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Magma air quality maintenance systems.

MAGMA

Magma Copper Company
A Subsidiary of Newmont Mining Corporation
P.O. Box M, San Manuel, Arizona 85631

Our goal... cleaner air.

Magma Copper Company and its parent company, Newmont Mining Corporation, are committed to the control of smelter emissions to whatever degree may be necessary to protect the health and welfare of residents in the area influenced by the San Manuel smelter.

Magma's air quality control systems have been designed and built to insure compliance with the ambient air quality standards established by the State and Federal governments.

By 1975, Magma had taken these actions, which resulted in cleaner air:

- Installed the sulfuric acid plant at San Manuel to control up to 96% of the sulfur dioxide in smelter converter emissions.
- Installed electrostatic precipitators at the smelter and dust collection systems throughout the plant during original construction and later expansions (1954—1965—1971).
- Closed the Superior Division smelter in 1971 to consolidate smelting operations at San Manuel.
- Established comprehensive air monitoring in the area of influence of the smelter, collecting primary data on actual ambient air quality.
- Gave financial support to University of Arizona Atmospheric Analysis Laboratory.
- Cooperated with the U.S. Bureau of Mines in research and investigation of the citrate process to convert sulfur dioxide to elemental sulfur at a pilot plant in San Manuel.

- Participated in a second pilot plant project at San Manuel with other mining companies to study and evaluate the feasibility of scrubbing the weak gases from reverberatory furnaces.

- Conducted independent research programs through Newmont Mining Corporation's Research Laboratories, including study and evaluation of alternative smelting methods.

- Completed steps to utilize or dispose of acid product to avoid further environmental problems.

- Cooperated fully with and contributed information and experience to State and Federal agencies in the promulgation and administration of air quality standards.

Capital outlays between 1971 and 1975 for Magma's air quality control system approach $40,000,000. In addition to initial construction costs, future operating and maintenance costs will be significant.

Controlling the elusive sulfur.

Copper sulfide mineral concentrates produced at the San Manuel and Superior Divisions of Magma Copper Company contain approximately 28% copper, 30% iron and 32% sulfur. They also contain

Copper Converter at Magma Copper Company's San Manuel, Arizona, smelter.

minor amounts of other important minerals including molybdenum, gold, silver, rhenium and selenium.

In the smelting process, the iron is oxidized and combined with silica fluxes to form slag. The final slag is an inert material which is discarded near the smelter.

Sulfur is released by oxidization in both the reverberatory furnaces and converters. The major oxidization, which produces sulfur dioxide, occurs in the converting process, while only weak gases are released from the reverberatory furnaces.

There is no feasible technology available for processing the weak (less than 2% by volume) sulfur oxide gases from the reverberatory furnaces. However, the converters are capable of producing a richer (3% to 7% by volume) sulfur gas which is manageable with the contact sulfuric acid process.

Even for this purpose, the sulfur dioxide is frequently marginal in strength and tight hoods and gas collection systems are placed on the converters to keep air from diluting the gas. The hoods are high quality steel but do not have the advantage of refractory surfaces, so they must be water-cooled to survive the hot gases evolved in the converting phase of the smelting process.

The gas stream feeding the acid plant must have reasonably continuous flows of relatively strong sulfur dioxide. Converter operations must be coordinated and scheduled to maximize the sulfur dioxide content of continuous gas feed.

The feed gas stream is drawn through specially designed systems of high velocity flues and into electrostatic precipitators for first stage cleaning and cooling.

Gas Cleaning, Conversion and Absorption Systems of Sulfuric Acid Plant.

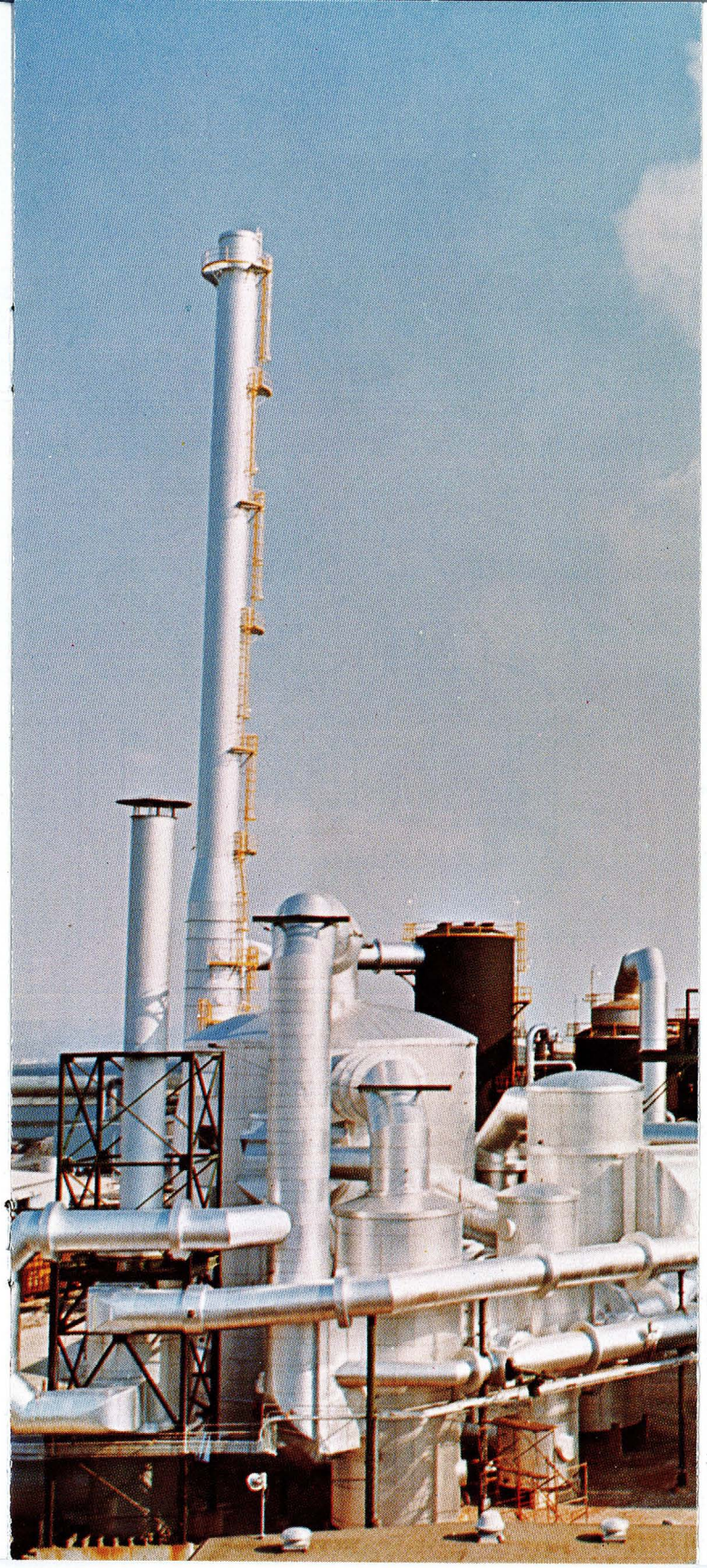
The contact sulfuric acid process.

The San Manuel sulfuric acid plant uses the contact process in a two-train or modular system. All of the converter gases are cleaned and cooled in a common system, and then split into two separate conversion and absorption systems.

Upon leaving the high velocity flues, the sulfur laden gases, principally sulfur dioxide, are pulled through a large electrostatic precipitator to remove dust and particulate matter, then through cooling and humidifying towers, and finally through a bank of eight electrostatic mist precipitators to remove all remaining solids and acid mist.

