

Copper concentrate, averaging about 28% copper and about 10% moisture, is drawn from storage bins by conveyor belts and is fed to each of three 102-feet long, brick, suspended-arch reverbatory furnaces through hoppers located along the sidewalls.

The concentrate is smelted at temperatures of approximately 2700°F using coal, natural gas or light oil for fuel interchangeably. Combustion air is preheated for higher efficiency and fuel conservation.

Slag is skimmed from the reverberatory bath into railroad slag pots of 380 cubic foot capacity for hauling to the slag dump.

Matte, composed of copper, iron, and sulfur is tapped into 300 cubic foot ladles and transferred by 60-ton overhead cranes to one of six Peirce-Smith type converters. Three converters are 13′ x 35′ and three are 15′ x 35′.

A silica flux is added to the converter bath where it combines with iron oxide to form a slag which is returned to the reverberatory furnaces. Compressed air is blown through the bath, oxidizing the sulfur to sulfur dioxide and leaving metallic blister copper. Several charges, slag skims, and blowing cycles over an 18-hour period are required to finish a batch of 115 - 130 tons of blister copper in each converter.

Molten copper from the converters is transferred by ladle to one of four holding furnaces where finish blowing and slagging is performed. Final excess oxygen is removed by injection of reformed natural gas or propane in the reduction or "poling" stage.

The finished or "fire refined" copper, about 99.7% pure, is poured by an automatic, computer controlled, system which delivers a precise weight of molten copper into anode molds on one of two revolving casting wheels. The molds are copper castings weighing approximately 5,700 pounds and are poured as needed. A releasing agent prevents the anodes from adhering to the molds.

Single anodes are poured on the smaller wheel and removed by an operator controlled mechanism to a quench tank for cooling. On the larger wheel two anodes are automatically poured and removed and quenched in pairs with an automatic take off device. Each anode weighs 820 pounds.

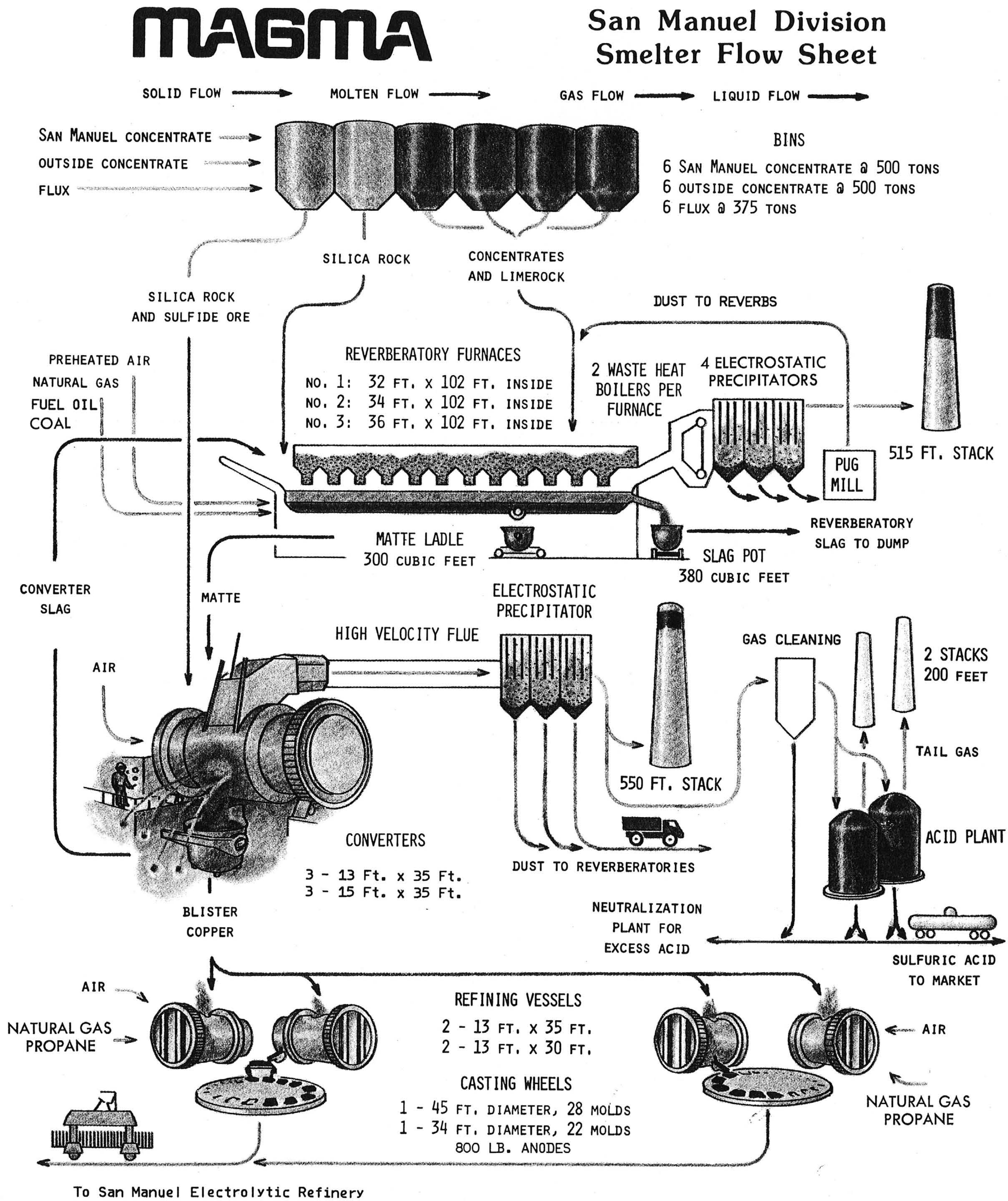
The anodes are removed by fork lift to the yard where they are inspected and loaded into bolsters for transport by 20-ton straddle carrier to the electrolytic refinery. The bolster racks are designed to hold the correct number of anodes, at proper spacing, for direct charging into the tank house refining cells.

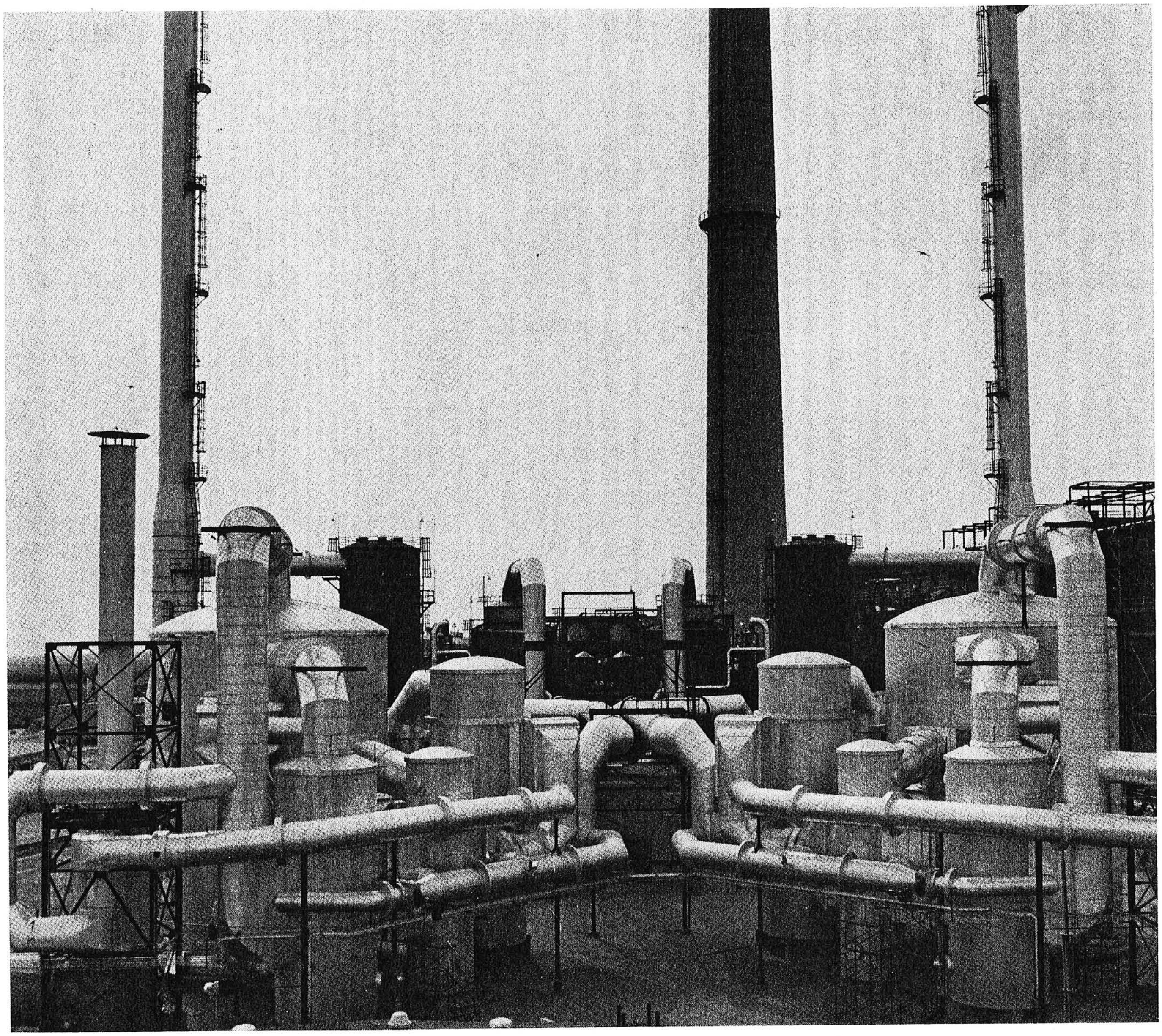
THE SMELTER POWER PLANT

Approximately 20% of the Division electrical power requirements are generated at the smelter power plant which has a capacity of 32,975 KW.

Gases from each reverberatory furnace pass through two waste heat boilers which furnish steam at 475 psig to the power house. There are three steam turbine generators, one rated at 12,975 KW and two rated at 10,000 KW. In addition there are five turbine compressed air blowers, three rated 30,000 cfm and two 45,000 cfm. The electricity feeds into the nearby utility substation and can be routed to the mine or plant facilities.

San Manuel Division Smelter Flow Sheet





SAN MANUEL SULFURIC ACID PLANT

SMELTER EMISSION CONTROL SYSTEMS

The two independent sources of gas emissions from the smelter are the reverberatory furnaces and the converters. Each source produces a unique emission and must utilize a unique control system.

REVERB EMISSIONS

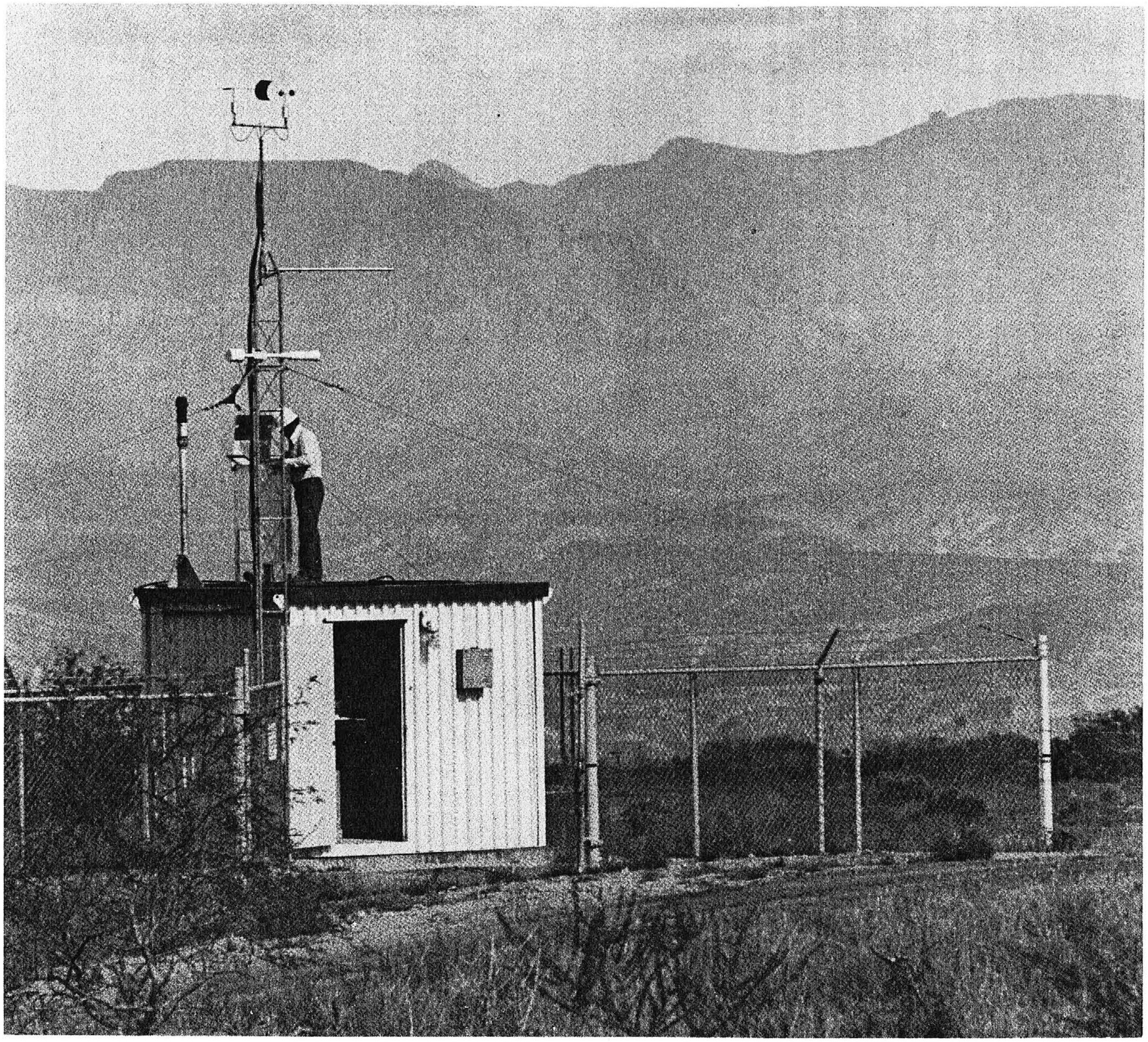
The emission gases from the reverberatory furnaces contain large amounts of particulates, and water vapor and small amounts of sulfur dioxide (less than 1% SO2 by volume). For control of the particulates the gases pass through a three-module electrostatic precipitator. Approximately 96% of the particulate matter is removed and returned to the furnaces. The normal plume from the 515′ western smelter stack is composed of approximately 1% sulfur dioxide, 15% water vapor, and 84% inert natural air components.

CONVERTER EMISSIONS

Emission gases from the six converters contain about 4% of sulfur dioxide and lesser amounts of moisture and dust. All converter emissions are passed to the sulfuric acid plant which is capable of recovering approximately 96% of this sulfur.

The gas collection system in the smelter includes water cooled converter hoods, balloon settling flues, and high velocity flues. Converter operations are scheduled to provide reasonably continuous flows of relatively strong sulfur dioxide to feed the acid plant.

An electrostatic precipitator removes dust before the gas is passed through cooling and humidifying towers and then through a bank of 6 mist precipitators to remove all remaining solids and acid mist.



REMOTE AIR MONITORING STATION NEAR SAN MANUEL

The resulting clean and dry sulfur dioxide gas is split into two trains, or modules, where it is passed through beds of a catalyst, vanadium pentoxide, which converts it to sulfur trioxide.

