The Mine
GENERAL INFORMATION

MAGMA COPPER COMPANY

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

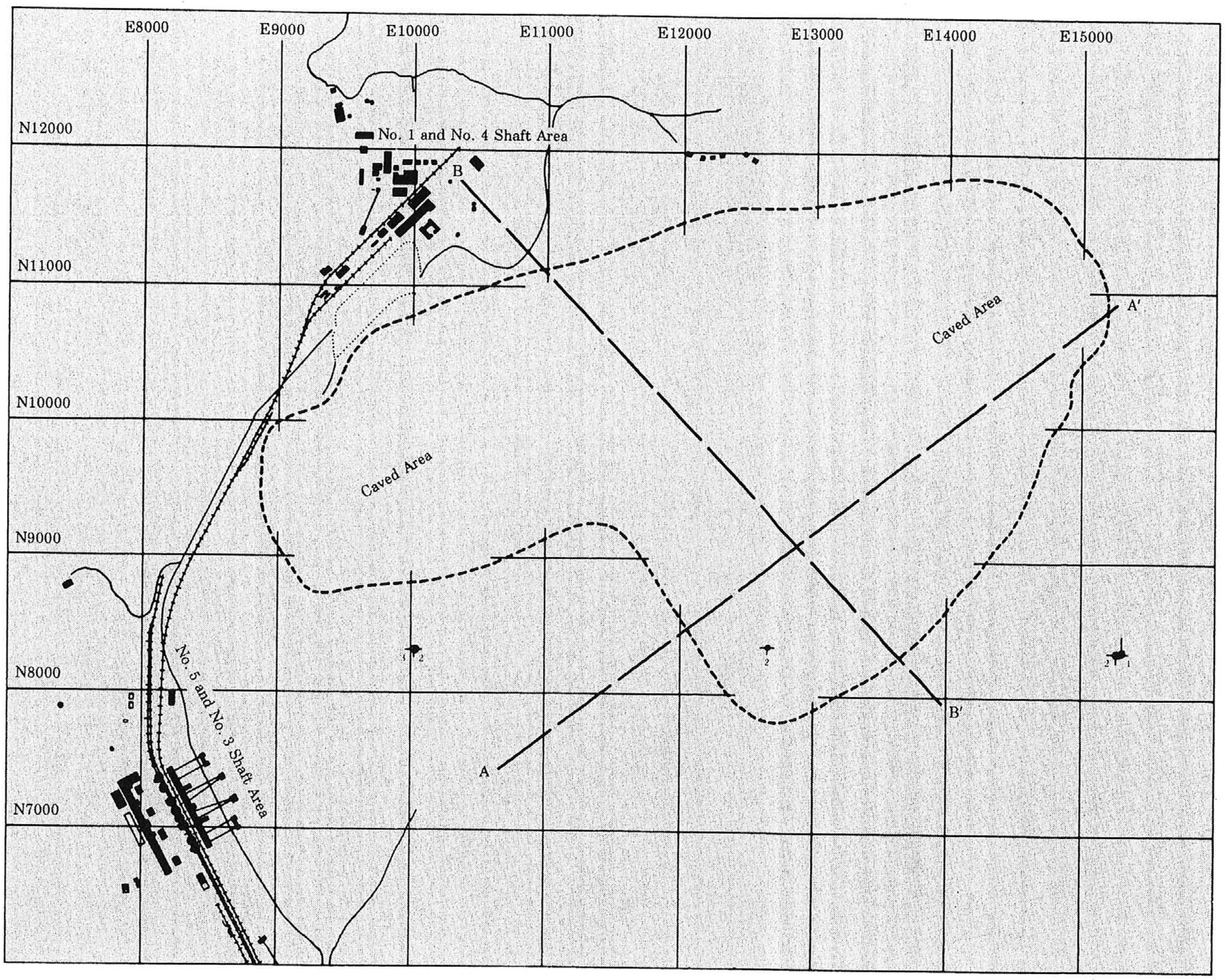
Table of Contents

This booklet contains basic information relative to the geology, engineering, statistics, etc. pertaining to the Magma Copper Company San Manuel Mine. The techniques and information described are continually undergoing change as new, improved methods are discovered, but the booklet, for the most part, is an accurate assessment of operations.