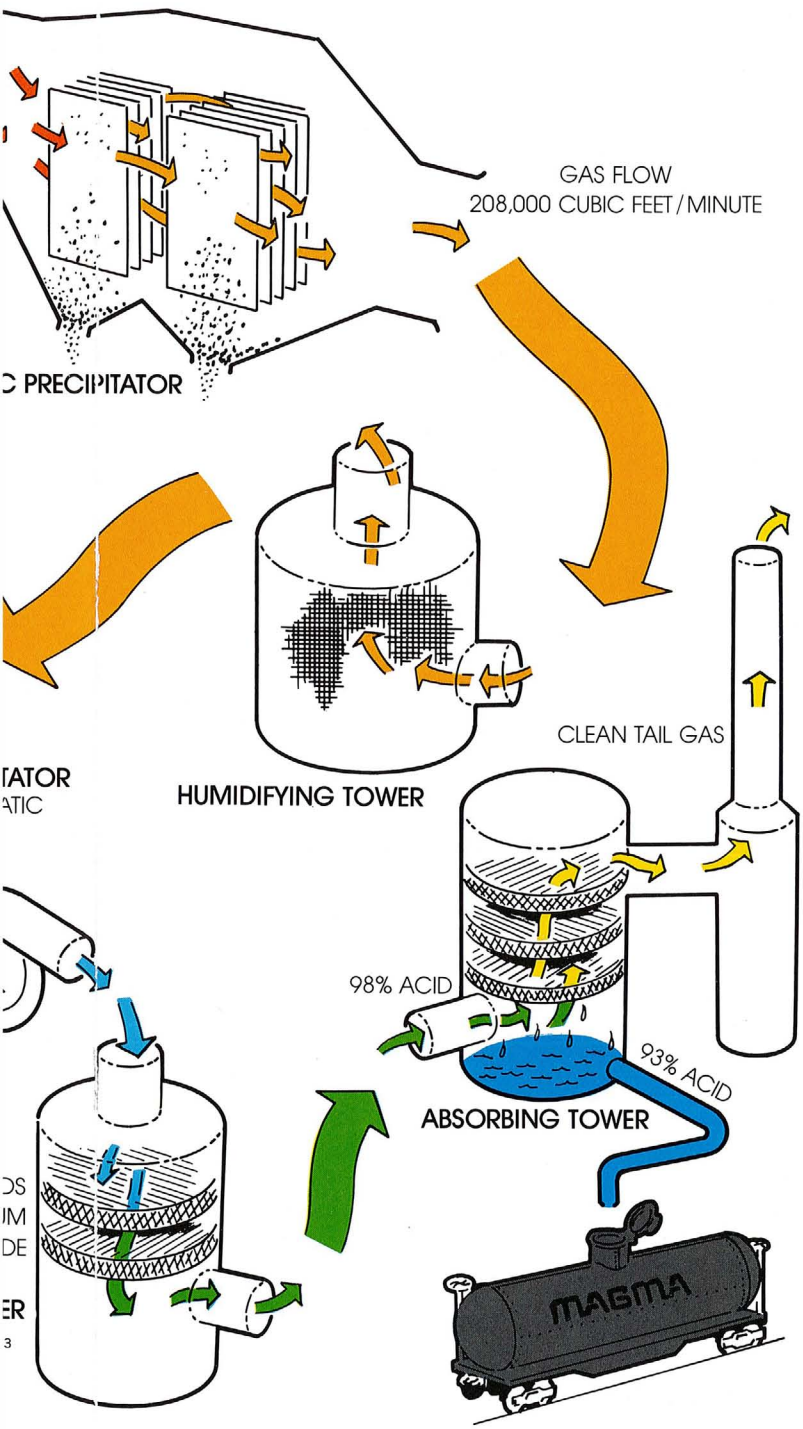
The resulting clean sulfur dioxide gas is split into two trains, or processing modules, where it is compressed and passed through beds of a catalyst, vanadium pentoxide, where it is converted into sulfur trioxide, SO_3. Several passes over the catalyst are necessary.

The sulfur trioxide passes to absorption towers where it is absorbed into circulating sulfuric acid. The resulting saturated acid can be concentrated to any specified grade, usually the commercial grade of 93 percent.



Magma Copper Company's San Manuel, Arizona, Sulfuric Acid Plant.

Acid Plant



Temperatures and strengths of the acid systems circulating within the plant are critical to its operation and must be maintained within strict limits. This is accomplished by an elaborate system of automated controls to maintain efficient operations.

The San Manuel plant has a designed production capacity of up to 2,000 tons per day of sulfuric acid.

The reverberatory stack plume.

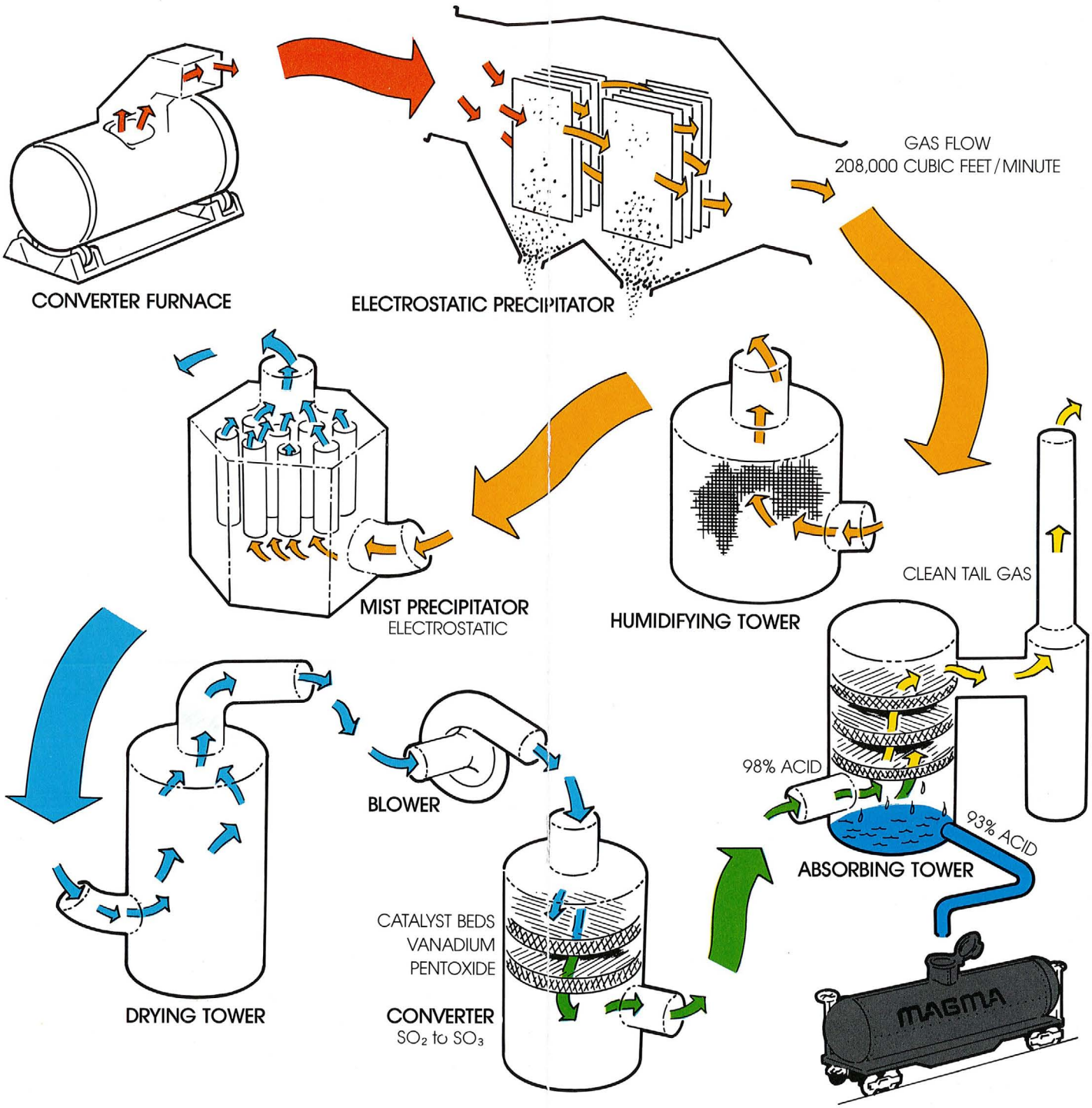
The visibility of a white plume from the reverberatory furnace stack is largely the result of moisture which is present in the mineral concentrates and also is produced as a product of combustion. About 500 tons of moisture per day are released from the three reverberatory furnaces of the San Manuel smelter.