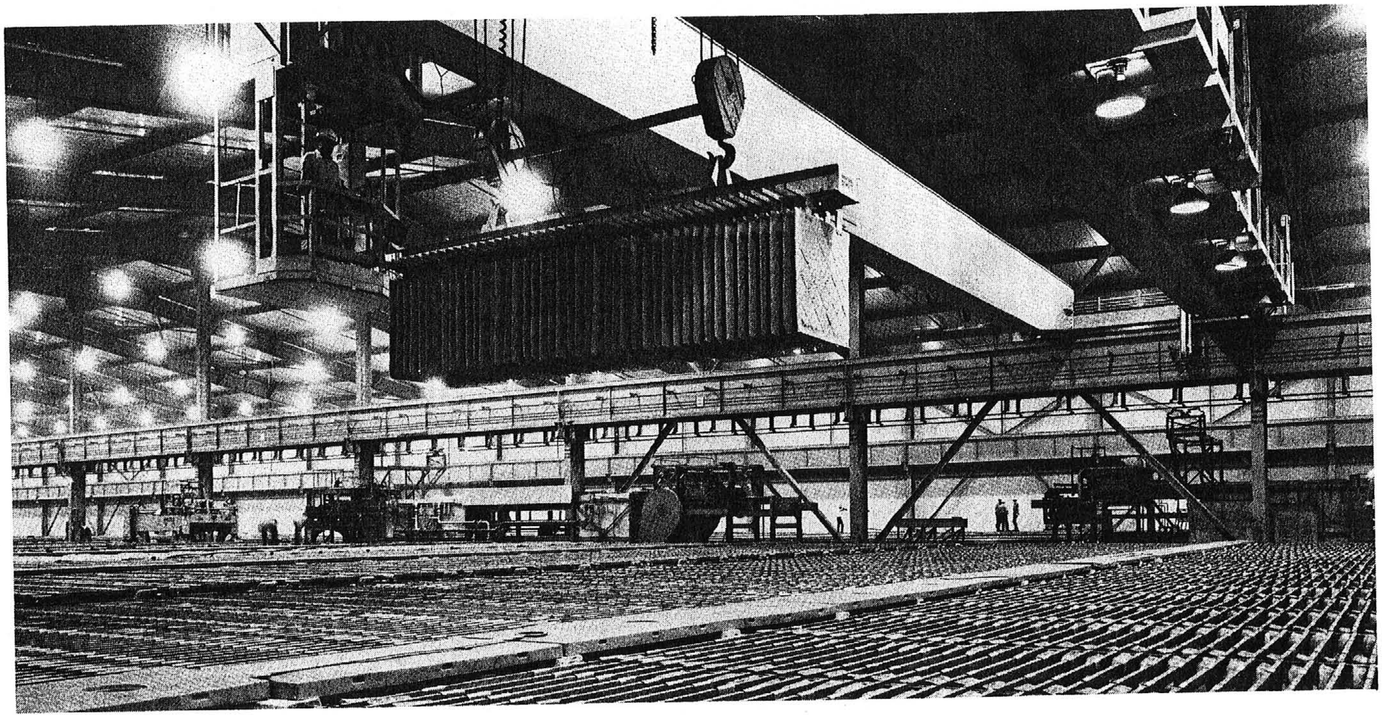
The sulfur trioxide passes to towers where it is absorbed into circulating sulfuric acid. The resulting saturated acid is then diluted to 93.4% commercial grade for storage and transport to market.

The plant has a production capacity of approximately 2,000 tons per day of sulfuric acid. Storage is provided at the loading docks for 20,000 tons. Neutralizing facilities are provided for any amounts of acid, including, if necessary, the entire production. A limestone slurry is mixed with the acid and the resulting gypsum slurry is introduced into the on-line tailings disposal stream from the concentrator.

When the sulfuric acid plant is in full operation there are no emissions from the eastern 550-foot high smelter stack. Minor tail gases from the two stainless steel acid plant stacks are invisible.

AIR MONITORING

Regulations require that ambient air standards will not be violated during adverse weather conditions so extensive system of eight continuous air monitors measures and records air quality conditions throughout the area of the smelter's influence. Special computer programs produce guidance information about potential air pollution episodes. The data is monitored in the Environmental Control Center and standing operating procedures provide for reduction or curtailment of emission producing operations if necessary to maintain ambient air standards.



OVEHEAD CRANE TRANSPORTING CATHODES IN TANK HOUSE

THE ELECTROLYTIC COPPER REFINERY

The San Manuel Refinery with an annual design capacity of 215,000 tons of electrolytic copper was completed in October, 1971.

The rod plant produces 125,000 tons of continuous cast 5/16" diameter copper rod per year. The balance of the production is in the form of cathode copper. The continuous cast rod is shipped in coils of from 6,000 lbs. to 16,000 lbs. in gross weight by rail and/or truck. Cathodes are shipped in bundles of appropriate size and weight to facilitate materials handling and loading.

Process and Facilities

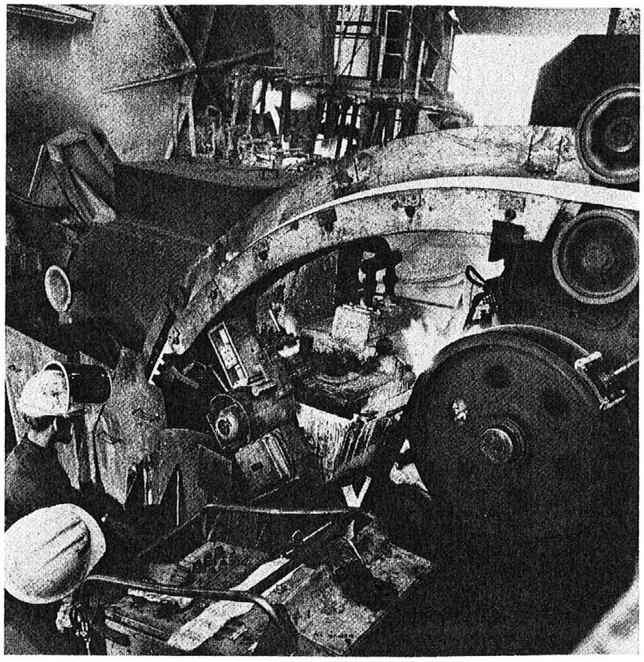
Refining takes place in the tankhouse. Smelter anodes are loaded in refining cells with 4" spacing with copper starting sheets suspended between the anodes. Electrolyte containing 50 grams per liter copper and 200 grams per liter sulfuric acid, with solution temperature controlled at 150°F, is circulated through each cell at the rate of 4 to 5 gpm.

Electric current is applied in a series-paralleled system to provide 20,600 amperes per cell. The DC voltage per cell is nominally 0.25. This provides a current density of slightly over 24 amperes per square foot of cathode surface. In the electro-refining process, copper ions go into solution at the surface of the anode. At the same time, copper ions are deposited from the electrolyte on the surface of the cathode. As the anode is depleted, the cathode grows in thickness and weight. Anodes are replaced after 28 days in circuit. Each anode charge produces two pulls of cathodes. Under normal operating conditions, an anode weighing 820 pounds produces two cathodes weighing 350 lbs. each. Approximately 100 lbs. of anode remain after 28 days exposure and is washed and returned to the smelter converters for recycling. Cathodes are washed and transferred to the rod casting plant or shipping docks.

Soluble impurities and copper which tend to concentrate in the electrolyte are controlled within strict concentration limits in the electrolyte purification (Liberator) section. The process of purifying the electrolyte is a modification of the commercial electrolytic refining process. Insoluble lead anodes are used with copper starting sheets as the cathode. Copper ions deposit on the cathode thereby depleting copper in the electrolyte. Partially decopperized cathodes are sent to the rod plant shaft furnace for melting.

Copper starting sheets, interspaced between the anodes at the start of the 14-day cathode cycle, are produced in the stripper (or starting sheet) section of the tankhouse. In the stripper section, rolled copper blanks with prepared surfaces are interspaced between copper anodes. Electrodeposition occurs in the same manner as the commercial sections. Blanks are pulled after 22½ hours of deposition and the thin, copper deposits are stripped from the blanks. Each day, 5,400 starting sheets weighing approximately 12 pounds each are produced. Two loops cut from starting sheet stock are automatically attached to each of the starting sheets and copper suspension bars inserted to complete the starting sheet assembly.

Impurities in anode copper either go into solution in the electrolyte or settle to the bottom of the electrolytic cell as slime. The slime, which contains various impurities including precious metals, is washed from the cells at the end of each 28-day anode cycle. It is collected and transferred to an acid leaching, filtering, and drying section. The dry slime is sampled and packed in plastic lined drums for shipment to a precious metals refinery for recovery of gold, silver, and selenium metals values.



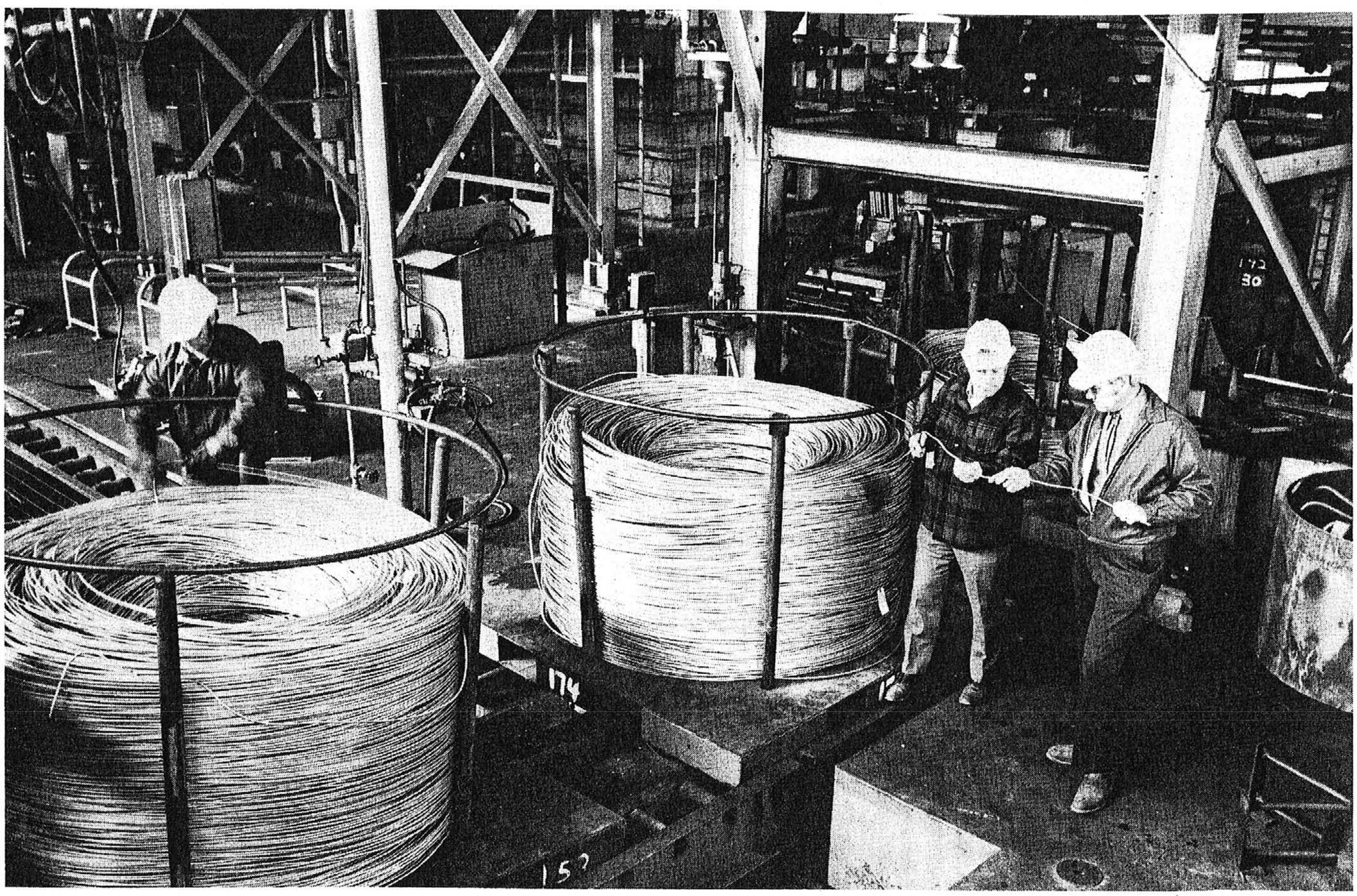
Continuous Rod Casting

Refined copper, in the form of cathodes, with dimensions approximately 38" x 38" and weighing approximately 350 pounds are transferred to the rod plant. Approximately 125,000 tons per year are melted and cast into 5/16" or 13/32" diameter rod.

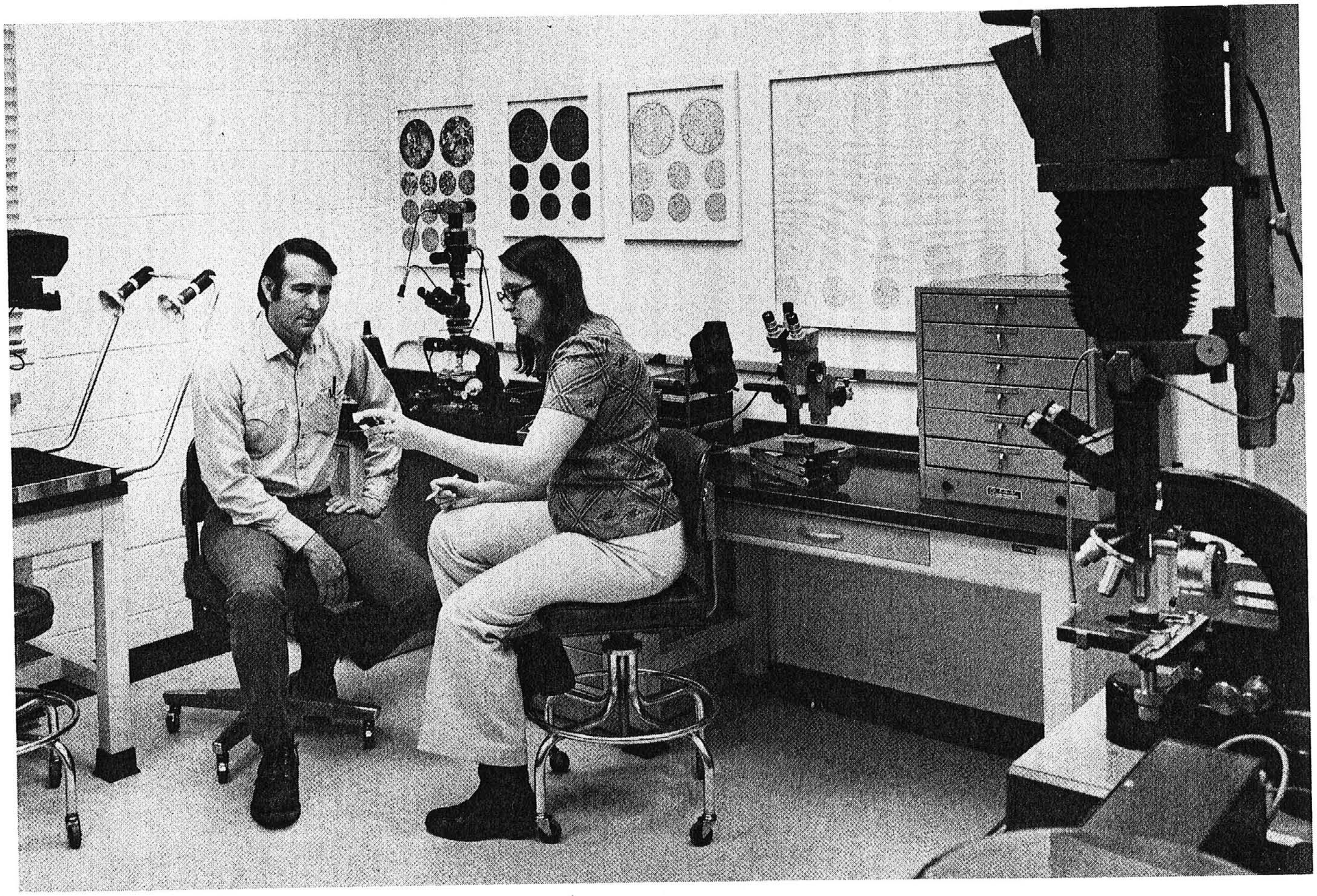
Cathode melting takes place in a gas-fired shaft furnace. Molten copper flows through a heated launder system to a 15-ton capacity gas fired, holding furnace.

Molten copper is fed to the rod casting machine at a controlled rate of 34 tons per hour by rotating the holding furnace. The molten copper flows into a casting ladle which directs the flow into the cavity of the casting wheel. The copper casting wheel is 96" in diameter with a rim cavity specifically designed and machined to produce a casting with 6 square inches of cross-sectional area. The entire casting assembly is water cooled and lubricated to produce a smooth casting.

The copper casting formed on the casting wheel is continuously withdrawn and fed to a large multiple stand rolling mill which reduces the original casting in 12 step reductions to 5/16" continuous rod or 10 steps for 13/32" rod. After leaving the rolling mill, the rod is pickled in a dilute sulfuric acid solution, washed and coated enroute to the coiling mechanism. Equipment is provided to coil and package the rod in various weight coils required by the customers. Packaged coils of finished rod are weighed and loaded directly into boxcars or upon trucks for shipment.