Geology

The San Manuel Orebody is a large, low grade disseminated orebody in which primary chalcopyrite mineralization has been deposited as an elliptical, hollow cylindrical shell whose present longitudinal axis trends in a northeasterly direction and plunges gently to the southwest. Interior to the cylindrical ore shell proper is a marginally mineralized zone of monzonite porphyry rock showing K-Feldspar Biotite alteration. Thickness of the elliptical ore shell itself (as defined by a 0.50% Cu cutoff) varies from 100 to 1,000 feet. The entire system of mineralization-alteration, of which the ore shell is a part, is known to have a longitudinal dimension of some 8,000 feet, with major and minor cross-sectional axis of about 5,000 and 2,500 feet respectively. This system of mineralization-alteration is believed to have been formed in conjunction with the intrusion of a Laramide monzonite porphyry into the pre-Cambrian porphyritic quartz monzonite basement rock (the Oracle granite). These two igneous masses comprise the major host rocks of the orebody.

Intrusion of the Laramide porphyry and its accompanying mineralization-alteration phenomena apparently occurred along a central longitudinal axis which originally was much steeper than the present axis. After the total cylindrical system was formed, it underwent periodic rotation to the northeast and concomitantly was bisected at an acute angle by the San Manuel fault, a normal fault with post-fault rotation, producing two offset segments of copper ore. Displacement along the San Manuel fault was approximately 8,000 ft. of dip-slip movement. The fault now dips SW at a 25-30° angle. The ore segment in the footwall is known as the San Manuel Orebody while the segment in the hanging wall has been called the Kalamazoo Ore-body, the Kalamazoo being essentially a mirror image of the San Manuel.