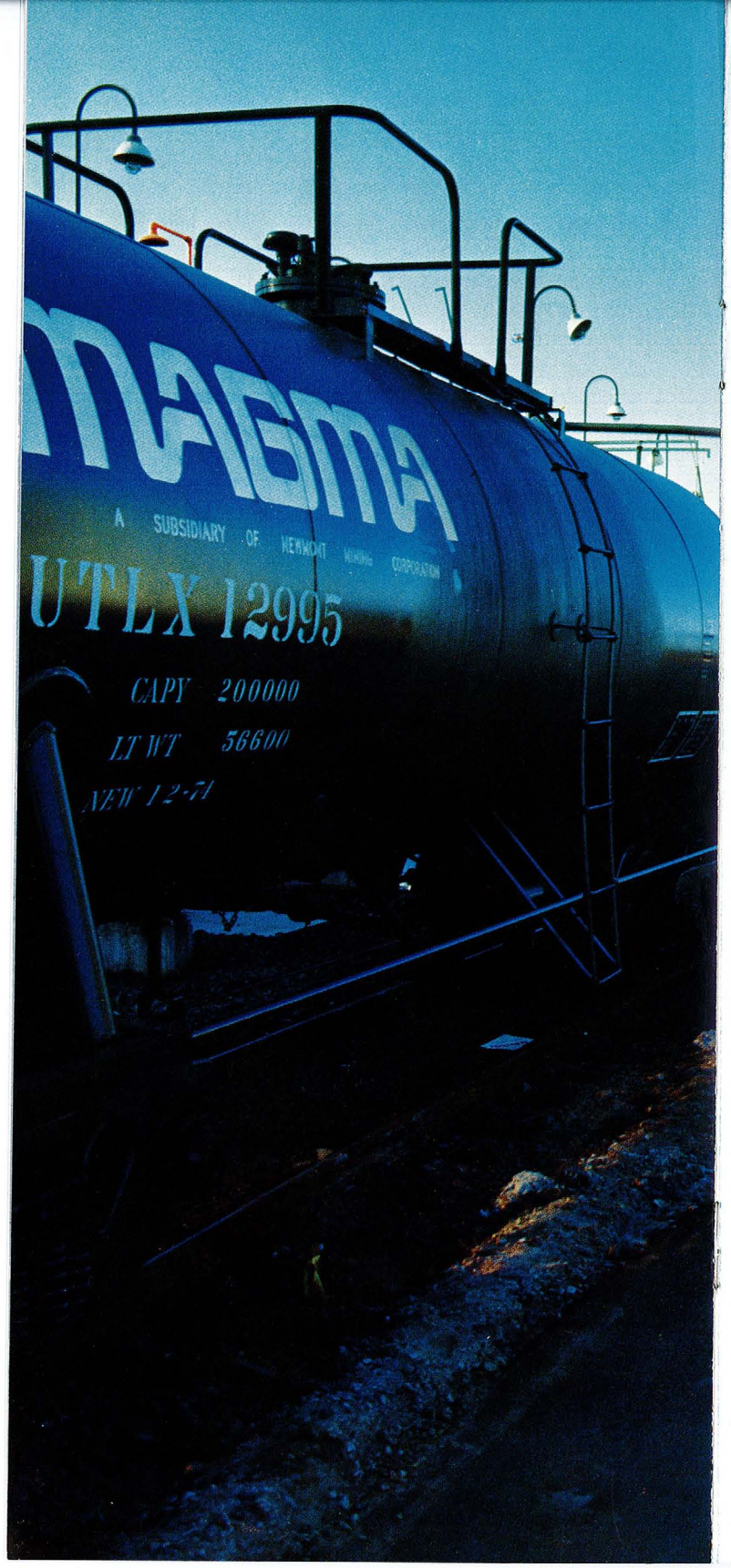
A new electrostatic precipitator at the reverberatory stack is highly efficient and is designed to remove in excess of 98% of particulate matter in the reverberatory plume.

With all air quality control systems operating normally, components of the single white plume from the San Manuel smelter will be approximately 15% water vapor, less than 2% sulfur dioxide, and 83% inert natural air components.

San Manuel Sulfuric Acid Plant

Sulfur dioxide conversion process.





From waste... useful products.

Sulfuric acid is a common chemical used widely in industry, mining and agriculture. Large quantities are produced and used in industrialized regions.

Southwestern markets are limited but Magma has taken steps to develop regional outlets for as much of its sulfuric acid production as possible.

Mining—Arizona has large quantities of the silicate and oxide ores whose copper can be extracted by leaching with sulfuric acid. The acid is also used in the processing of uranium, tungsten and other minerals.

Agriculture—Fertilizer production uses large quantities of sulfuric acid which also may be applied directly to irrigation water to help neutralize soil alkalinity.

Industry—Limited amounts of Magma acid will enter national markets for use in oil refining and consumer products, such as automobile batteries.

To transport the acid, Magma operates a fleet of railroad tank cars. In addition, a significant amount of acid is shipped by truck.

Storage is provided at the San Manuel shipping terminal for up to 20,000 tons of acid.

Sulfuric Acid Loading at San Manuel, Arizona.

Neutralization... a standby necessity.

As important as the production of the acid itself is the necessity for providing for its disposal in the event that production exceeds the amount which can be disposed of beneficially through use or sale. In addition, the plant generates small amounts of weak acid waste which must be discarded.

To avoid possible land and water contamination, Magma's acid neutralization system has the capacity to process the full production of the San Manuel acid plant, if necessary.

The process involves neutralization of acid with finely ground limestone to form an inert and insoluble gypsum slurry, which can be discarded with the concentrator tailings. Approximately one ton of limestone and one ton of water are required to neutralize one ton of sulfuric acid.

To obtain this limestone, a quarry was located seven miles south of San Manuel and several small limestone hills must be excavated. A road was built for haulage and additional water wells were developed.

The limestone is crushed and prepared through existing concentrator circuits so that an ample supply can be made available as needed.

The cost of neutralizing the acid approximates the cost of its production.

Magma Copper Company's Smelter and the community of San Manuel, Arizona.

Air monitoring and intermittent controls.

Under clean air regulations, the San Manuel smelter is required to maintain positive control over approximately 60% of the sulfur dioxide generated by the smelting process.

The acid plant is capable of controlling 96% of the SO_2 from the converters; but, since it does not treat reverberatory furnace gases, the overall emission control of total smelter gases is approximately 70%, well within State and Federal requirements for positive control.

For the reverberatory furnace, a new, large, high efficiency electrostatic precipitator is designed to remove in excess of 98% of the particulate matter, as required by regulations.

As an added precaution that ambient air standards will not be violated during adverse weather conditions, an extensive air monitoring system continuously measures sulfur dioxide concentrations and weather conditions throughout the area influenced by the smelter.