FINISHED 7-TON LAID COILS OF 5/16" CONTINUOUS CAST MAGMA ROD



QUALITY CONTROL IS ESSENTIAL IN PRODUCTION OF MAGMA COPPER

METALLURGY

The Division Metallurgy Department maintains service for assay, quality control, testing, and research for all operating divisions. Laboratory equipment and methods include x-ray fluorescent spectrometer, atomic absorption, optical emission spectrometer, gas chromatograph, wet chemical and fire assay, non-destructive testing, microscopy and physical metallurgy.

Four modern, fully equipped laboratories serve the Division, one of which is a quality control unit located at the continuous rod casting plant for production testing of finished product.

The metallurgical department operations include ore assay, process materials assay, product quality determination, stack gas analysis, weight and measure standards, process efficiency analysis, equipment wear and failure analysis, lubricant controls, combustion analysis, and research on new processes and products.

Extensive use of electronic data processing is utilized for metallurgical determinations and a teletype network gives prompt information at operational control points throughout the Division.

OTHER PLANT FACILITIES

The flux preparation plant is located between the smelter and concentrator buildings and includes receiving bins and crushers for handling limestone and silica flux. A lime kiln for calcining limestone, and a slaker provide metallurgical lime for the concentrator.

Other plant facilities include a machine shop with locomotive service and repair pits, electric shops, carpenter, and truck shops, warehouses, time offices, and change houses.

The San Manuel Arizona Railroad Company, a wholly owned subsidiary of Magma Copper Company, operates on thirty miles of standard gauge railroad from San Manuel to connect with the Southern Pacific Railroad at Hayden, Arizona. The depot is just north of the smelter-refinery gate. SMARRCO is a licensed interstate carrier.

SAN MANUEL, ARIZONA

THE TOWNSITE

To provide adequate permanent housing facilities for the construction period, as well as the future productive life of the mine, an agreement was made with the Del E. Webb Construction Company and M.O.W. Homes, Inc., under which they were to finance and build a community suitable for the accommodation of San Manuel's employes.

Active construction was started in mid-1953, and by late 1954, the community of San Manuel, consisting of 1,000 homes, shopping facilities, and hospital, was completed. Magma Copper Company acquired the property early in 1955. Additional houses were built in 1957 and in 1971 bringing the total to 1,276.

The community at San Manuel, Arizona, contains modern homes, shops, and surfaced streets, on the sloping west side of the San Pedro Valley. To the east are the Galiuro Mountains, while to the west are the Santa Catalina Mountains.

San Manuel was conceived and built for those who work for Magma Copper Company, as well as for those in related activities — merchants, police officers, clergymen, and others.

The main shopping center covers 32 landscaped acres off McNab Parkway. The shops located there offer San Manuel a wide variety of merchandise and services. This is supplemented by a second shopping center located in the lower part of the town.

The townsite properties are managed from the San Manuel Townsite Office of the San Manuel Division of Magma Copper Company.

The San Manuel Division Hospital, a half-million dollar institution, maintains the very latest equipment, and a complete medical staff services the needs of San Manuel and vicinity.

Within the hospital there is a completely equipped surgery, nursery, two obstetrical rooms, emergency room, x-ray room, x-ray developing room, a patients' wing of 30 beds, doctors' offices, laboratories, therapy rooms, reception room, waiting room, offices, kitchen facilities, and dining rooms.

In this same area is located the Administration Building which houses the various management, accounting, purchasing, and personnel offices.

San Manuel elementary schools, Mammoth elementary school and San Manuel High School and Junior High School serve the Mammoth Public School District.

Five schools were completed at a cost of more than than $5,000,000 for buildings and equipment. The School Board is elected by the registered electorate without regard to property ownership.

A 10,000-book library serves the town of San Manuel and supplements the school libraries. The library has gradually expanded from a small one-room area in the Community Center building to its own quarters with over 1,500 square feet of floor space.

Parks, playgrounds, community center, and swimming pool facilities are provided by the Townsite for the residents of San Manuel.

STATISTICAL DATA

ORE DEPOSIT

Type	Dessiminated copper
Gangue rock	Quartz monzonite porphyry
Metallic minerals	Pyrite, chalcopyrite, chalcocite, molybdenite, silver and gold
Copper content	About 0.75%
Molybdenum sulfide content	About 0.025%
Gold and silver contents	Trace amounts

OREBODY

Orebody	The control as to size and shape of the orebody is an economic cutoff based on copper content of the mineralized rock. Therefore, that portion considered economically feasible to mine appears in the more northerly portion as a tabular mass up to 400 feet thick with its long dimension bearing northeast and lying at an angle of 55° from horizontal to the southeast. This attitude persists down dip for about 2,400 feet where it flattens and then rolls upward to form a cross-sectional fishhook shape.
Fracture pattern	Intricate, three-dimensional network
Mineral occurrence	Desseminated through the gangue rock

OVERBURDEN OR CAPPING

Description	Gila conglomerate and weakly mineralized monzonite
Thickness	Averages 670 feet

MINE OPENINGS

Support	All ground requires support, either timber, steel or concrete
Water	Newly-opened areas may show appreciable flow. Orebody drains rapidly
Temperatures	Moderate

MINE PRODUCTION

Capacity	62,500 tons daily
Mining method	Block caving
Underground haulage	Electric trolley locomotives; ore car capacity: 12.5 tons rotary dump, 15 cars per train, and 15.5 ton bottom dump cars, 10 cars per train
Hoisting	Hoisted through four vertical shafts First hoisting level 1475 feet (now completely mined out) Intermediate hoisting level, 1775 ft., now depleted Second hoisting level, 2075 feet Intermediate level, 2375 feet Third hoisting level, 2675 feet Hoists: 2 - 6000-hp, double drum 2 - 7000-hp, double drum Hoisting speed: 2500 to 3000 fpm Capacity of skip: 21 to 28 tons Run-of-mine ore: up to 14 inches

ORE CRUSHING

Bin capacity	Four ore receiving bins hold 5,000 tons each
Primary crushers	Four gyratory crushers 1,000 tons per hour each

ORE TRANSPORTATION — MINE TO CONCENTRATOR

Storage	At mine loading point — four 10,000 ton bins
Ore moved	Rail shuttle service, 18 round trips daily
Railway construction	Six mile, standard gauge, 132-pound rail, level, minimum curves with liberal radius
Type of Cars	Bottom-dump, air-operated
Capacity of car	100 tons or 72 cubic yards
Cars per train	36
Locomotives	4 ALCO 1600hp Electric-Diesels

ORE CRUSHING (PLANT)

Coarse ore bin	20,000 tons capacity
Secondary crushing	Four 7-foot standard cone crushers, 600 tph each
Tertiary crushing	Seven 7-foot short-head cone crushers, 360 tph each
Fine ore bin	702,500 tons capacity

CONCENTRATION OF ORE

Concentrator	62,500 tons per day capacity
Rod mills	Ten 10′ x 13′ rod mills and three 12′6″ x 16′ rod mills; primary grind in open circuit
Secondary Grind	In closed circuit with 20-inch cyclone classifiers; twenty 10′ x 10′ and six 12′6″ x 14′ ball mills with twenty-six sets (122) 20-inch cyclone classifiers
Flotation	1056-40 C.F. and 63-300 C.F. mechanical cells.
Concentrate regrind	Eight 8′ x 12″ ball mills
Cleaner concentrate	1300 to 1500 tons of concentrate to molybdenum plant for recovery of molybdenum
Molybdenum plant	Products — 90% MoS_2 concentrate ready to market and 28% copper concentrate to smelter storage bins

SMELTING OF COPPER CONCENTRATE

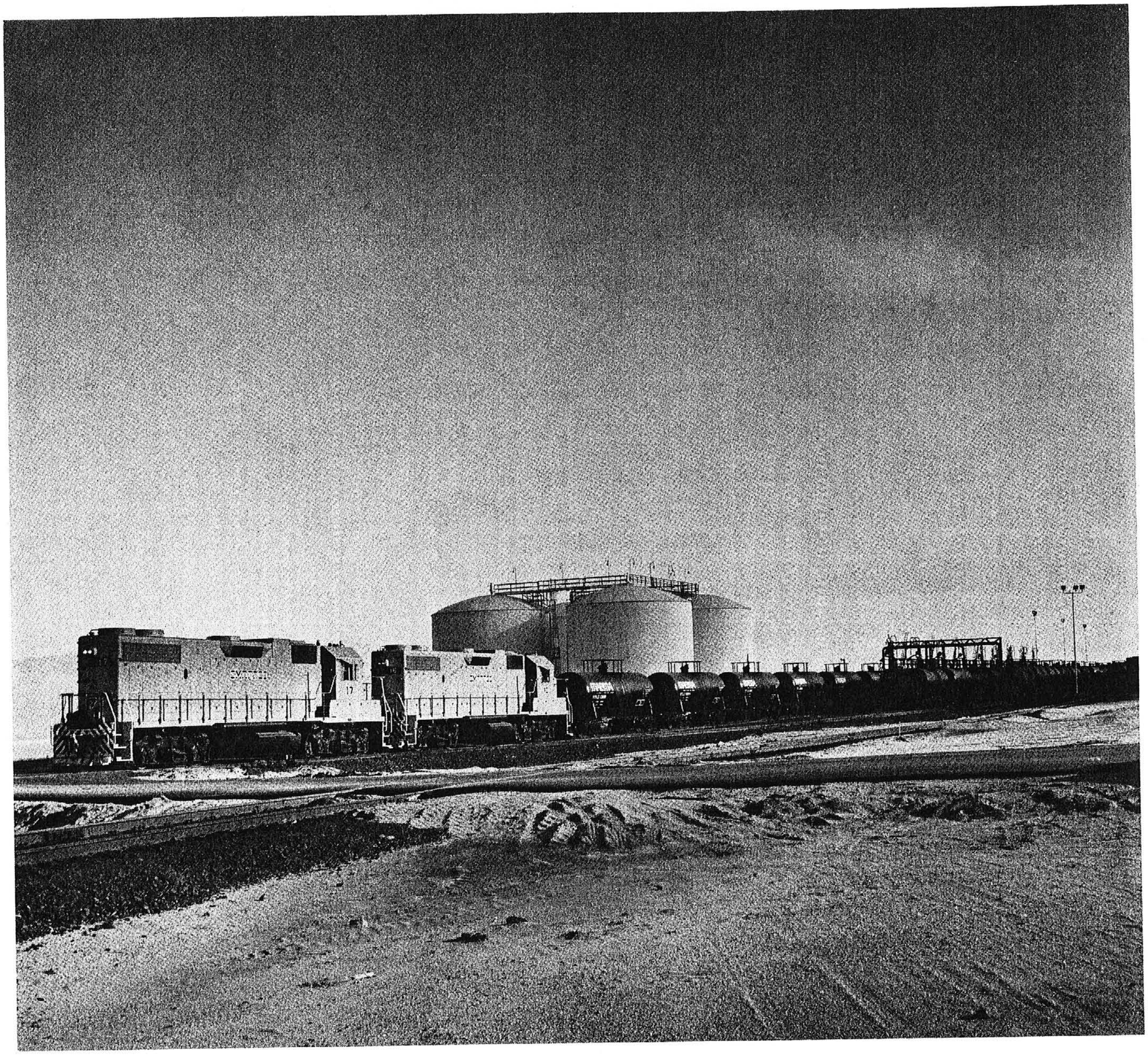
Copper concentrate	28% final copper concentrate to one of three coal, natural-gas, or oil fired, side feed, reverberatory furnaces, 32′ x 102′, 34′ x 102′ and 36′ x 102′.
Reverberatory products	Matte at 28% to 34% copper. Slag to slag dump. Waste gases — about 50% of contained heat recovered by two waste-heat boilers on each furnace. Flue dust recovered from gases by a three compartment electrostatic precipitator before entering 20′ x 515′ stack.
Matte to converters	Three 13′ x 35′ and three 15′ x 35′ Peirce-Smith type converters.
Converter products	Slag, return to reverberatory furnace. Waste gases to electrostatic precipitator and contact acid plant. Blister copper, delivered to 4 anode holding furnaces where it is fire refined prior to casting into 820 pound anodes.

REFINERY PRODUCTION

Anodes charged per day	740 Tons
Cathodes pulled per day	620 Tons
Anode scrap pulled per day	114 Tons
Average weight — Anodes	
Commercial Sections	820 Pounds
Starting sheet section	783 Pounds
Starting sheets per day	5400
Starting sheet blanks in cells	2700
Average weight — starting sheets	12 Pounds
Anodes per cell	46
Cathodes per cell	45
Cathodes pulled per day	3357

MISCELLANEOUS

1979 Employees	4,786
1979 Payroll	$ 86,310,428
1979 Fringe Benefits	$ 27,296,519
1979 Arizona Purchases	$ 59,877,927
1979 Arizona Taxes	$ 16,245,898
1979 Refined Copper Produced	160,539 Tons



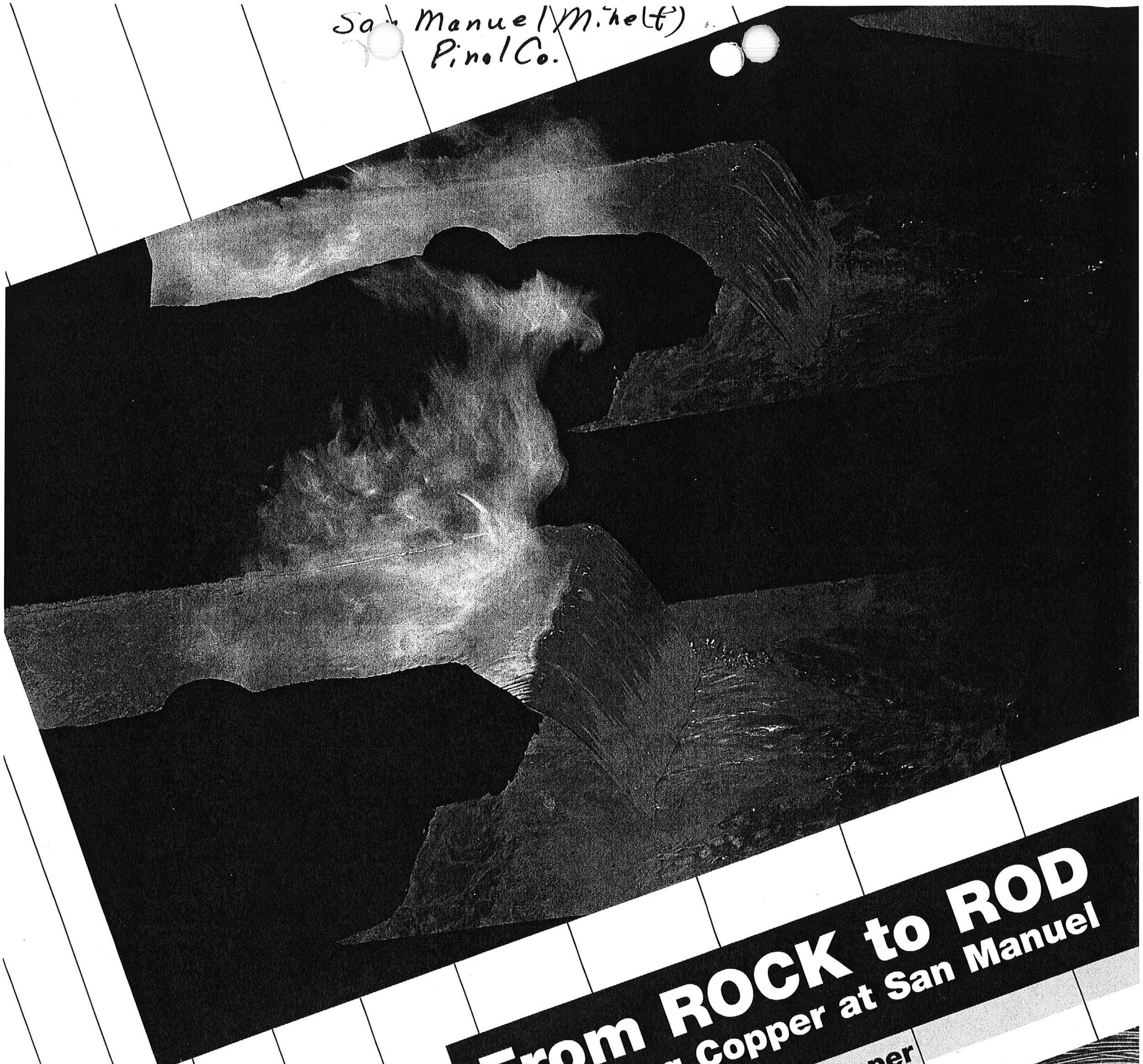
STRING OF SULFURIC ACID TANK CARS START TO MARKET VIA SMARRCO

San Manuel Arizona Railroad Company

WHOLLY OWNED SUBSIDIARY OF MAGMA COPPER COMPANY

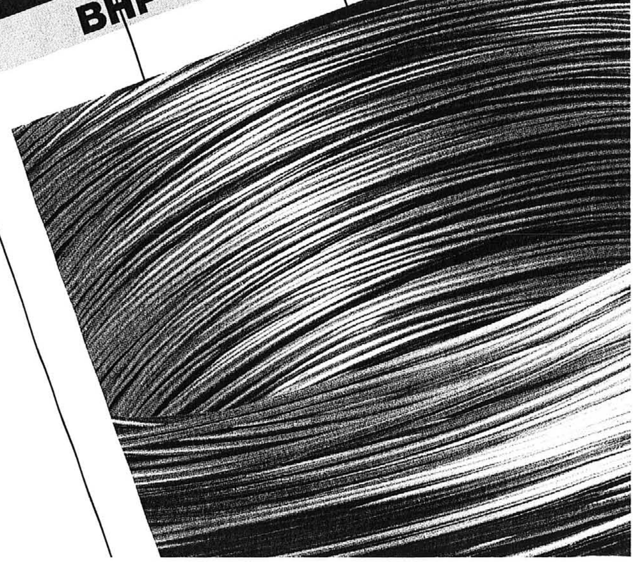
Incorporated	September 1953
Track mileage	San Manuel-Hayden Junction 29.42 miles
Freight carried 1979	783,000 Tons
Locomotives	4 ALCO 1600hp Electric diesel road switchers 2 EMD 2000hp Electric diesel road switchers
Employees	35
Schedule	Operates daily to Hayden Junction connection with Southern Pacific.