Mine Surface Map Showing Caved Areas

1″ = 1200′

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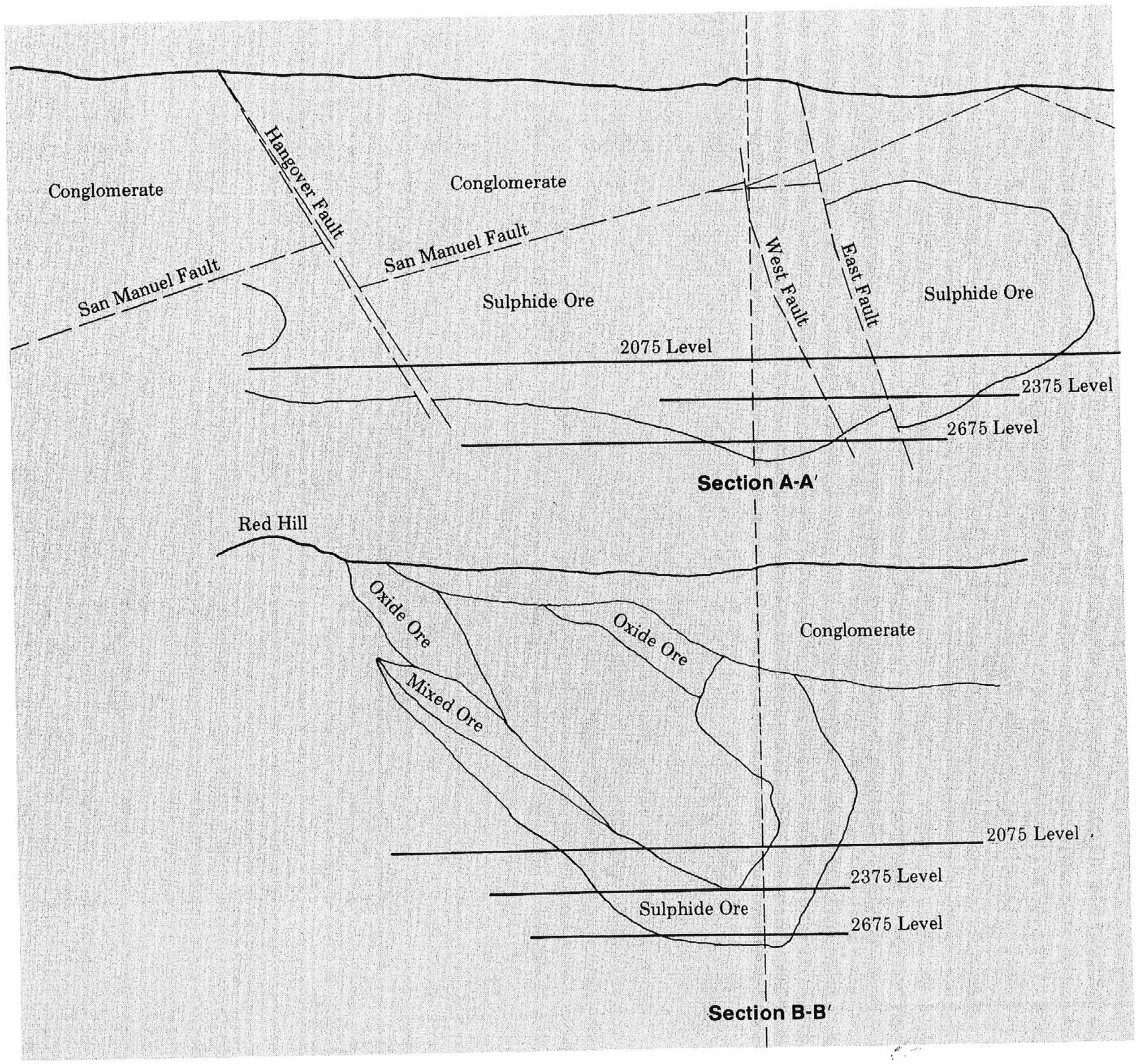
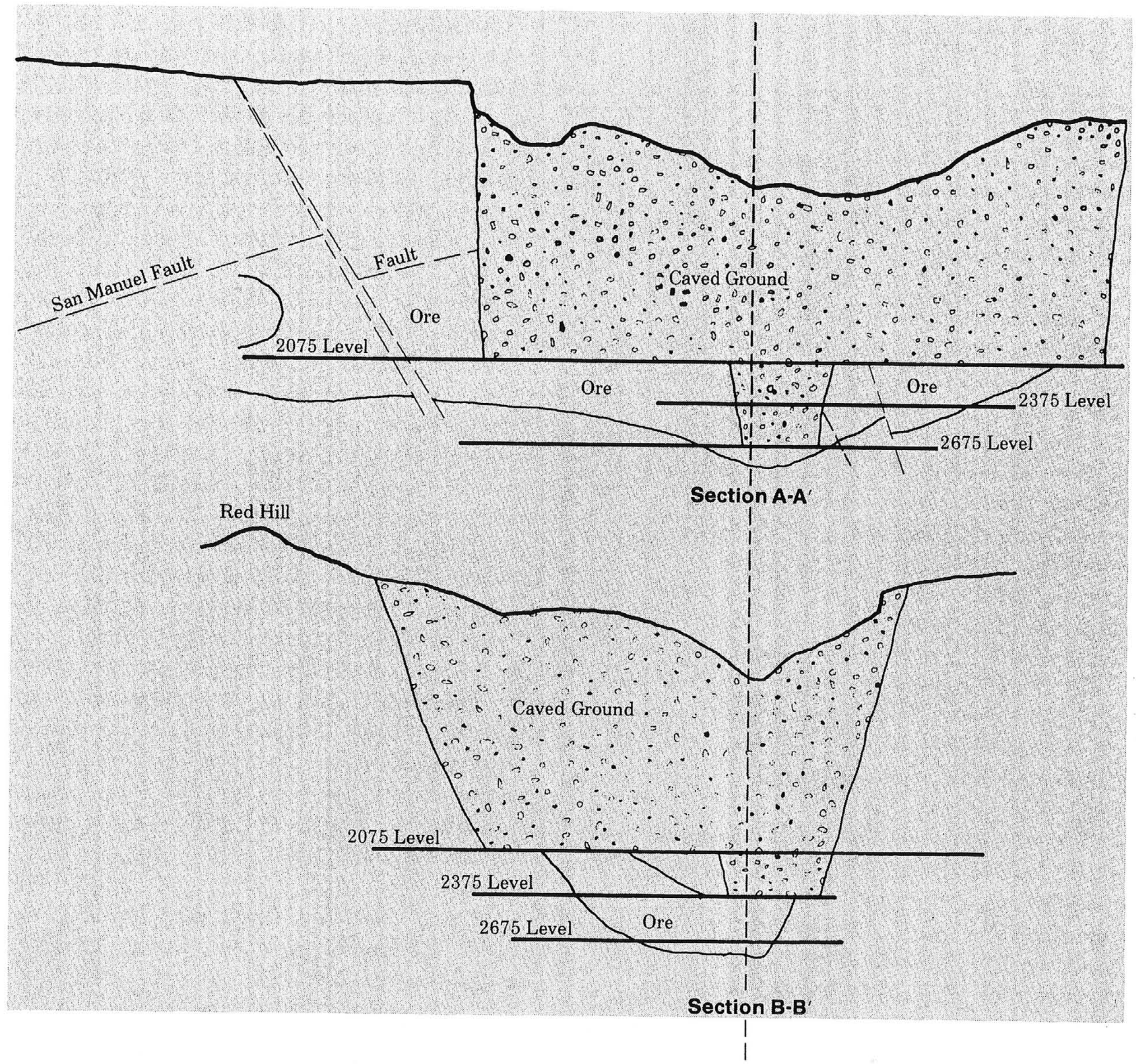