Seven permanent monitoring stations and one mobile station are equipped with continuous weather and sulfur dioxide monitoring instruments and radios which transmit data to a computer in San Manuel every three minutes.

Special computer programs produce guidance information about possible adverse weather conditions and potential air pollution episodes. This information is continuously displayed for management review. If necessary, timely action can be taken to reduce or curtail smelting operations to maintain ambient air quality standards.

The air monitoring system is supervised by meteorologists. Their continuing studies of the regional weather and characteristics of smelter emissions add substance to the body of scientific knowledge about air quality in Arizona.

Air Monitoring Station, one of eight, continuously measures air quality near San Manuel smelter.

Producing Arizona copper since 1910.

Magma Copper Company is a highly integrated producer of primary copper, controlling the entire process from underground ore bodies through refining and having a production capacity of 200,000 tons of metal per year.

Magma was founded in 1910 by William Boyce Thompson who purchased the Silver Queen mine near Superior and then began to explore and develop its high-grade copper veins. This extraordinarily rich mine has developed and expanded, and today produces 3,000 tons per day of ore with an average grade of 4.5% copper.

In 1944, Magma acquired the San Manuel group of claims and, with Federal assistance, launched the program of exploration and development which resulted in the present day San Manuel mine, community, concentrator, smelter and refinery. First production from the San Manuel plant was in 1956.

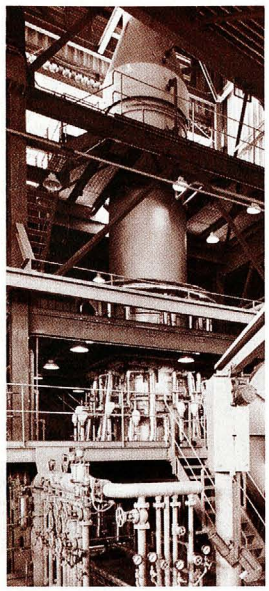
The San Manuel mine contains an estimated one billion tons of copper ore averaging 0.7% copper. Its production is 60,000 tons of ore per day, which is all processed daily through the concentrator and smelter. Concentrates from Superior are shipped to San Manuel for smelting and refining.

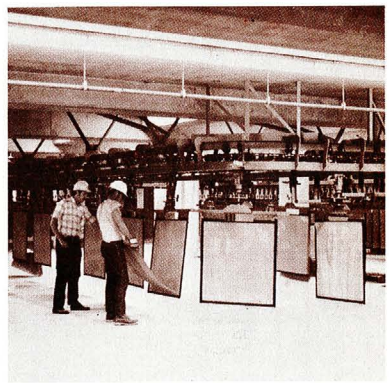
In 1969, Magma became a wholly owned subsidiary of Newmont Mining Corporation, an international firm specializing in the development and production of diversified mineral resources.

Continuous cast 5/16 inch copper rod of the highest purity is produced at San Manuel for the wire and cable industry.

MAGMA

Magma Copper Company
A Subsidiary of Newmont Mining Corporation
P.O. Box M, San Manuel, Arizona 85631





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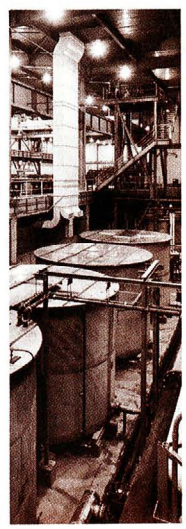
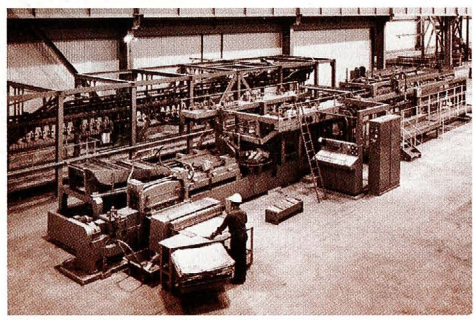




MAGMA electrolytic copper

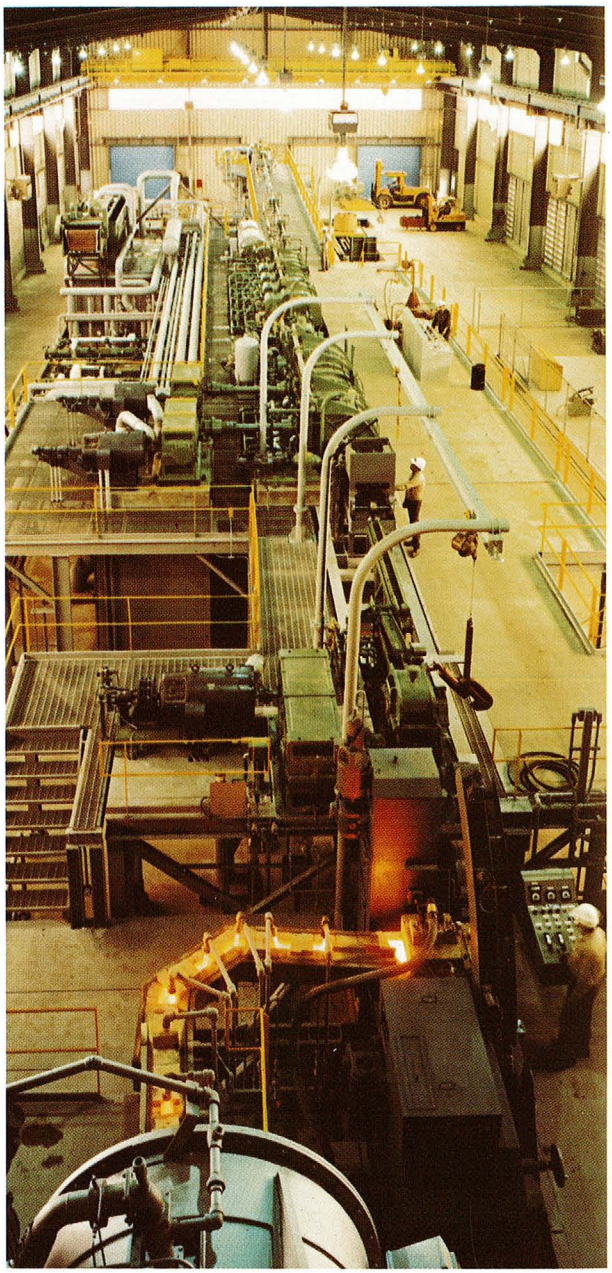
IN ARIZONA SINCE 1910

SAN MANUEL AND SUPERIOR

A Subsidiary of Newmont Mining Corporation

a new dimension in arizona copper

MAGMA



Beginning in 1971-72 Magma Copper Company enters a new phase in the production of Arizona copper by operating a major electrolytic copper refinery which supplies pure continuous cast copper rod and cathode plate to western manufacturers and other industrial customers throughout the nation.

In the past, Magma's copper was shipped in the form of either blister copper or copper anodes out of state to refineries for processing. Now the entire production process, from mining to rod casting takes place at San Manuel.