San Manuel (Mine(f))
Pinal Co.



From ROCK to ROD
Producing Copper at San Manuel

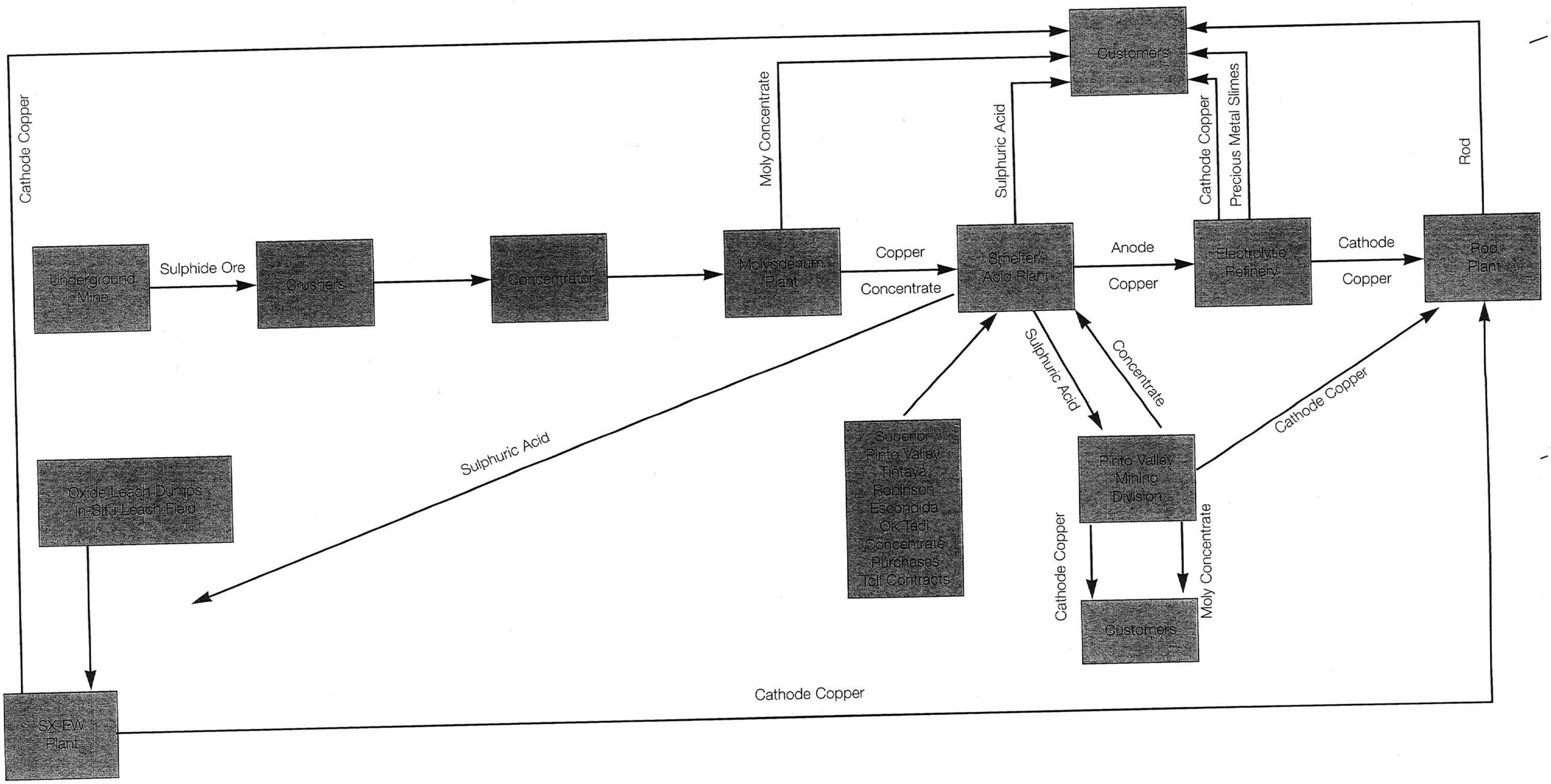
BHP Copper

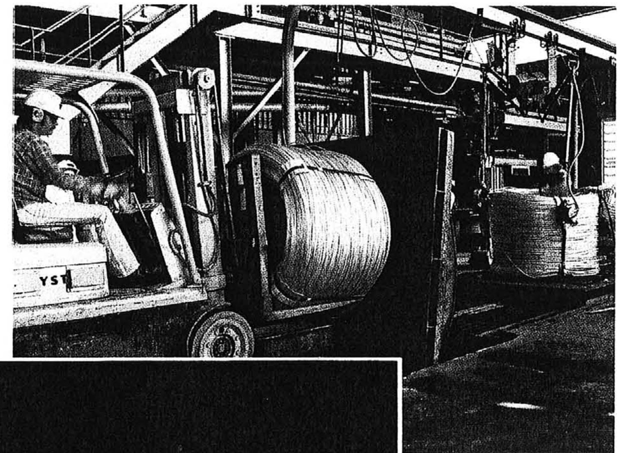


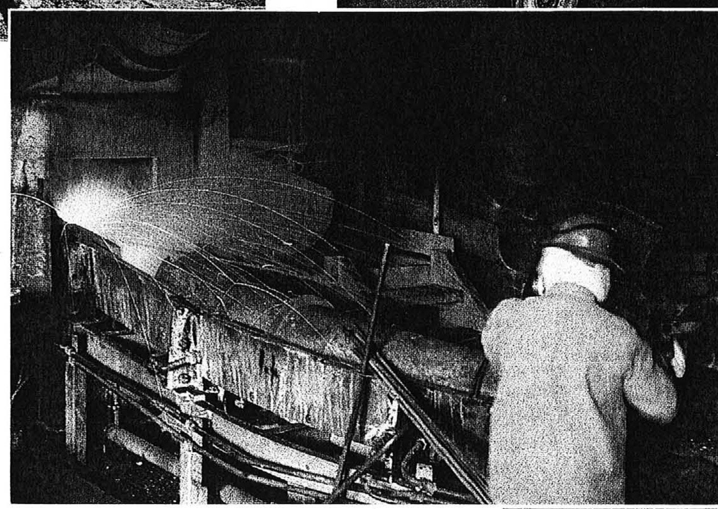
BHP

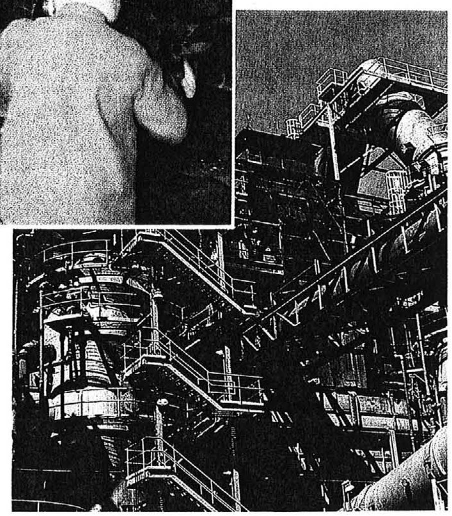
BHP Copper

MAJOR OPERATIONS at SAN MANUEL









BHP Copper

San Manuel, Arizona copper production operations have a unique degree of vertical integration of underground mining, in situ leaching, solvent extraction-electrowinning, concentrating, smelting, electrolytic refining, continuous rod casting, sulphuric acid production, transportation and shipping.

These interconnected operations result in a synergy which provides efficient, economical operations and quality products.

Mining

The San Manuel and Kalamazoo underground sulphide mines are the largest underground mining operations in North America and since start-up in 1956 have produced over 583 million tonnes of ore.

Concentrating

Sulphide ore from the underground mine is crushed, milled and concentrated in a modern bulk flotation plant. In addition smelter slag is recycled through the concentrator and special circuits recover by-product molybdenum.

In Situ Leaching

Acidic leaching solutions are injected directly into a copper oxide reserve where they dissolve copper minerals and are pumped to the surface for processing.

The in situ well field occupies a former open pit oxide mine. Ore from the pit, previously placed on leach pads, continues to be leached for optimum recovery of copper.

SX-EW/Solvent Extraction - Electrowinning

Copper-rich leaching solutions are concentrated in the solvent extraction process and the copper is electroplated out in the form of high purity cathode copper for utilisation at the San Manuel rod plant or for direct sale to customers.

Smelting

The flash smelter at San Manuel handles approximately 25% of the U.S. copper smelting capacity and processes BHP Copper concentrates, purchased custom concentrates and toll concentrates.

Refining

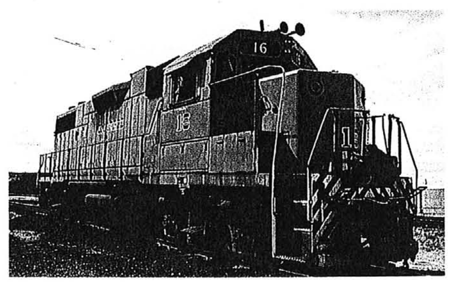
The electrolytic refinery produces premium grade cathode copper for market.

Rod Plant

Located at the electrolytic refinery, the rod plant produces continuous cast 7.9 mm copper rod for the wire and cable industry.

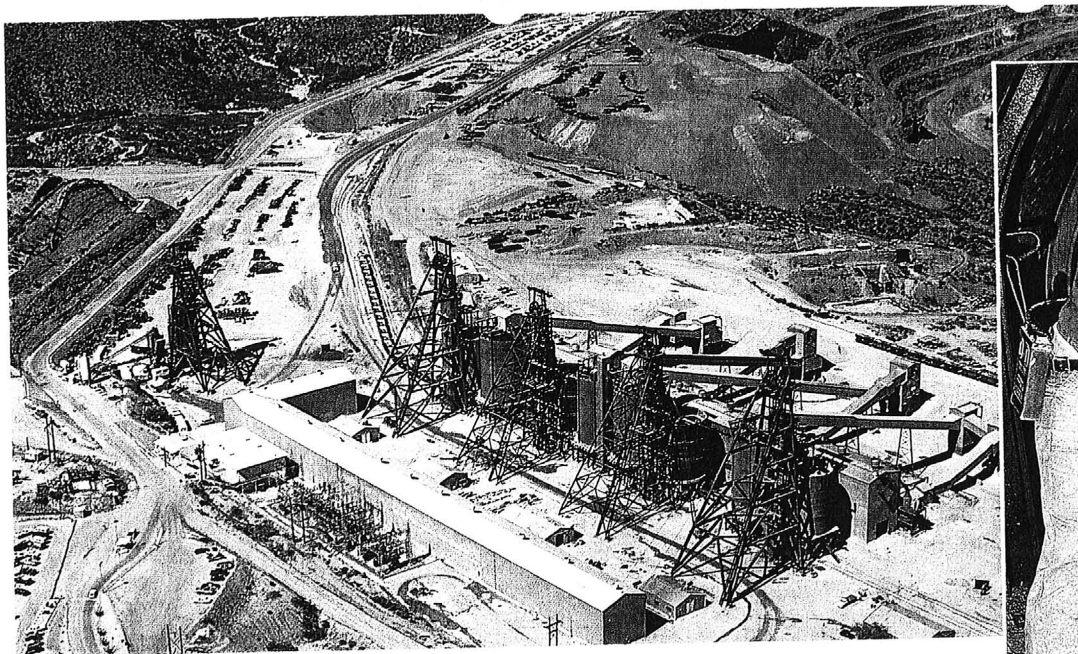
Products

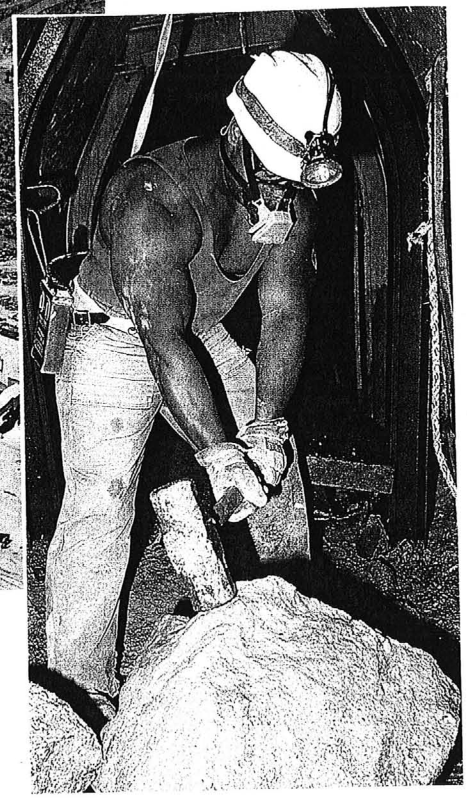
Full plate electrolytic copper cathode
7.9mm copper rod
Molybdenite concentrate
Sulphuric acid
Gold and silver residue



Railroads

The San Manuel Arizona Railroad Company interconnects with the Southern Pacific rail system to provide North American freight service.





THE UNDERGROUND MINE

In production since 1956, the San Manuel mine has hoisted over 583 million tonnes of ore from a mineral deposit of approximately 900 million tonnes of ore.

In terms of production capacity, orebody size and installed facilities the San Manuel mine is currently the largest underground copper mine in North America.

The economic minerals are mined from an elliptical-shaped porphyry cylinder some 2,400 metres long and 760 metres wide across, lying between 210 metres to 915 metres below the surface.

A faulted segment called the Kalamazoo, or "K" orebody, similar in size and composition, lies 1.6 km to the west and between 760 and 1,220 metres below the surface.

In 1990 this orebody was brought into production and is currently producing 14,500 tonnes of ore per day.

Production from the San Manuel and Kalamazoo orebodies is from zones of disseminated copper mineralisation at an average grade of 0.61% copper or approximately 6 kilograms of copper contained in each tonne of ore.

Too deep for open pit mining, the orebody is recovered by the underground block caving method. Total underground production is currently 54,430 tonnes of ore per day.

Block caving entails removal of a horizontal slice of ore so that the ore above will not support itself and will collapse by gravity into and through a gathering system funneling into an underlying haulage level.

Ore is loaded by gravity into trains hauling up to 270 tonnes per trip to the dumps at vertical hoisting shafts where it is hoisted to the surface.

There are four production shafts and three service shafts. The service shafts provide intake ventilation and supplies to the underground operation. The production shafts serve as exhaust ways. The forced-air ventilation system provides in excess of 34,000 cubic metres per minute of fresh air circulating through the mine.