Sections Before Caving

1″ = 1200′



Sections After Caving

1″ = 1200′

Mining System

The San Manuel mine operates with a full gravity block caving system. The orebody is divided into panels 140 ft. wide. These panels are further divided into blocks of varying sizes. The initial block undercut in any panel is at least 210 ft. by 140 ft. to ensure sufficient area to induce proper caving action. Subsequent blocks vary in size according to production requirements. Undercuts are generally taken in sequence from the initial undercut toward the outer edges of the orebody.

Where the orebody is high and essentially vertical, the lift or slice being mined is normally 600 ft. high. However, in areas where the orebody has considerable dip or rake, sublevels 300 ft. apart are used to maximize extraction.

Mining is accomplished through a pair of levels. The upper level is the mining or grizzly level and the lower level is the haulage level. Level placement and design are based on a preselected undercut elevation dependent on orebody geometry.

The sill of the grizzly level is currently placed 15 ft. below the undercut elevation and the haulage level is 75 ft. below the undercut. The levels are parallel and are sloped to provide a downhill haul for loaded trains at 0.4% grade to the shafts for hoisting.

Primary development starts with shaft sinking or deepening to a depth sufficient to allow loading facilities, spill handling facilities and sumps. Both types of levels require peripheral drifts surrounding the orebody. These are called fringe drifts on the grizzly level and haulage drifts on the haulage level. While these are being driven, support facilities are developed around the shafts.

When the haulage level development reaches an appropriate stage, panel drifts are started. These cross the ore body on 70 ft. centers and are centered below each half of each panel. Some of these are pull-through panels and some are back-in panels that are dead ended. Panel drifts are connected with vent crossovers at various places to facilitate ventilation and emergency access.

Concurrently with haulage panel development, panel drifts are driven on the grizzly level. These are driven across the orebody on 290 ft. centers to serve pairs of panels. A 10 ft. pillar is allowed over the drift.

All drifts through the orebody are concrete lined for maximum support. Most peripheral drifts have timber support. Ground support is varied to meet special conditions.

Secondary development, or block preparation, begins as soon as a sufficient amount of primary development is accomplished to allow access to the mining area.

On the haulage level, secondary development starts after the excavation of raise stations and installation of pony sets. These are spaced every 35 ft. along the drift, in conjunction with the grizzly drift spacing above. When the raise stations are completed, preparation is made for the drawing of ore by the installation of chutes and installation of trolley power for 20-ton haulage locomotives. Transfer raises are then driven and lined with armored cribbing. They are normally four-ft. square and are driven blind with a bell at the top.

When the raises are in, secondary development can begin on the mining level. Grizzly drifts are driven on 35 ft. centers at right angles to the panel drifts over the tops of the raises. Most of the broken rock falls down the raise, so very little mucking is required. Raise tops and grizzlies are installed as the drift proceeds. The drift is temporarily supported with wire mesh and rock bolts.

Next, the raise tops are formed and concreted. Permanent ground support of the drift is accomplished by placing forms in the drift starting from the far end and retreating outward to the panel drift. Windows are boxed in for a draw raise on each side of each grizzly. Grizzlies are spaced on 17.5 ft. centers. Concrete is placed behind the forms pneumatically and the forms are removed for reuse.

When several grizzly lines are driven, an access drift is driven parallel to the panel drift at the far end of the block. Rubber tired muckers are used to remove excavated rock. The access is formed and poured grizzly drift size. This drift provides ventilation connections and emergency access.

The next step is to drive the draw or finger raises. These are driven blind up to the undercut elevation, the muck dropping through the grizzly rails into the transfer raise. The grizzly drift is equipped with air, water and blasting lines, and guide rods for muck control boards. Sprays are installed under each grizzly for dust control.