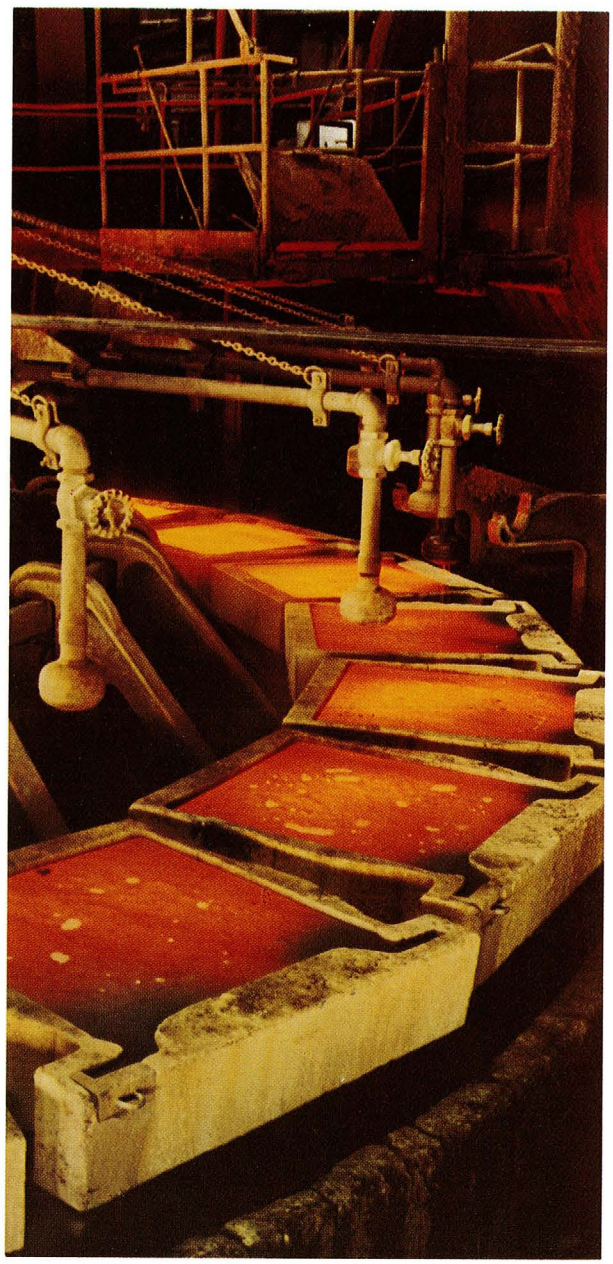
From the standpoint of practical economics, this new large copper refinery presents many new benefits to Arizona such as:

- Provides western-refined copper to western fabricators
- Provides additional skilled and unskilled employment
- Provides additional taxable assets and income
- Attracts companion industries and outside capital investment.

The Magma copper refinery increases Arizona's capacity for the production of electrolytic copper approximately three times. This production helps meet the growing demand for refined copper from Arizona and western manufacturers of electrical equipment and wire products, and thus reflects a geographical shift of traditional copper markets.

In these ways, Magma Copper Company reinforces and expands a broader dimension in the Arizona copper industry — the full copper production cycle from mining through refining.

process begins with anodes



The end product of the San Manuel smelter has been and will continue to be the copper anode, a casting of approximately 99.6 percent purity measuring 37 in. x 42-3/16 in. x 1-7/8 in. with its characteristic suspension lugs and weighing about 785 pounds.

To produce the anode, the ore is mined, crushed, and concentrated. The concentrates are smelted and metallic or blister copper is produced in the converters and placed in a holding furnace for final reduction of excess oxygen and for anode casting.

As the anode-casting wheel of 28 molds rotates clockwise, it is automatically positioned under the two pouring ladles. A self-operating weighing device measures the correct amount of molten copper being poured into each mold.

The molds are made of copper and weigh 5,730 pounds each. A mold wash of pulverized silica, obtained from concentrator tailings, prevents the molten copper from adhering to the molds.

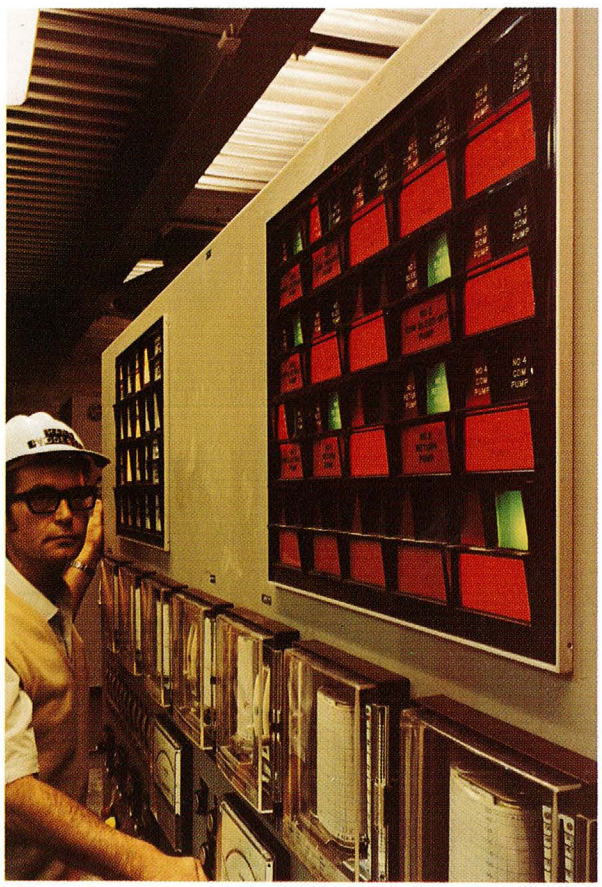
An automatic take-off device lifts the finished anodes from their molds, cools them with water sprays and places them on racks, accurately spaced for direct transfer to refinery electrolytic cells. The racks are then taken to the refinery tankhouse by straddle carrier.

MAGMA MAGMA

MAGMA

refining copper

The copper content of anodes is approximately 99.6 percent while that of cathode copper is 99.98 percent. The difference appears slight; however, to meet exacting requirements of fabricators and the electrical industry, the refinery must supply a product of 99.95 to 99.96 percent purity. Total metallic impurities in electrolytic copper must be under 0.01 percent.



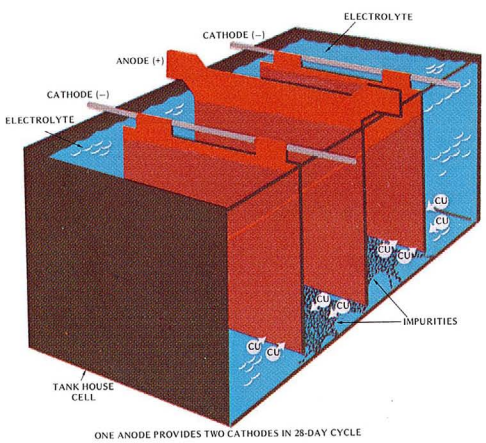
Copper is separated from any metals and impurities by electrolysis in a bath (electrolyte) which is a solution of copper sulfate and sulfuric acid. It is sufficiently electropositive to hydrogen in the solution to facilitate its deposition at relatively high current efficiency.

Metallic impurities either precipitate as insoluble compounds or remain in solution in the electrolyte.

Precipitated impurities are collected for subsequent treatment to recover any economic metal values. Impurities which remain in solution are controlled within strict limits through an electrolyte purification step in the liberator section.