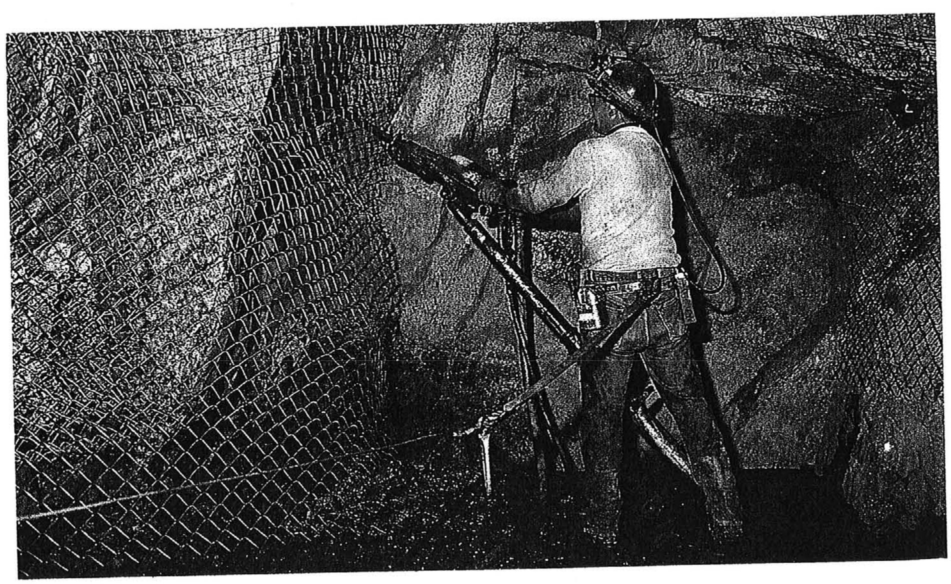
Primary development is performed with rail-mounted, pneumatic equipment, or rubber-tired LHD's (load-haul-dump) and hydraulic, rubber-tired drill jumbos. In the Lower Kalamazoo 10,000 metres of drift were excavated by means of a tunnel boring machine (TBM). Secondary development including undercutting uses jackleg drills.

All openings are supported by either timber, concrete, or steel mesh and rockbolts.

Ore production requires a pair of levels separated from each other by 18 vertical metres. The upper draw level funnels ore through a system of transfer raises to the underlying haulage level.

Filling the transfer raises are employees on the draw level who pull the ore from draw raises which reach up into the undercut zone of broken ore.

Thus the ore flows by gravity from the undercut 7 metres downward to the draw level and thence 18 metres down to the haulage. The caving system achieves its



production by drawing small tonnages of ore each day from an average of 900 draw points. The amount of ore and the specific draw points to be operated are determined by assays and according to the variables of production requirements.

As the ore is drawn, the surface subsides and produces a caved area which was utilised as a waste dump while the open pit mine was in operation.

Ore is hoisted to the surface in either 19 or 28 tonne capacity bottom dump skips through the four production shafts at 850 metres per minute. The hoists are either automatic or manual operation with 5.7cm rope winding on 4.6 metre double drums, powered by two 3000 hp DC motors. Surface ore bins have a total capacity of 36,000 tonnes for loading the trains which transport the ore to the mill.

Vital mine systems are monitored in a central surface control room where computers display the continuing status of all major switchgear, rectifiers, pumps and ventilation fans. Underground airflows and gas level monitoring provides information for fire prevention. Data on compressed air pressures and water flows help in the efficient use of these systems.

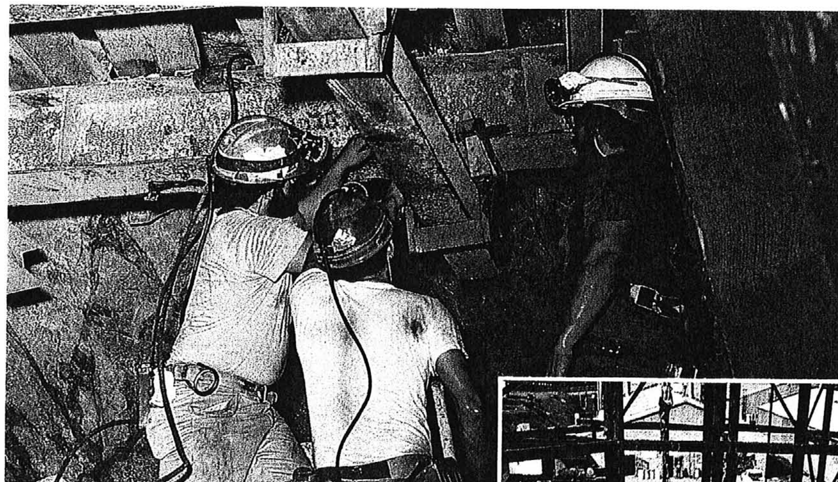
Lower K-Orebody Project

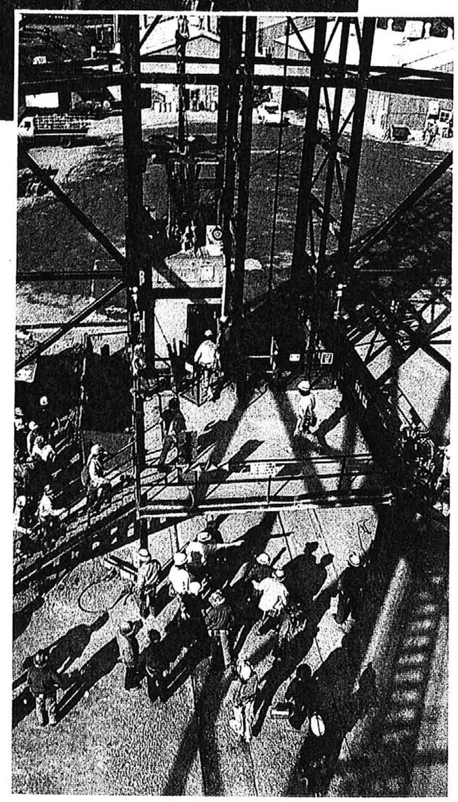
After completion of the latest exploration drilling program in 1992, additional ore reserves were confirmed below the 2950 haulage level of the Kalamazoo orebody. The first lift (2890/2950) of the Kalamazoo orebody was named the Upper K, while the deeper second lift (3440/3570) is known as the Lower K.

Following a detailed feasibility study completed in late 1992, the decision was made to invest $167.1 million to develop the Lower K in preparation for production. Due to critical time constraints during the development phase, it was decided that tunnel boring technology would be utilised for rapidly excavating access to the orebody. A 4.6 metre diameter tunnel boring machine (TBM) was assembled underground in 1993. The TBM completed 10,000 metres of drift during its two-year campaign.

In addition to the TBM, the Lower K also utilises raise boring technology. Raise boring machines capable of driving a 1.5 metre circular raise at an average rate of 2.1 metres/hr. will be utilised. Ore transportation along panel and main haulage drifts uses 1.4 metre and 1.8 metre wide conveyors respectively.

Production is scheduled to start in late 1996. Production from the Lower K will increase steadily over the years until it reaches a 50,000 tonne per day rate by the year 2000.



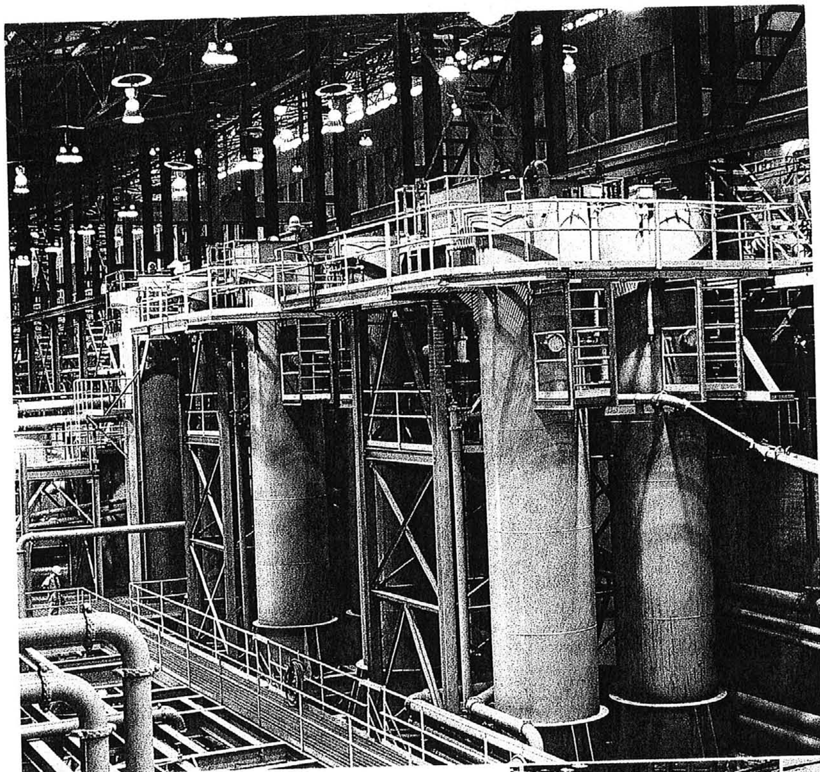


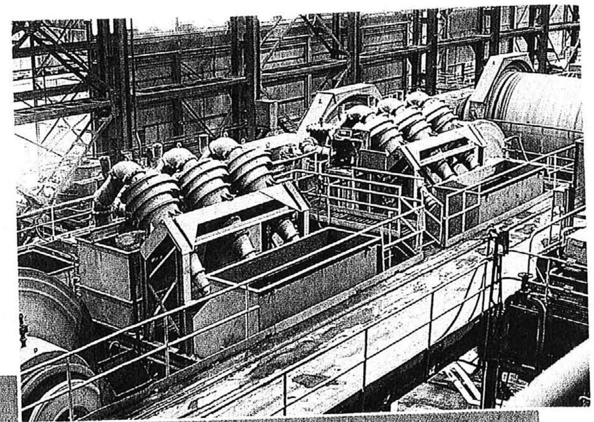
Mine Shafts at San Manuel

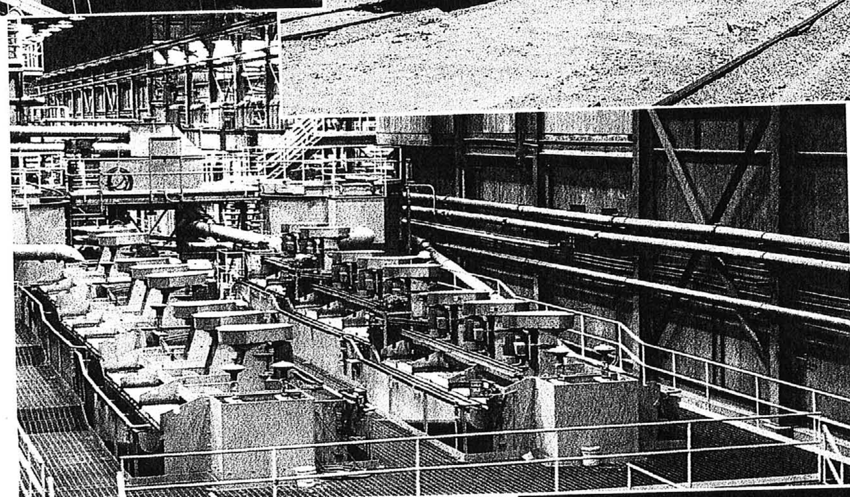
	#1	#4	#3A	#3B	#3C	#3D	#5
Current Depth (metres)	862	832	900	900	881	1,140	1,257
Ultimate Depth (metres)			1,140	1,140	1,140		
Headframe Height (metres)	31	33	55	55	61	61	48
Dimensions (metres)	7.8x1.8	8.1x4.3	8.8x2.1	8.8x2.1	6.7dia	6.7dia	7.6dia

#1	For supplying pump discharge, power lines and employee access.
#4	Main service shaft with two double-deck cages for employees and supplies. Shaft contains main compressed air lines and in situ pump lines.
#3A & #3B	Twin ore-hoisting shafts each contain two skips in counterbalance, an employee cage and a compartment for pipes and cables.
#3C & #3D	Twin ore-hoisting shafts each contain two skips in counterbalance, an employee cage, and a compartment for pipes and cables.
#5	Multipurpose shaft provides service to the "K" orebody. contains two supply and employee cages, two waste rock hoists and a compartment for pipe, cables and concrete lines.

All shafts are of reinforced concrete construction containing structural steel sets. Each contain ladderways.







CONCENTRATING AT SAN MANUEL

Two crushing plants size the ore from the underground mine, first at the mine site with four 1,100 tonne per hour gyratory crushers and then at the mill in two stages with 11 cone crushers.

Ore is transported from the primary crusher at the mine to the mill in a 40-unit ore train of 91 tonne bottom dump cars pulled by a 1,600 hp diesel electric locomotive.

The concentrator at San Manuel processes the ore production from the underground mine as well as slag from the smelter's flash furnace and converters.

The concentrator utilises 13 wet grinding sections, each with one rod mill and two ball mills, operated by digitally-based programmable controllers.

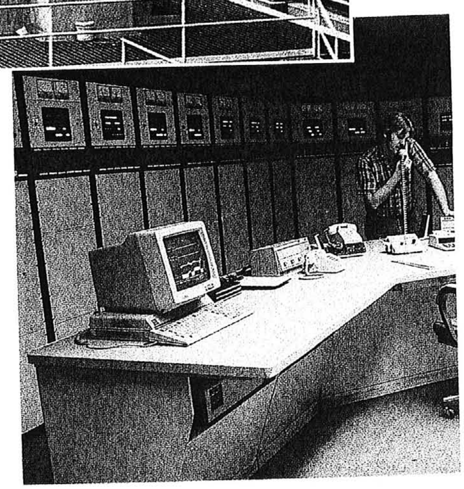
There are eight independent froth flotation sections. Rougher flotation occurs in ten 57 cubic metre and in one hundred forty three 8.5 cubic metre flotation machines.

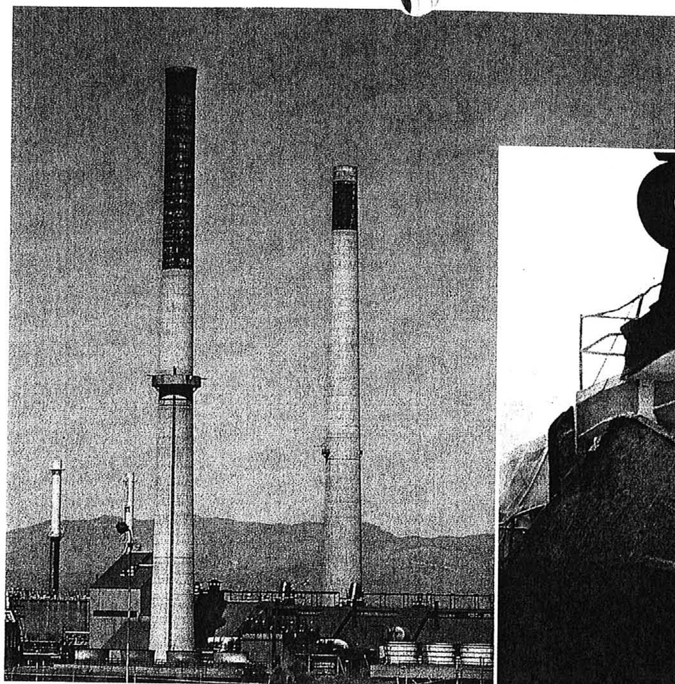
Cleaner flotation is performed in 16 state-of-the-art column cells which are 12 metres high.

The product from froth flotation is thickened and pumped to the molybdenite plant where a flotation process recovers a molybdenum disulphide concentrate, a major by-product of San Manuel.

Tailings from the moly plant are the final copper concentrates which, after filtering and drying, are transported by conveyor to the smelter.

Tailings from the copper plant are thickened and flow by gravity to the large tailings impoundments. All water from tailing dams and the thickeners is continuously recycled back into the milling process.

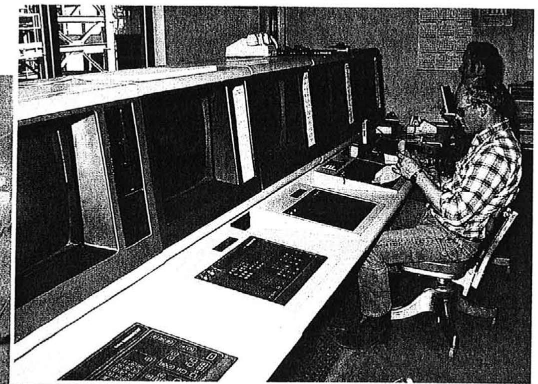




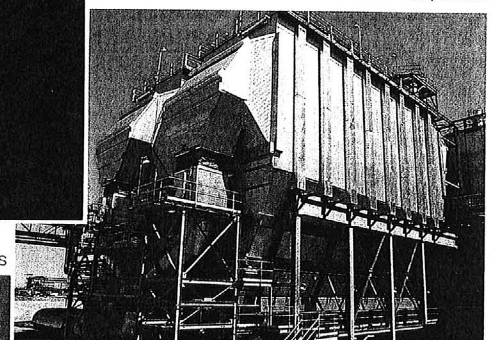
The San Manuel Smelter

Charging a Converter

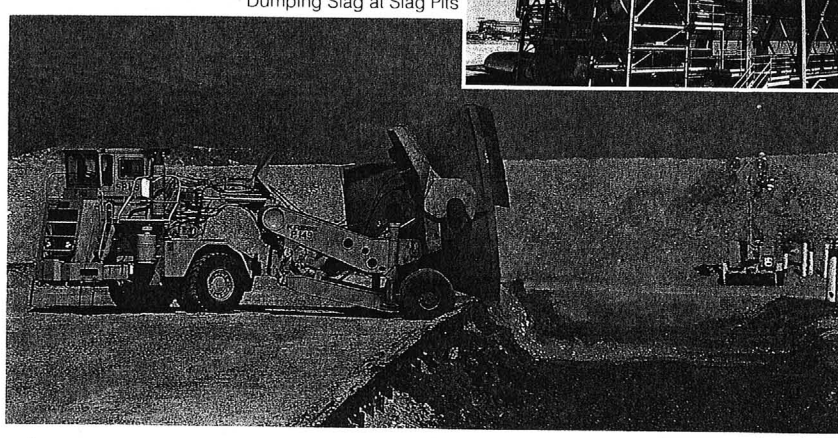
Flash Furnace Controls



Electrostatic Precipitators



Dumping Slag at Slag Pits



THE SMELTER

World's Largest Flash Furnace

Commissioned in 1988 the San Manuel flash furnace is an Outokumpu design and has a processing capacity of over 1.8 million tonnes per year of copper concentrate, more than 25% of the U.S. smelting capacity.