Two draw raises in every third line are equipped with ladders to provide access to the undercut. Please refer to page 21.

When undercutting above a draw point has been completed, production can begin. Muck is pulled from grizzly level draw points by means of several tools: bars, hooks and double jacks. The flow of rock is regulated by the control board, which is raised and lowered in front of the draw point. Boulders too large to fit between the grizzly rails (90# salvaged rail spaced at 14″) must be sized with the double jack hammer before they will fall into the transfer raise.

When boulders in draw points hang up and stop the flow of muck, secondary blasting is required. Scheduled lunchtime and quitting time blasts are used to fragment boulders on the grizzly that are too large to be broken with a double jack.

Once the ore is in the transfer raise, it can be loaded into ore trains by car loaders on the haulage level. Car loaders, standing in pony sets above the panel drifts, load a train as it passes below. Chute doors are air-operated guillotine type undercut gates. Signal lights operated by pull bottles located in all pony sets provide a means of communication between car loaders and the motorman.

Once a train has been loaded, the muck is hauled to the #3 Shaft area, where it is dumped by either an ASEA or a rotary dump. Four production shafts hoist the ore to the surface. It is then run through a primary crusher and stored in bins, ready for transportation to the mill for processing.

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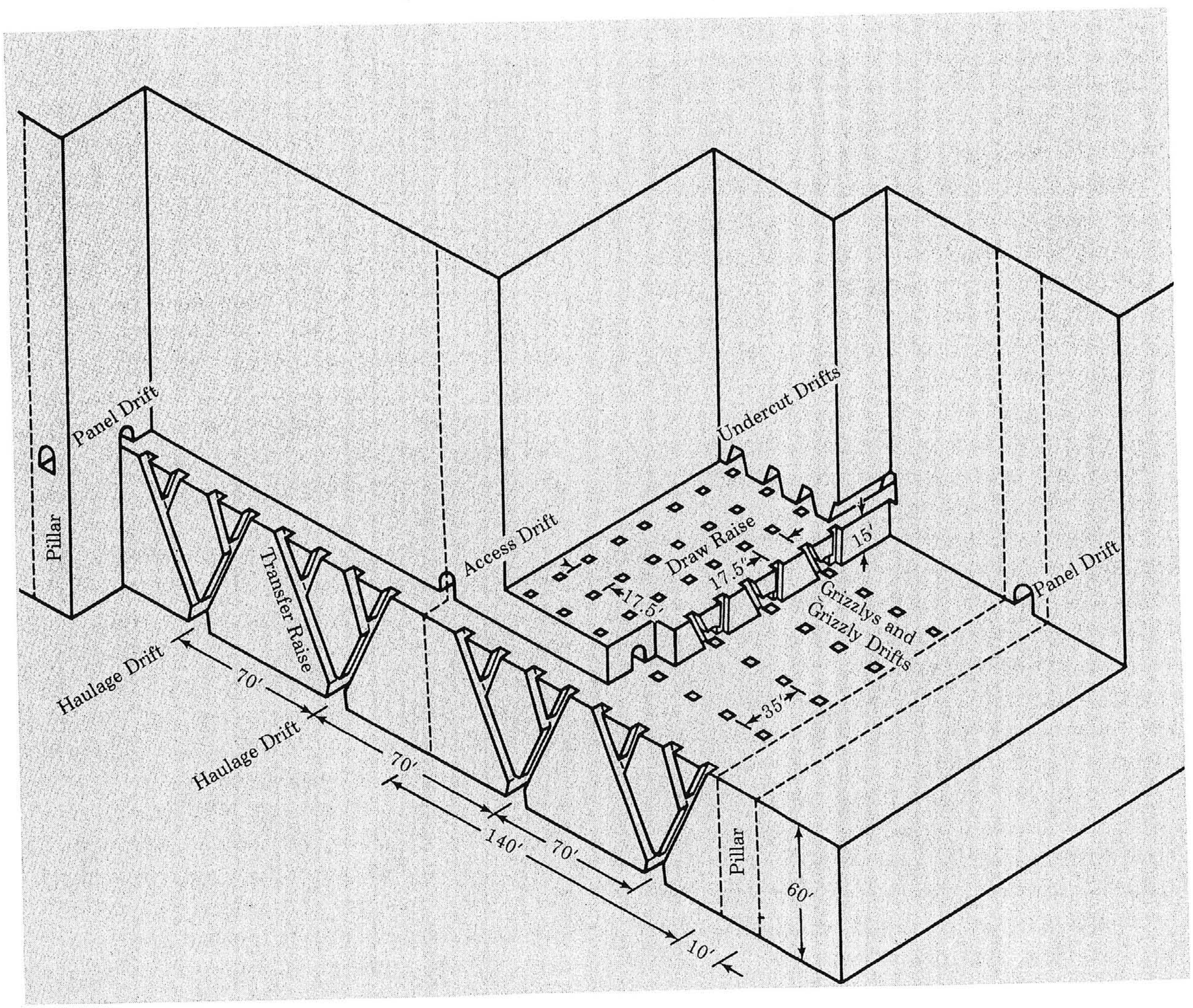