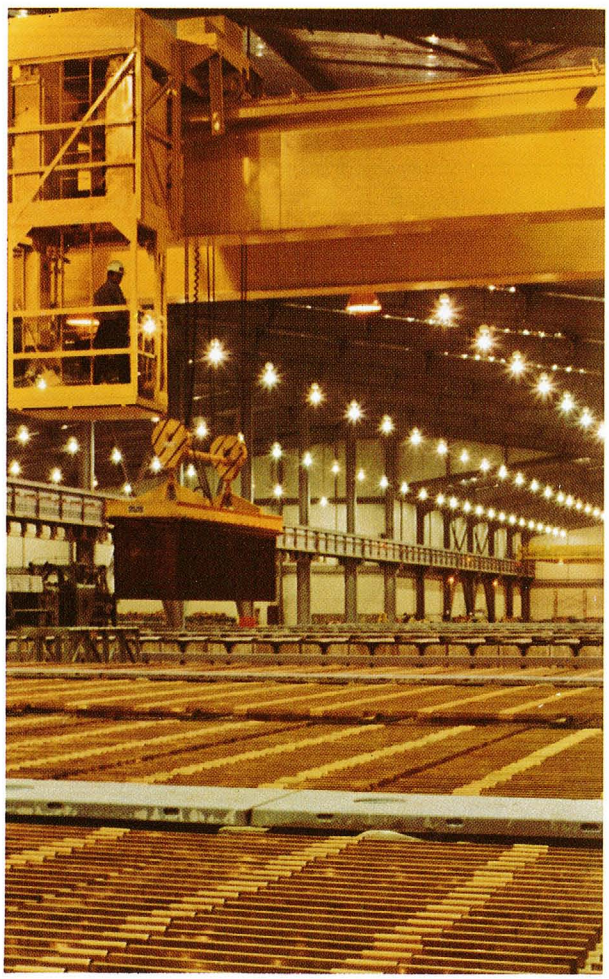
Although electrochemical reactions employed in the electrolytic refining of copper are complex, the principal reactions involve dissolution of copper at the surface of the anode and deposition of pure copper on the surface of the cathode.

Each anode provides two cathodes in a 28-day cycle. The cathodes weigh 330 pounds, and the remaining 125 pounds of anode scrap is recycled to the smelter where it is melted and recast into anodes.



Deposition of Refined Copper in Electrolytic Process

electrolytic copper produced in tankhouse cells



The Magma refinery has design capacity for producing 200,000 tons of electrolytic copper annually or about 650 tons per day.

The refining process takes place in the 1008 reinforced concrete, plastic-lined cells which are arranged in sections of 42 cells in the tankhouse.

In each cell, 46 anodes are placed alternately with 47 copper starting sheets. The heated electrolyte is circulated through the cell and the electric current applied. After 14 days, 47 cathodes are removed and replaced with new starting sheets. After another 14 days, another set of cathodes is removed along with the depleted anodes. New anodes and starting sheets are placed in the tanks and the entire cycle begins anew.

The cathodes are removed from cells to one of a specially designed pair of washing machines mounted on tracks to move from one end of the tankhouse to the other.

In order to maintain production rates and smooth operating schedules, the cycles are staggered so that 3948 cathodes are pulled daily from 84 cells during a 6-day production week.

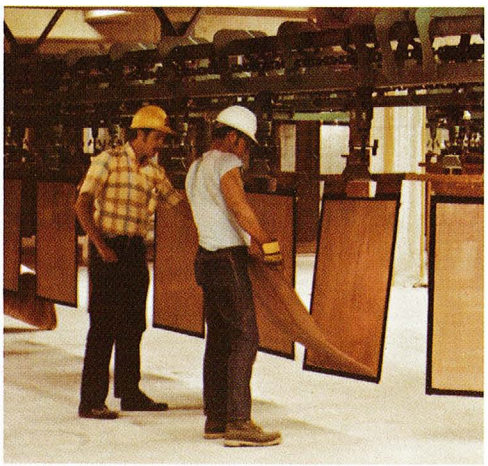
MAGMA MAGMA

magma copper company
san manuel division

MAGMA

MAGMA

cathode starting sheets mass produced by stripper



Approximately 5400 copper starting sheets, each weighing 12 pounds, can be produced daily in the stripper section of the tankhouse. They are produced in a manner similar to cathode production but are the result of only 24 hours of deposition of electrolytic copper.

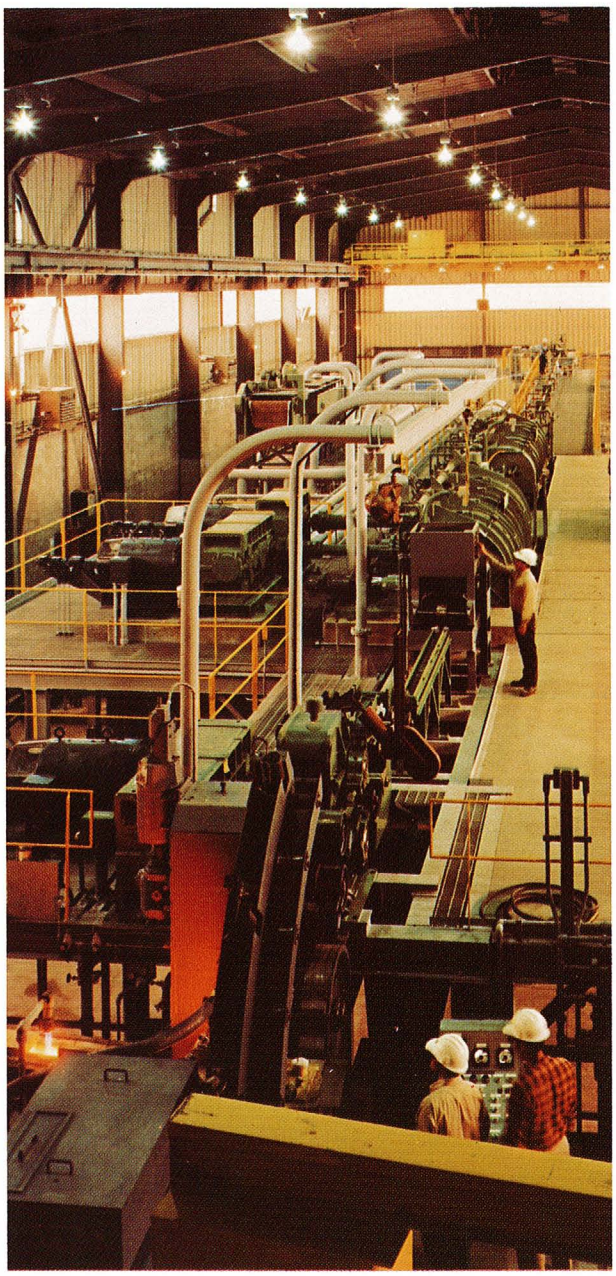
In the stripper section, some 2700 rolled copper blanks with specially treated surfaces are interspersed in tanks between anodes. Electrodeposition occurs in the same manner as in the commercial tank sections, but is halted after 24 hours.

The blanks are pulled and workmen peel or strip away the thin sheets of copper deposit from the blanks. Some of the sheets are slit into 4-inch strips and two of these strips and a copper suspension rod are mechanically attached to each starting sheet to complete a full starting sheet assembly. The sheets are pressed and embossed to give them rigidity in the electrolytic cells.

The assemblies are suspended in racks, and carried by bridge crane to sections of the tankhouse, ready to be charged.

MAGMA

continuous cast rod



About one-half of Magma's production of electrolytic copper is continuously melted, cast, and rolled into 5/16-inch continuous cast copper redraw rod, a basic form used by the electrical wire industry.

Finished cathodes are transferred to the casting house, melted in a gas-fired shaft furnace, and fed continuously from a 15-ton capacity holding furnace and pouring ladle to the 8-foot diameter casting wheel.