This state-of-the-art smelter is operated through a sophisticated, distributed-control computer system, recovers 99% of the input sulphur and is environmentally the best in the U.S.

The smelter processes BHP Copper concentrate, purchases custom concentrates and provides toll smelting services for domestic and foreign producers.

Copper concentrate contains about 30% copper, 27% iron and 33% sulphur and this mineral combination oxidizes readily. Flash smelting takes advantage of this by providing an oxygen-rich (50%) atmosphere into which fine, dry concentrates and fluxes are injected through a single concentrate burner.

The minerals are rapidly oxidized and emit sufficient heat to melt all the ingredients of the charge as the particles fall down the 4.51 metre high reaction shaft into the settler.

The resulting hot gas loaded with dust particles and containing nearly 26% sulphur dioxide, is drawn through the uptake shaft into the waste heat boiler where the heat is removed for the production of steam by the San Manuel power plant.

The cooled gas is ducted to two high-efficiency electrostatic precipitators. Dust from the waste heat boiler and precipitators is contained within flues, collected and recycled.

Molten copper matte containing about 61% copper is tapped through covered launders into ladles positioned in tunnels beneath the furnace. Full ladles are taken by overhead crane and the matte is poured into one of three hot converters.

In the converters further oxidation of sulphur, and slagging of iron and other metals, takes place over a ten-hour period until the copper reaches a purity of 99%.

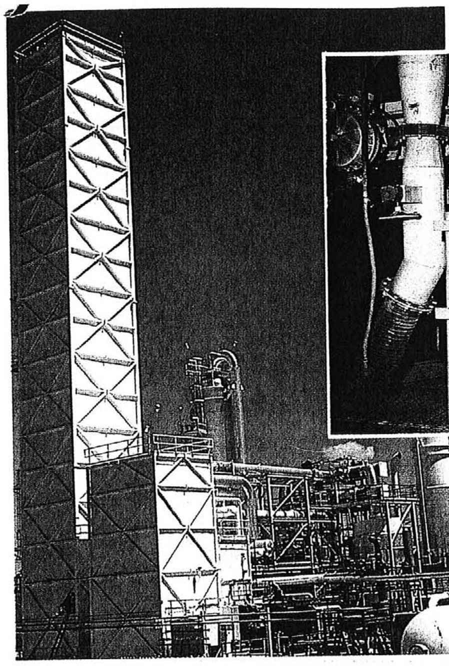
This molten copper, called blister, is transferred by overhead crane to the casting department where it is fire refined for the removal of oxygen and cast into 380 kg pound anodes for transport to the electrolytic refinery.

Molten slag, containing approximately 2% copper from the furnace and/or 6% from the converters, is skimmed into pots which are transported by rubber-tired diesel haulers to shallow slag pits. Here the slag is air cooled, then water cooled, broken, crushed and loaded into rail cars for copper content recovery by wet grinding and froth flotation. The resulting slag concentrate rejoins the other furnace feed.

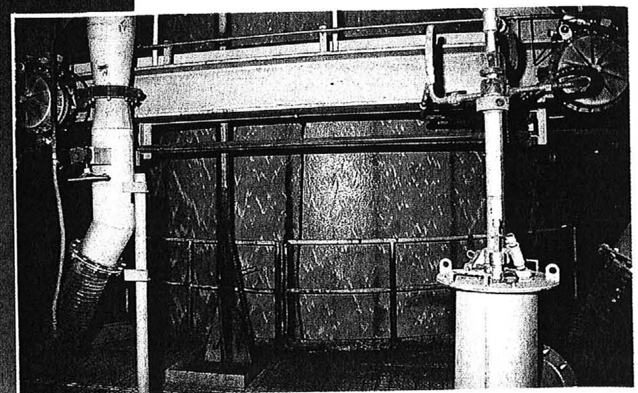
Each of the four converters utilises primary and secondary hoods for maximum capture of SO_2. Behind each converter is a gas scrubbing system which prepares the gas stream for processing in the double-absorption sulphuric acid plant.

In the acid plant the SO_2 is cleaned, dried and converted by catalyst to sulphur trioxide (SO_3). The SO_3 is readily absorbed in circulating sulphuric acid to become salable grade acid.

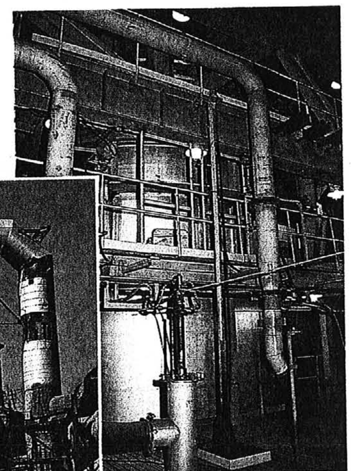
Oxygen for the flash reaction is produced by fractional distillation at -190ºC at the oxygen plant. Oxygen is provided at the rate of 780 tonnes per day. Nitrogen is also produced and used as a non-combustable atmosphere in the concentrate drying system to reduce the fire hazard.



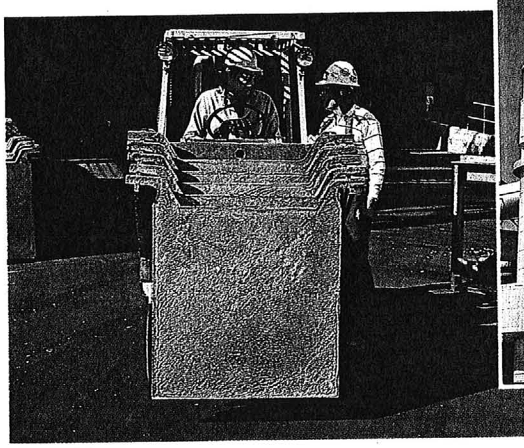
Air Separation Plant



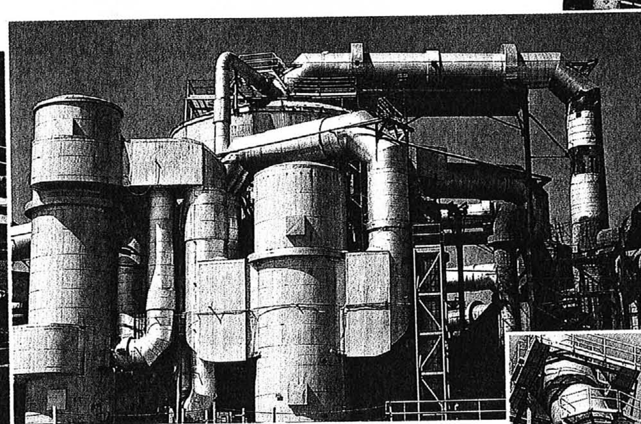
Reaction Shaft



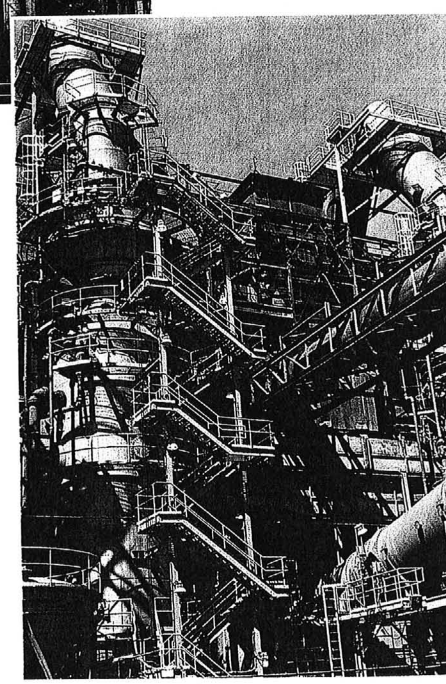
Gas Uptake Shaft



Finished Anodes



Sulfuric Acid Plant



Converter Gas Scrubbers

Flash Furnace Data (tonnes)

Furnace Feed Rate	
Concentrate	181 TPH
Flue Dust	6-7 TPH
Flux	16 TPH
Total	204 TPH
Furnace Matte Produced	77 TPH
Furnace Slag Produced	75 TPH
Off Gas to Acid Plant	
Volume	107,000 Nm^3/Hr
SO_2 Content	26%
Temperature	315ºC
Oxygen Consumed	25,500 Nm^3/Hr
Natural Gas Consumed	510 Nm^3/Hr
Steam Production	
Volume	54.5 TPH
Pressure	60 Bar

Converter Data

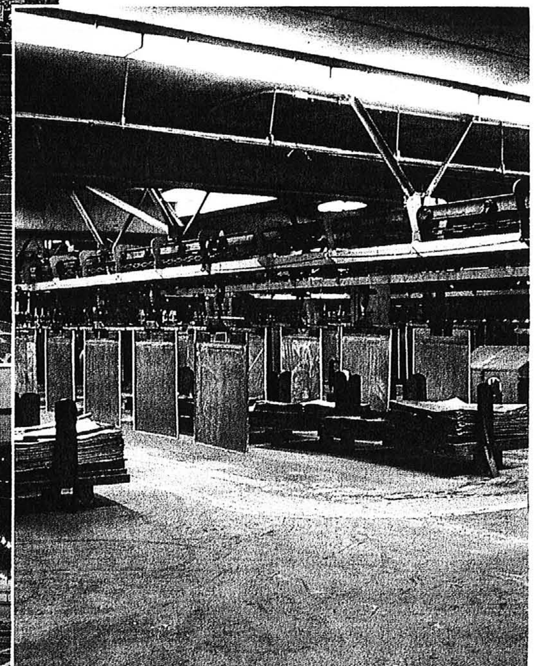
Converter Feed	
Matte	1,850 TPD
Flux	144 TPD
Scrap Copper	190 TPD
Gas Flow to Acid Plant	
Volume	160,000 Nm^3/Hr
SO_2 Content	Avg. 4.8%
Temperature	63ºC

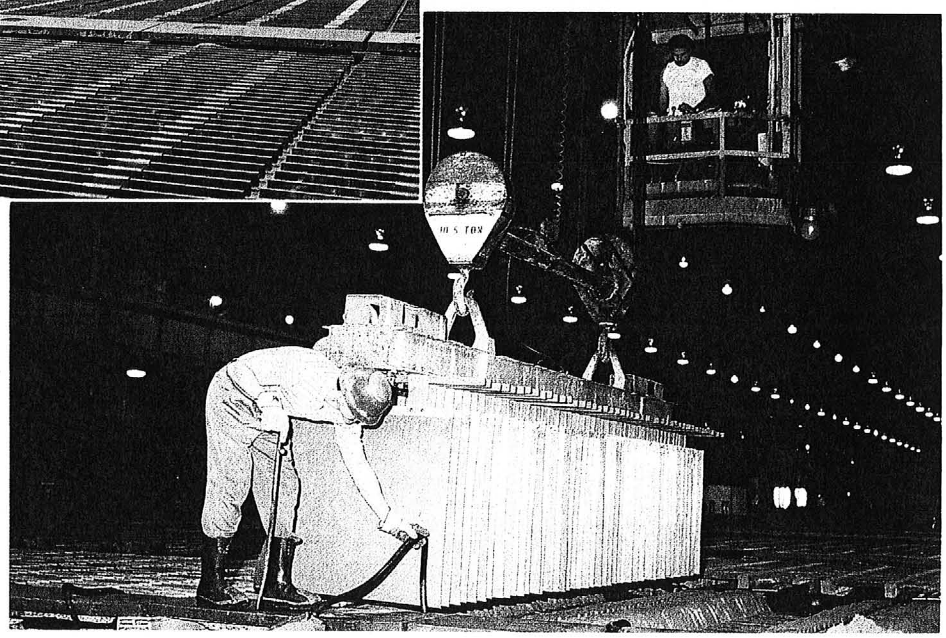
Sulphuric Acid Plant

Total Gas Feed	
Volume	460,000 Nm^3/Hr
SO_2 Content	10%
Temperature	315ºC FSF 63ºC Conv.
Production	3,200 TPD

Copper Production

New Copper	1,075 TPD
Anodes Cast	1,140 TPD





ELECTROLYTIC REFINING

In an electrolyte composed of sulphuric acid, copper sulphate and plating reagents, copper is transferred from an anode at the positive pole of an electric circuit to the cathode at the negative pole. The copper is plated at the cathode and impurities settle to the bottom of the refining cell.

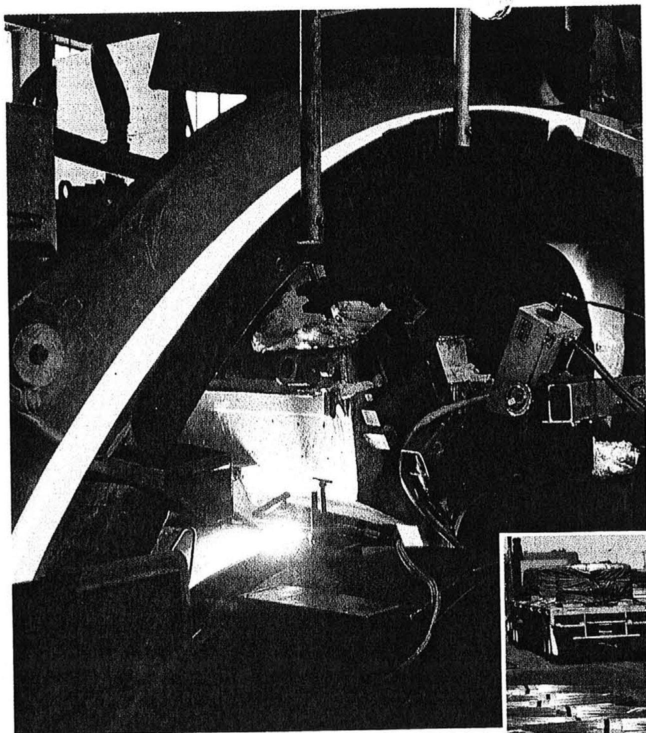
At the San Manuel electrolytic refinery tankhouse there are 28 refining sections each with 42 cells into each of which are suspended 46 anodes and 45 copper starting sheets.

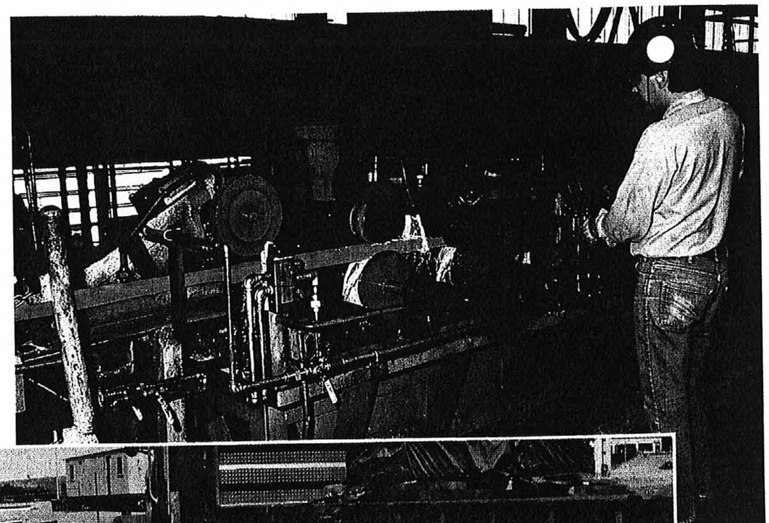
Direct current at .275 volts and 28,000 amperes is applied to the electrodes. Two, 10-day cycles of plating at a current density of 336 amps per square meter produce 170 kg cathodes from each anode charge.