Isometric Diagram of a Block

1″ = 80′

Production Control

Before secondary development is begun, cross sections through the orebody are diamond drilled by contract drillers under the direction of the Geology Department. Core is logged and assayed. This information, as well as drift sampling, mapping, experience factors, etc., are utilized to predict grade, production efficiency, extraction and weight problems.

Production Engineers, using this information, production requirements, and stope availability, assign quotas to the operating crews. These quotas are designed to maintain the desired production and grade for the mine and an optimum rate of draw from each area and draw point.

Various factors are involved in determining the desirable rate of draw. If not pulled fast enough, a draw point or area may take weight and cave. If pulled too fast, a draw point may pipe through to waste prematurely. Some areas contain too much oxide or too little recoverable copper and production may be curtailed here to maintain a relatively uniform grade for the mine output.

Quality control is effected by a sampling program which is basically computer-controlled and is another function of the Production Engineers.

Tonnage drawn from each draw point is tabulated daily by computers in the Data Processing Section. When the computer determines that sufficient tonnage, usually 200 tons, has been extracted from a given draw point since the last sample, it issues a sample card for that draw point.

When production records and assays indicate a stope is approaching depletion, regular sampling procedures are normally suspended. At this time, the production engineer initiates procedures which include close visual inspection of ore drawn and special sampling. The engineer manually orders samples on a much more frequent basis, perhaps daily, according to production pressures and the characteristics of each area.

Development drift samples are taken by the Geology Department while mapping the headings. Production area samples are taken by four full time samplers working a 5-day week, who are capable of taking more than 300 samples a day.

Samples are assayed at the plant site under the direction of the Quality Control Department.

Assaying is by atomic absorption and X-Ray fluorescence equipment which transmits results directly to the computer. The computer processes the data and can transmit results via teletype directly to those portions of the operation needing rapid analysis.

No. 1 Shaft

Depth: 2,829 ft. (for the Third Lift.)
Dimensions: 25′-5⅞″ x 6′ inside concrete.
Four compartments:
2 Hoisting, 6′-5½″ x 6′-0″.
1 Manway, 5′-0⅛″ x 6′-0″.
1 Service Cage, 5′-0″ x 6′-0″.
Ventilation downcast.
Structural steel sets in reinforced concrete.
Headframe: 100′-6″ to ℄ sheaves.
Two 12′ diameter steel sheaves with wear liners.
Skips: Two, 4-ton capacity each, in counterbalance, Kimberly type.
Hoists: Main Hoist, two 200-hp motors, double drum.
Rope speed = 800 fpm, with Lebus wind.
Rope size = 1⅛″.
Service Hoist: single drum, 200-hp.
Rope speed = 545 fpm.
Rope size = 1″.

This shaft is used to hoist rock from the development headings. The manway compartment contains pump discharge columns and power transmission lines. The service compartment has one pump line and three 8-in. heavy-duty pipes for passing concrete from the automated concrete batching plant at the collar of the shaft to the underground mining levels.

3A-3B Shafts

Twin ore hoist shafts.
Depth 3A: 3,680′ by Dec., 1985
Depth 3B: 2,950′ by Dec., 1981 (for third lift)
Dimensions: 29′ x 7′ inside concrete.
Four compartments, each 6′-6″ x 7′-0″.
Ventilation exhaust shafts, 195′ apart.
Structural steel sets in reinforced concrete for smooth lining. Reinforced concrete curtain walls between each compartment, with 3′-7½″ x 4′ windows in each set.
In each of the two hoisting compartments, structural tubing guides are of Corten steel. These guides are supported every 6 ft.
Timber guides in service compartment are supported every 6 ft.
Headframe: 181′ to ℄ sheaves.
14′ diameter cast steel sheaves.