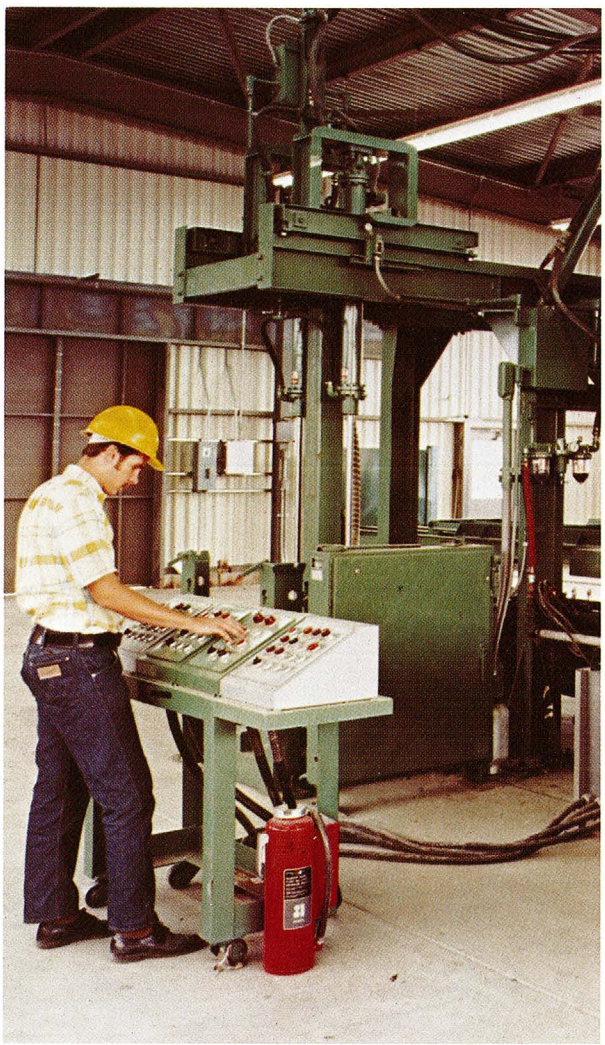
As the wheel turns, it continuously casts a 5-square-inch bar, which is fed to a rolling mill consisting of 12 stands. The casting is rolled into alternate oval and round shapes, progressively smaller down to five-sixteenth inch. The sequence takes place at rates up to 4000 feet per minute.

After leaving the rolling mill, the rod is pickled with dilute sulfuric acid, rinsed, coated, and finally wound into coils of various sizes specified by customers.

Each coil undergoes rigorous inspection and strict physical and metallurgical tests to ensure consistent high quality. Coils are sampled for oxygen and sulfur content and tested for tensile strength, twisting characteristics, and conductivity and are subjected to spectrographic analysis.

Various sizes of coils are produced weighing from 5000 to 16,000 pounds. The coiling machinery is adjacent to the loading dock where the coils are weighed and check-weighed on highly accurate scales prior to loading directly into railroad cars or trucks.

cathode plate sheared to customer requirements



The Magma electrolytic copper refinery processes about one-half of its output as full plate cathode copper, a basic form used by manufacturers of industrial copper products.

About 75 percent of this cathode production will be shipped as full plate cathodes bundled according to specified customer requirements.

Custom cut plate is available up to approximately 25,000 tons per year with the operation of a 150-ton, fully automatic, hydraulic shear, capable of cutting full, half, quarter, third, or sixth parts of a plate. (The full finished cathode measures 38 in. x 41 in. x 3/4 in.)

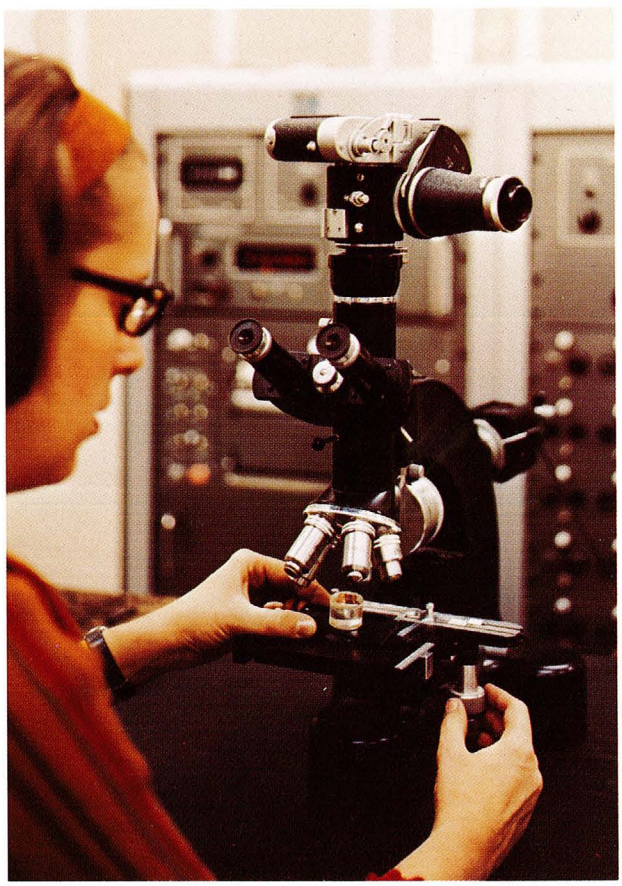
A vacuum mechanism lifts the 330-pound cathodes, feeds them to the shear blade, removes the cut, discards the scrap, and bundles the completed stack of sheared cathodes.

The plate-shearing capability gives extra flexibility to serve the needs of customers who have particular requirements.

controlling high quality is the job of metallurgists

The new metallurgical laboratory at Magma's San Manuel Division is equipped with modern equipment and maintains high product standards, as well as operational efficiency, from geophysical exploration of ore bodies through mining, concentration, smelting and refining.

Advanced metallurgical technology, through electronic measurement, data processing, and analysis, is utilized in all production processes to maintain positive operating and quality control



Magma copper company — in Arizona since 1910

With the addition of the Electrolytic Refinery, Magma Copper Company becomes a more highly integrated producer of primary copper, controlling the entire process from underground ore bodies through refining.

Magma was founded in 1910 by William Boyce Thompson who had purchased the Silver Queen mine near Superior and began to explore and develop its high-grade copper veins. This extraordinarily rich mine has developed and expanded and today produces 1500 tons of ore per day, with an average grade in excess of 4 percent copper.

In 1944, Magma acquired the San Manuel group of claims and, with Federal assistance, launched the program of exploration and development which resulted in the present day San Manuel mine, community, concentrator, smelter and refinery. First production from the San Manuel plant was in 1956.

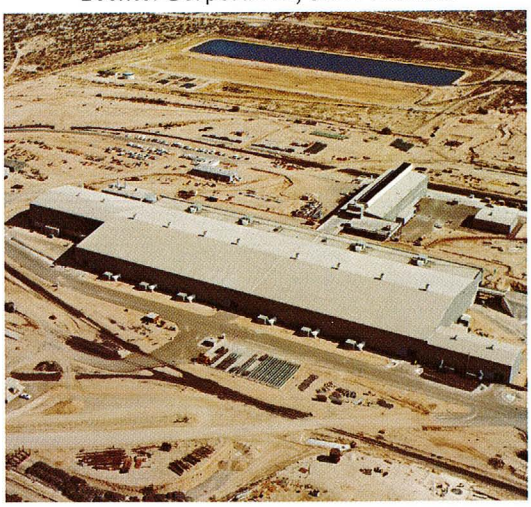
The San Manuel mine contains an estimated 1 billion tons of copper ore averaging 0.7 percent copper. Ore production is 60,000 tons per day, which is processed through the concentrator, smelter and refinery. Concentrates from Superior are shipped to San Manuel for smelting and refining.