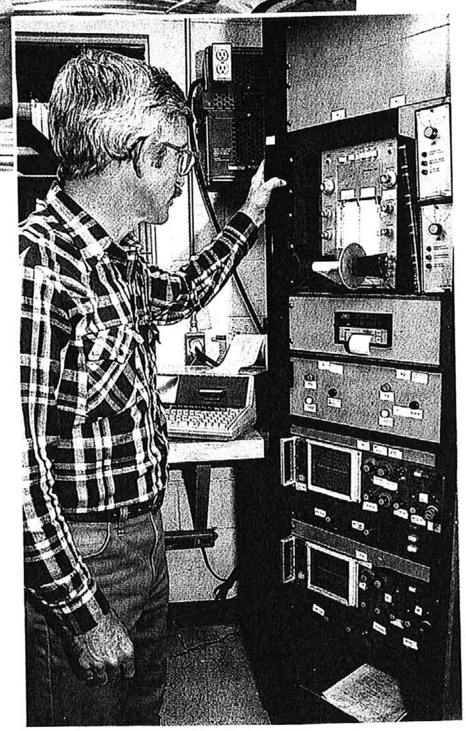
Starting sheets are produced in a 24-hour cycle and are plated on rolled copper mother blanks. The 6.4 kg starting sheets are finished and assembled mechanically at the rate of 5,300 sheets per day.

Settled residue from the refining process is collected and leached to recover copper. The remaining residues containing precious metals are filtered, dried and packaged for shipment.

The San Manuel cathode is certified grade 1 by the London Metal Exchange and the New York Commodity Exchange and meets all quality standards for rod casting or direct sale to copper fabricators.







CONTINUOUS CAST COPPER ROD

About 35-40% of San Manuel's copper production is converted into premium quality continuous cast 5/16 inch (7.9 mm) wire rod for customers in the wire and cable industry. It is shipped in three standard, plastic-wrapped packages of either three, four or five tonne coils, with other sizes available on request.

The San Manuel rod plant utilises the Southwire casting system and the 12-stand Morgan non-twist rolling mill.

Cathodes from the electrolytic refinery and the San Manuel and Pinto Valley SX-EW plants are fed to a natural gas fired shaft furnace for melting and the stream discharges to a holding furnace.

The molten copper is fed to a 2,440 mm diameter rotating, vertical casting wheel at the rate of 33 tph which produces a bar casting having 45.20 mm^2 of cross-sectional area.

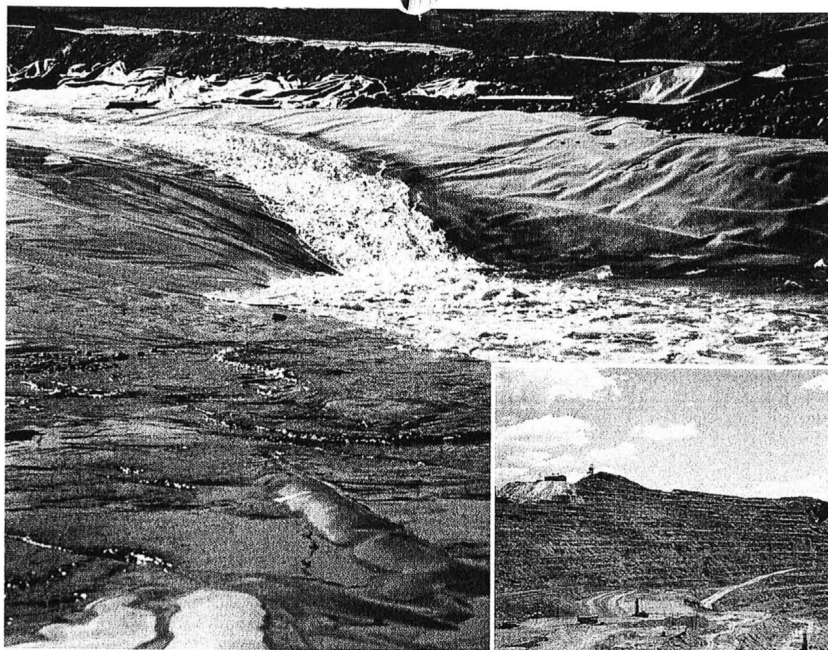
The bar continuously moves through the 12-stand rolling mill where it is sequentially reduced to the 7.9 mm diameter and then pickled, rinsed, waxed and coiled.

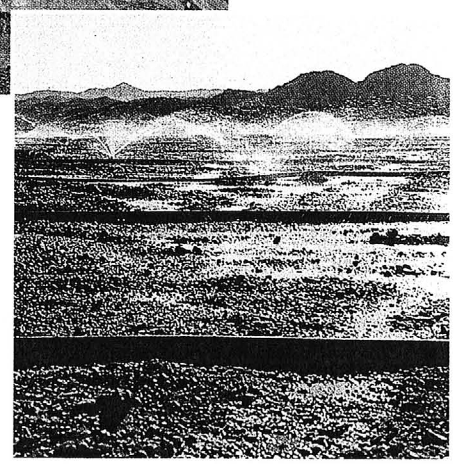
The bar casting moves from the wheel at 13.5 m/minute, then through the roughing and finishing mills and exits the coiler at 1,170 meters per minute.

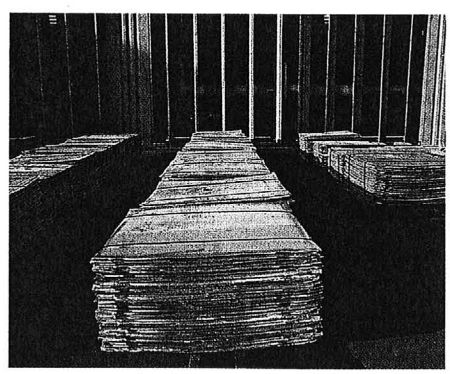
The coils are banded, wrapped, weighed and loaded on trucks or rail cars for shipment.

A sample of each coil is subjected to rigid quality-control tests before loading and shipment is permitted.

The rod plant has a production capacity of 190,000 tonnes per year.







THE IN SITU MINE AND HEAP LEACHING

Located in the subsidence zone of the San Manuel underground mine, the now-completed oxide open pit was established to recover a large reserve of copper oxide ore. The principal oxide mineral leached is chrysocolla.

Waste material was dumped into the adjacent cave area created by the underground mine and ore was hauled a short distance to the leaching pads.

The leach pads are built on an area of 104 hectares underlain with a thick, high-density polyethylene liner to prevent any loss of leaching fluids into the surrounding watershed.

Approximately 84 million tonnes of oxide ore mined over the open pit's nine and one-half year life span now rests on the lined area. The height of the heaped ore is over 104 metres.

For leaching, a network of pipes and wobbler sprinklers is laid on the surface of the completed dump and a weak solution of sulphuric acid is continuously sprayed at the rate of 0.32 litres per square metre of surface area.

The leach solution percolates down through the dump, dissolving copper in the ore, flows from the dump's base as pregnant leach solution (PLS), drains into a collection pond and is then pumped to the 37.8 million litre feed pond for the solvent extraction plant.

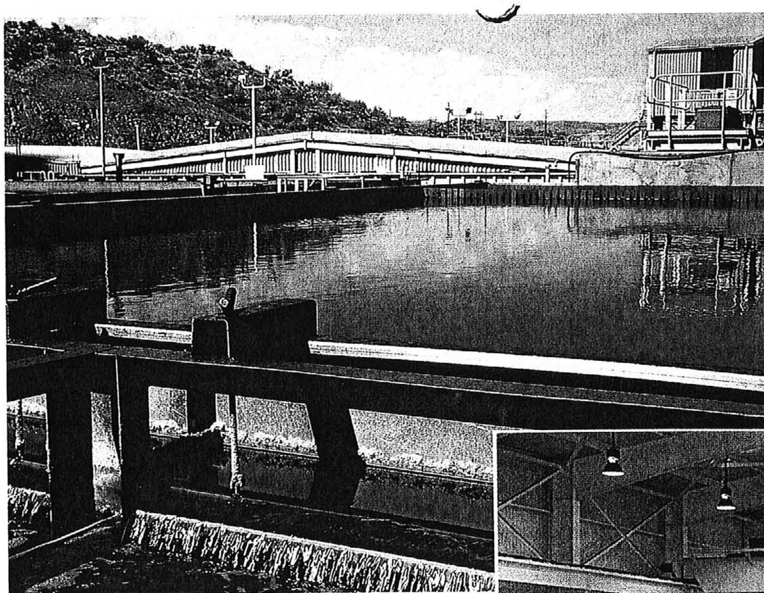
IN SITU LEACHING

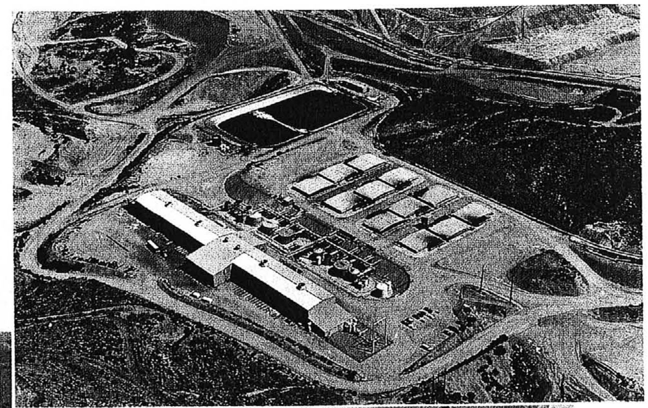
Additional reserves of acid-soluble oxide ore lie beneath the open pit area and above the depleted portion of the underground mine and are available to the in-place method of in situ leaching.

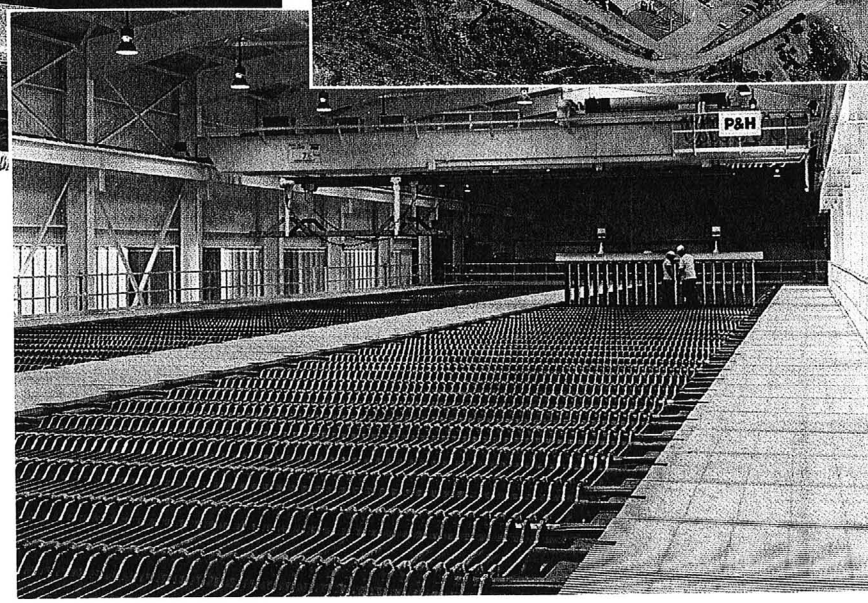
Injection and production wells are drilled into this zone to an average depth of 152 metres. The wells are cased with perforated PVC pipe strategically placed to allow a weak sulphuric acid solution to interact directly with the orebody.

The resultant copper-bearing solution (PLS) is recovered primarily by adjacent production wells. These wells are either 15 or 20 cm in diameter and contain stainless steel submersible pumping units which lift the PLS to surface processing systems.

Solutions targeted for the lower portion of the oxide orebody are allowed to drain into an underground collection area. The area consists of unused haulage drifts in the depleted section of the underground mine. This PLS is pumped to the surface and joins copper-bearing solution from both the leach dump and the in situ surface production wells for processing in the SX-EW plant.







SX-EW/SOLVENT EXTRACTION-ELECTROWINNING

Solvent Extraction

While the process of electrowinning copper from a rich electrolytic solution is as old as industrial electrical applications, the technology of solvent extraction is newer and with the development of special reagents can now be applied efficiently to large-scale operations.

The purpose of solvent extraction is to remove copper from the pregnant leach solution (PLS) by mixing it with an organic extractant and then removing the copper from the organic into a rich solution of sulphuric acid and copper sulphate.

The solvent extraction process takes place in each of four stainless steel tank trains at the rate of 15,140 litres per minute each.

The resulting electrolyte solution is pumped to the electrowinning tankhouse, the organic and reagents are recycled and the now barren PLS called raffinate is discharged to the raffinate pond for recycling to heap leaching.

ELECTROWINNING

Electrowinning is an electro-chemical process in which copper from an electrolyte is plated onto a cathode. The primary difference from electro-refining is that refining uses a copper anode while a lead alloy anode is utilised in electrowinning.

The electrowinning tankhouse has 188 concrete cells each containing 61 lead anodes and 60 stainless steel cathode mother blanks.

The plating cycle is seven days to obtain a 45 kilogram cathode from each side of a mother blank.

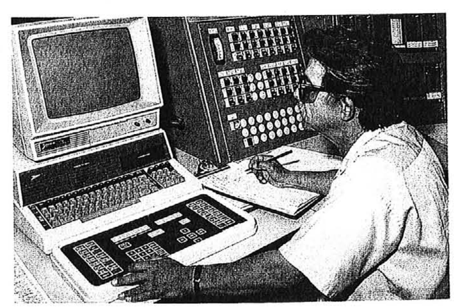
The cathodes are stripped mechanically from the mother blanks and are either sold as is or transported directly to the San Manuel rod plant for continuous casting. The electrowon copper is guaranteed 99.999% pure. It is certified for sale against COMEX grade 1 and LME grade A cathode standards.

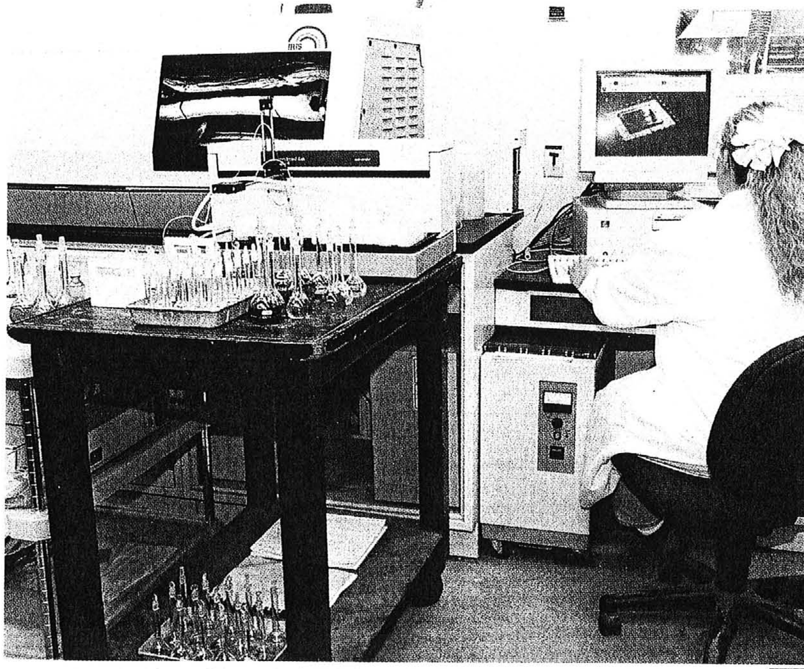
The extractant used in the solvent extraction process is very selective to only transfer copper from the leach solutions. This results in especially high-purity copper metal production during electrowinning.

All SX-EW functions are fully instrumented for automatic operations and direction from a comprehensive distributive control system.

Altogether BHP Copper operates three SX-EW plants in Arizona:

Location	**Production Capacity**
San Manuel	68,000 tonnes/yr.
Pinto Valley Unit	7,250 tonnes/yr.
Miami In Situ Unit	5,500 tonnes/yr.





METALLURGY AND QUALITY ASSURANCE

BHP Copper is dedicated to producing and delivering the highest quality copper rod and cathode to our customers.

In addition BHP Copper believes strongly in the responsibility for prompt and aggressive customer service to insure the integrity of the quality assurance program and to maintain complete customer satisfaction.