Coarse Ore Bins:
Diameter: 60′
Height: 66′-6″; top of bin 92′ above collar.
Capacity: 750 tons total.
Loading Gates: 2 on each track per bin, air operated.
2 loading tracks.

3A-3B Shafts, continued

Fine Ore Bins:
- Diameter: 65′
- Height: 81′-6″; top of bin 107′ above collar.
- Capacity: 10,000 tons total.
- Loading Gates: 6 on each track per bin, air operated. On same two tracks as coarse ore bins.

Loading Pockets: Two in 3A, one below 2075 Level; one below 2675 Level, capacity = 1,500 tons. One in 3B below 2075 Level, capacity = 1,500 tons.

Skips: Bottom-dump Corten steel skips, with alloy steel liners and impact railmat, running on solid rubber tires.
- Capacity: 23 tons with ± 4.0% moisture.
- Dimensions: 35′-5″ long, 6′-1″ wide, 6′-3″ deep.
- Weight: 30,000 lbs. (Approximate)

Automation: Skip loading and hoisting are fully automated. Skip loading and dumping are viewed on closed circuit television, and the car dumping and hoisting systems are monitored on a control panel.

Hoists: Double drum with Lebus wind; automatic or manual operation; 15′ diameter drums having a 109″ face, spooling 4,700 ft. of 2¼″ rope in two layers.
- Drum Shaft: 27″ diameter through drums.
- Hoisting Speed: 2,800 fpm.
- Two 3,000-hp DC motors equipped with MG set consisting of one 4,000-hp motor and two 2,500 KW DC generators. Steel plate flywheel, 44 tons (approximate) for 80% power peak equalization.

Service hoists are equipped with an 18-passenger cage and 45 cubic ft. skip combination with solid rubber tires running on timber guides. Hoisting ropes are 1″ at 3A and 1⅛″ at 3B. The cage and skip are counterbalanced by an 8,400-lb. counterweight in the shaft manway.

Primary Crusher: The 460′ x 50′ crusher building houses four 42-65 gyratory crushers. There are four 96″ x 62′-0″ pan feeders, with a capacity of 1,500 tons per hour; one fed from the 3A, one from the 3B, one from the 3C and the other from the 3D coarse ore bins. At 3A and 3B, 48″ conveyor belts transfer the crushed ore from the crusher building to transfer towers (222′) and back to the fine ore bins (421′).

3C-3D Shafts

Identical ore hoisting shafts, 3C is 195 ft. north of 3A; 3D is 195 ft. south of 3B. Height of the headframes is 200 feet.

Depth: 3C = 2,890 ft. The sinking and furnishing of this shaft was completed April 12, 1971. Hoisting from 3C started in August, 1971.

3D = 3,740 ft. Shaft sinking is complete.

Dimensions: 22′-0″ inside diameter, circular, concreted.

Two ore hoisting compartments, service cage, manway and pipe compartments.

Ventilation exhaust shafts.

Steel box-section Corten guides supported every 12 ft. in hoisting compartment.

Douglas fir timber guides in service compartment supported every 6 ft.

Headframe: Structural box members of Corten steel.

15′ diameter fabricated steel sheaves.

Loading Pockets: Two in 3C: one below 2375 level with 800-ton capacity, one below 2675 level with 1,500-ton capacity, both for ASEA trains. One in 3D below 2375 level, capacity = 1,500 tons.

Skips: Bottom-dump Corten steel skips, impact railmat alloy steel liners, with solid rubber tires running on Corten steel box-section guides.

Capacity: 29 tons.

Dimensions: Length, 37′-4½″; Width, 6′-8″; Depth 6′-3½″; Weight, 30,860 lbs.

Automation: Same as 3A-3B.

Hoists: Double drum with Lebus wind; automatic or manual operation, 15′ diameter drums having a 109″ face, spooling 2¼″ wire rope.

Hoisting Speed: 2,800 fpm.

Each hoist has two 3,500-hp DC motors powered from a MG set consisting of one 6,000-hp 514 rpm synchronous motor driving two 2,800 KW generators. MG set has no flywheel.