In 1969, Magma became a wholly owned subsidiary of Newmont Mining Corporation, an international firm specializing in the development and production of diversified mineral resources.

the magma electrolytic refinery

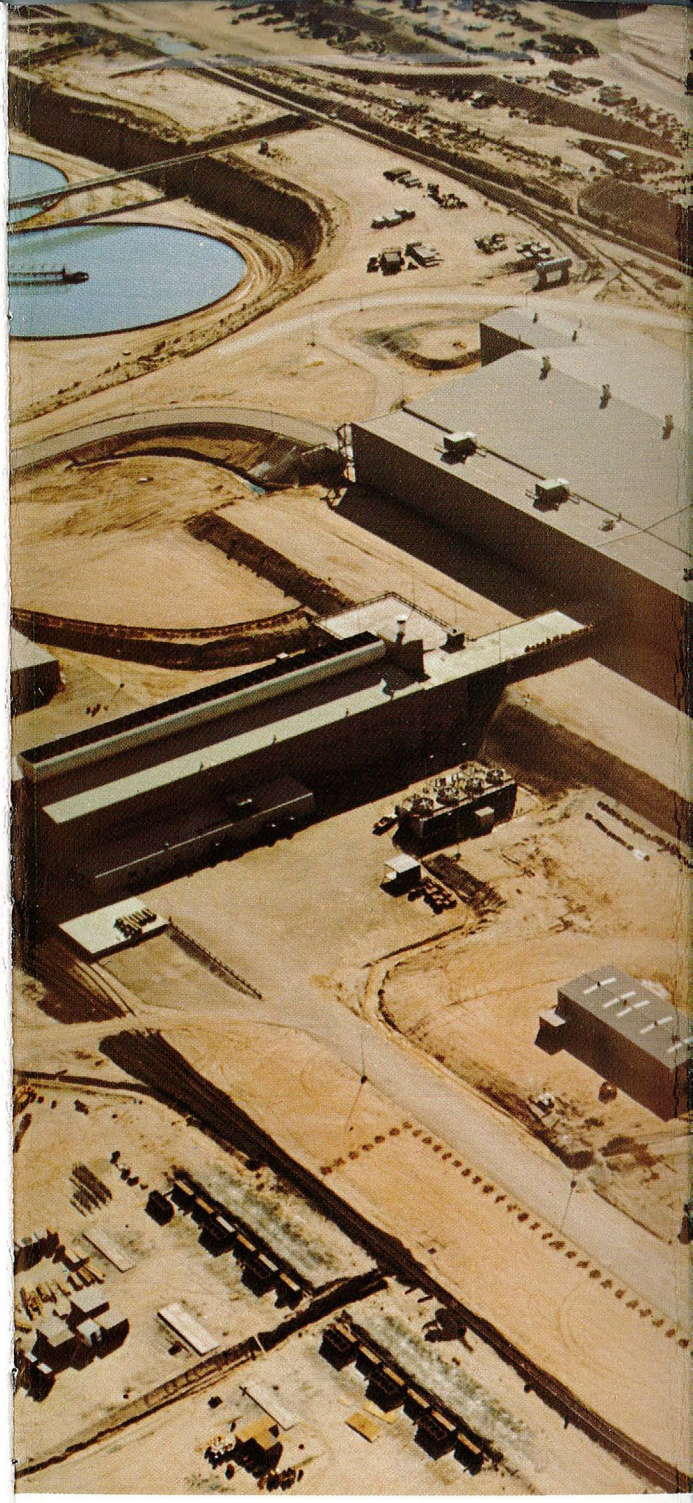
Completed: October, 1971

Engineer and General Contractor:
Bechtel Corporation, San Francisco



Tankhouse Statistics:

Floor space under roof	179,333 square feet
Length of electrolyte supply pipes	18,500 feet (3-1/2 miles)
Weight of copper in electrical system	492 tons
Concrete poured for building	16,511 cubic yards
Weight of steel used in construction	1,365 tons
Weight of stainless steel	102 tons
Electrolyte solutions in system	1,235,000 gallons
Illumination	402,000 watts
Power consumption	11,000 kva continuous



magma coppe
san manuel
electrolytic

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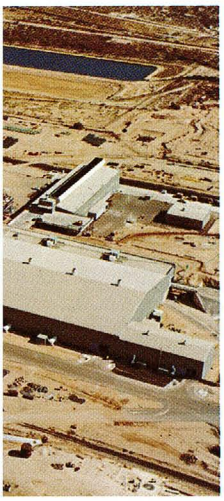
ober, 1971
l Contractor:
San Francisco

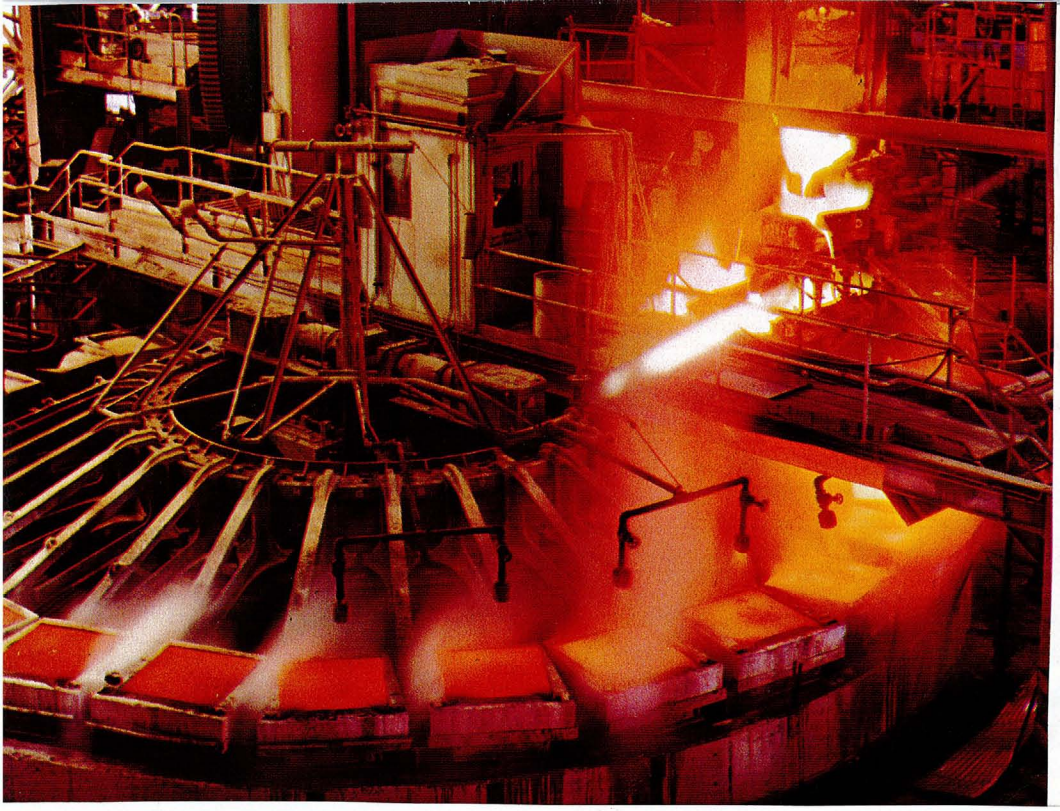


79,333 square feet
3,500 feet -1/2 miles)
92 tons
5,511 cubic yards
,365 tons
02 tons
,235,000 gallons
02,000 watts
1,000 kva ntinuous

magma copper company
san manuel division
electrolytic refinery

MAGMA COPPER COMPANY

Magma Copper Company Production Plant, San Manuel, Arizona, with town sight and Catalina Mountains in the background. View looking southerly.



LEFT: *This computerized anode casting wheel at Magma's San Manuel smelter, continuously produces precision weight anodes of 800 pounds each. They are the end product of the smeltering furnaces and are 99.7% pure, but must be refined to even greater purity to meet requirements of the electrical industry. The wheel delivers 60 tons of anodes per hour.* — RAY MANLEY STUDIOS

An overhead crane deposits copper anodes into tanks at Magma's Electrolytic Refinery at San Manuel, Arizona. Here, amid stainless steel and plastic surroundings, they are converted from smelter purity of 99.7% to cathode copper of 99.9% purity. This process of electroplating takes 14 days. Impurities, if we may call them that, are precious metals such as gold, silver and selenium which are collected in the sludge at the bottom of the tanks and sold to precious metal refiners. The product is now ready for world market.

— RAY MANLEY STUDIOS