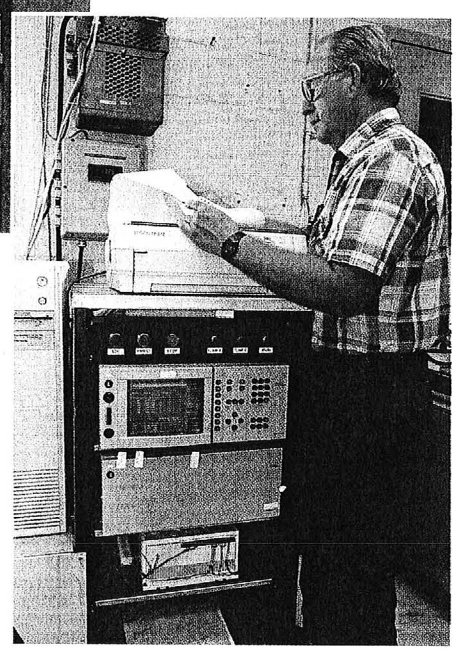
Each operating department from the mines through the rod plant has goals for quality of workmanship and for delivery of the process materials to the next operating level.

At the refinery and rod plant a program of statistical process control is used for maintaining product quality.

Metallurgical testing occurs at each process level and rigid quality control testing of cathode and rod determine if final shipment will be made to a customer.

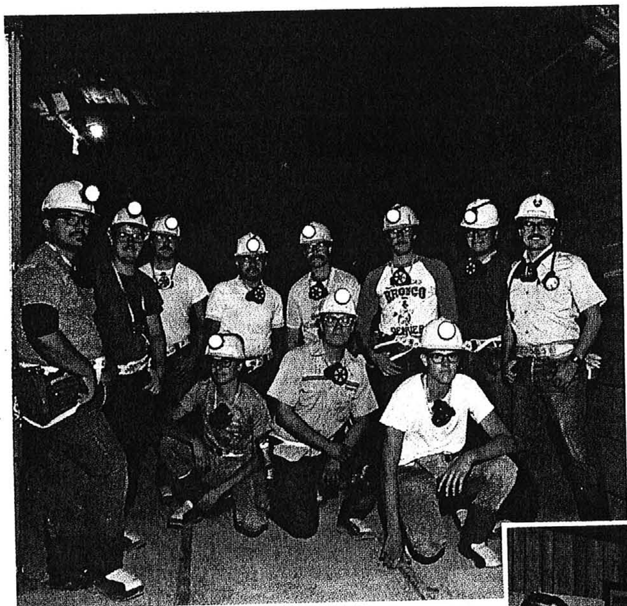
Laboratory methods include x-ray fluorescence spectography, atomic absorption analysis, emission spectography, gas chromatography, electron microscopy, wet chemistry, and both physical and process metallurgical testing.

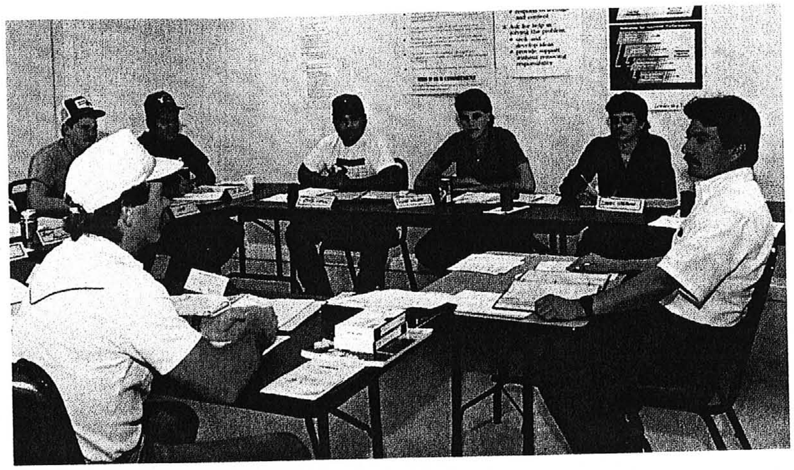
Six fully-equipped, modern laboratories serve the San Manuel production operations, one of which is the quality assurance unit located adjacent to the coiler in the rod plant for testing of each production coil of rod.

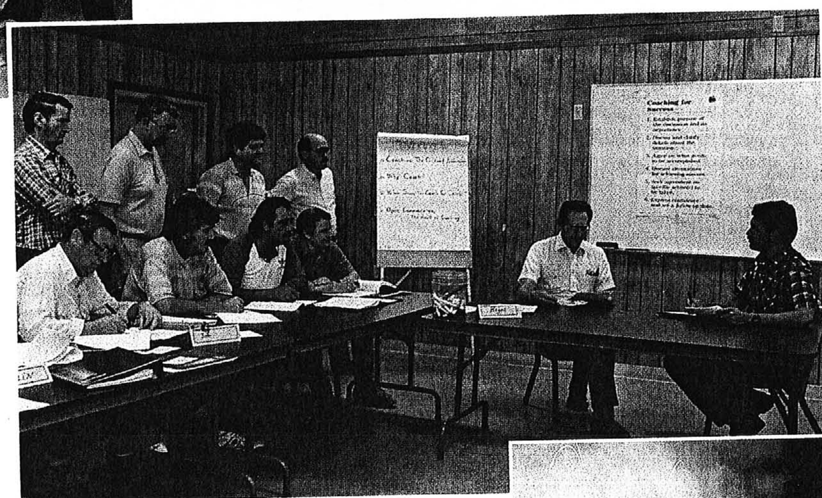


Metallurgical department operations include ore assay, process materials assay, product quality determination, furnace gas analysis, process efficiency analysis, equipment wear and failure analysis, lubricant controls, research on new processes and products and flow chart development.

The department also has a team of metallurgists who provide technical service to rod customers, including feedback for product improvement as well as assisting customers in use of the products.







EMPLOYEE INVOLVEMENT, EDUCATION AND SAFETY

Approximately 3,300 individuals each contribute their own special skills and knowledge to their jobs at San Manuel.

In reaching the goals and objectives of the organization, BHP Copper values and seeks the ideas and contributions of employees. By actively involving those employees who do the work, more cost-effective ways to meet company goals are often found. Active participation in the jobs has the benefit of making those jobs more challenging, satisfying and productive.

Another key to high employee productivity is the high level of union-management cooperation with those unions representing San Manuel employees.

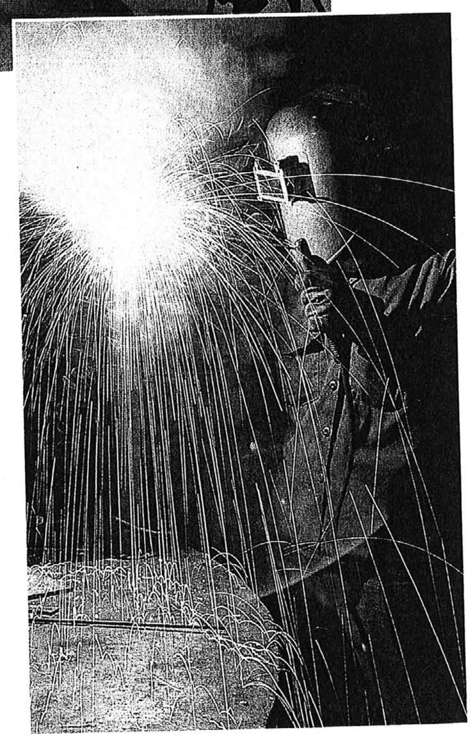
To better utilise employees' experience to solve work problems and to analyze production methods, tools, and procedures, employees join together in work teams which are increasingly self directed and participate in breakthrough project teams. Focusing their combined experience on problems brings about sensible solutions and results in cost-effective and efficient processes and procedures.

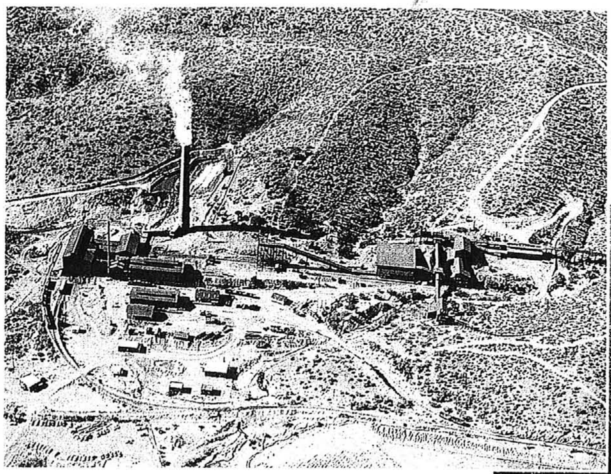
All employees participate in safety programs aimed at accident prevention by awareness of the work environment and respect for proper work procedures. At San Manuel, safety is more important than production.

Employees exposed to possible hazardous materials or environments are carefully trained in the handling of these hazards and are provided with personal protective clothing and equipment.

Supervisors' training is conducted at all levels to ensure common understanding and fair implementation of company policies and to learn techniques in human resource skills.

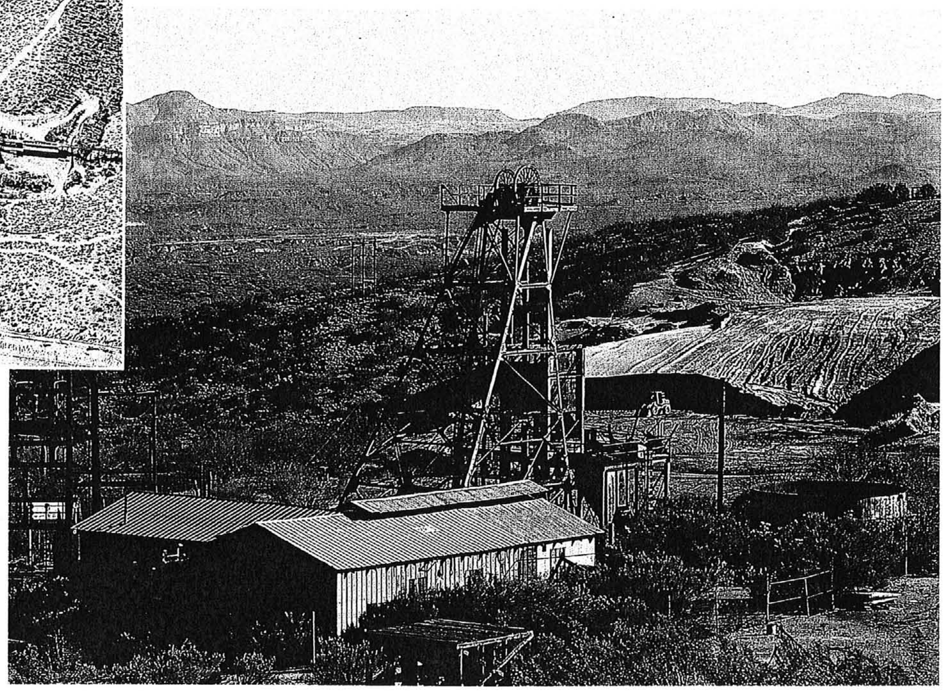
San Manuel employees and their unions are, in every sense, partners in the company's efforts to achieve and maintain an accident-free workplace, outstanding product quality, technical leadership and business success.





Superior Smelter in the 1950's

Historic Tiger Mine at Mammoth, Arizona.



OUTLINE HISTORY OF SAN MANUEL

1877 Silver Queen Mine in production at Hastings (Superior) Pioneer Mining district, Arizona Territory.

1879 Mines started in Old Hat District around Mammoth (gold and silver mines).

1896 Post Office opens for Schultz, Arizona, later renamed Tiger (located adjacent to San Manuel's SX-EW plant).

1910 Magma Copper Company organized, Superior, Arizona Territory, holding the old Silver Queen mining property.

1915-19 Molybdenum and vanadium campaigns at Tiger.

1921 Newmont Mining Corporation founded.

1924 Smelter erected at Superior, Arizona.

1934 St. Anthony Mining Company buys Tiger mines.

1935-43 Renewal of activity; lead and zinc campaigns at Tiger.

1942 War Production Board investigates Mammoth area for copper.

1943-45 Exploration Drilling by U.S. Bureau of Mines at Red Hill (San Manuel).

1944 Magma consolidates and purchases San Manuel claims and begins additional exploration and drilling.

1948 Underground exploration and development begins.

1952 Federal loan of $94,000,000 made to Magma to build the San Manuel mine, plant, rail roads and community.

1953 Construction begins on surface plant.

1956 First stopes undercut and first smelting begins.

1965 Expansion from 27,200 tonnes of ore per day to 36,300 TPD.

1968 Purchase of nearby Kalamazoo orebody doubles size of reserves.

1969 Merger with Newmont Mining Corporation.

1971 Superior smelter is shut down.

1972 Expansion from 36,300 to 54,430 TPD ore processing. Operation of electrolytic refinery and continuous rod casting begins. Smelter expansion underway.

1973 New Superior mine-plant in operation; expanded to 3,000 TPD.

1974 Start up of air quality control systems and sulphuric acid plant at San Manuel.

1982 Superior Division is shut down.

1985 Development of open pit at San Manuel begins.

1986 Oxide open pit, leaching and SX-EW plant begin production. Newmont recapitalises Magma and contributes Pinto Valley as an operating division.

1987 Magma is reorganised and spun-off to stockholders of Newmont. In situ leaching production starts. Development of Kalamazoo orebody begins. Modernisation programs begin.

1988 Flash furnace at smelter started, old reverbs shut down. Mill and refinery expansion and modernisation programs are completed.

1989 Recapitalisation and repurchase of Newmont interests result in new era of indepen dence for Magma.

1990 Superior Division operations resume. Kalamazoo mine start up.

1991 Historic 15-year labor agreement ratified.

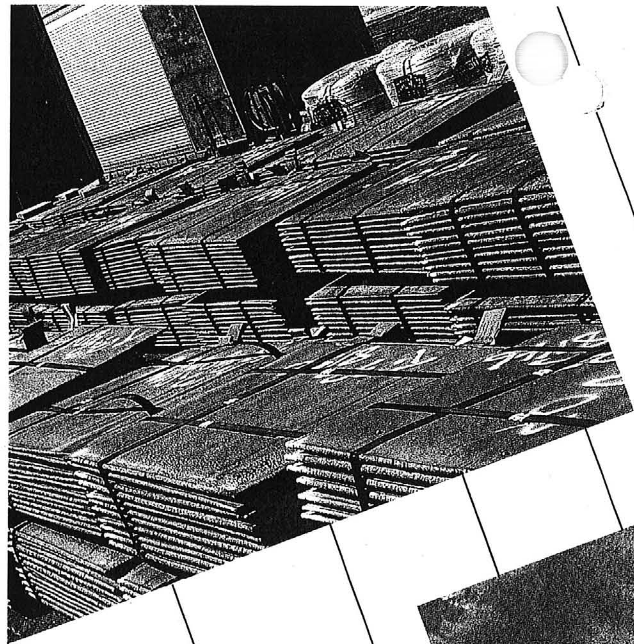
1992 Magma Metals Company and Magma Nevada Mining Company organised.

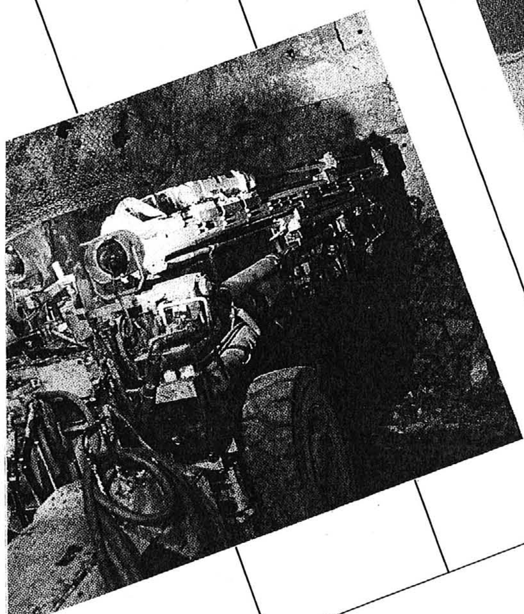
1993 Expansion projects begin at smelter. Lower K orebody development begins.

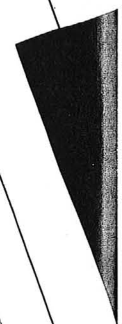
1994 Smelter completes 20% expansion with addition of 3rd acid plant. Robinson begins construction and Tintaya, Peru acquired.

1995 Robinson Mine at Ely, Nevada begins production. San Manuel open pit completed.

1996 Merger to form BHP Copper.







At San Manuel mineral ores are processed through a series of extractive operations to produce premium quality copper which is sold throughout the world for the production of basic industrial and consumer products.

One of the first metals discovered and utilised by man, copper is so much a part of civilisation it is difficult to conceive of progress without its contributions.

Reaching from the past and extending into the future BHP Copper is proud to be a part of the tradition of copper.

BHP

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