3C Service Hoist: Single drum, manually operated, powered by a 250-hp DC motor capable of handling an 8,000-lb. load at a depth of 3,600 ft. Adjustable DC voltage for driving the hoist motor will be supplied by silicomatic I-power conversion equipment converting AC to DC power through silicon control rectifier cells. Speed is 800 fpm. Rope size is 1″.

3C-3D Shafts, continued

Primary Crusher: At 3C and 3D, 48″ conveyor belts transfer the crushed ore from the crusher building to transfer towers (169′) and back to the fine ore bins (365′). Skip dumping, fine ore bin capacity and transfer belts are viewed on closed circuit television. The entire automated crusher is monitored from control panels at each crusher location.

No. 4 Shaft

Depth: 2,729 ft.
Dimensions: 26′-6″ x 14′. Structural steel sets are poured in concrete for smooth lining.
Two cage compartments, each 14′ x 8′; two rounded end compartments for manway, pipes, electric cables and ventilation. Manway compartment also contains the main compressed air line supplying the mine.

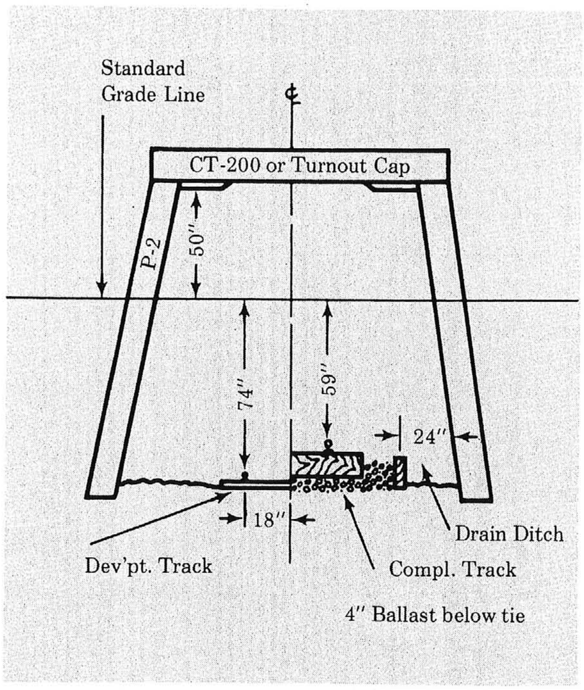
Man and supply shaft, and downcast ventilation.
Cages: 2 decks, 50 men per deck.
Inside dimensions: 6′-9½″ x 13′-6″.
Rated Capacities: 20,000 lbs. supplies per deck.
12,000 lbs. men per deck.
Cage Weight: 24,000 lbs. (approximate).
Headframe: 109′ to ℄ sheaves.
Two 14′ cast steel sheaves.
Hoist: Double drum.
15′ diameter, 90″ face drums.
2¼″ hoisting rope.
Maximum hoisting speed: 1,500 fpm.
Single reduction drive, two 700-hp DC motors equipped with MG set consisting of one 1,750-hp AC motor and two 600-KW DC generators. Hoisthouse equipped with 30-ton crane, with 5-ton auxiliary.

No. 5 Shaft

Lining: 24″ thick reinforced concrete lining.
Depth: 4,123 ft.
Dimensions: 25 ft. diameter inside the concrete line.
Of the four hoisting compartments, two are used for handling men and supplies, and two are used for hoisting waste rock. The shaft has compartments for manway, pipe lines, electric cables, and concrete transportation lines.
Man and supply shaft, downcast ventilation.
Hoists: Double drum production hoist powered by one 1,000-hp DC motor.
9′ diameter, 103.5″ face.
1⅜″ hoisting rope.
Hoist speed: 1,925 fpm.
Skip capacity: 5.5 tons.
A static rectifier rated at 1,000 KW supplies power to the production hoist motor.

Service Hoist: Double drum service hoist (for men and materials), powered by two DC motors, each having 1,000-hp.
15′ diameter, 105″ face.
2⅛″ rope.
Hoist speed: 1,856 fpm.
Man cage: Similar to that at No. 4 Shaft.
Headframe: 157 ft.

Haulage Level Primary Development Drifts



Timber

Posts: 12" x 12" x 10'-4"
Caps: 12" x 12" x 11'.
Sets on 5' centers.
Crews: Single Heading—2 men.
Two Headings—4 men.
64 holes drilled per set.
75 lbs. ± Aquagel 1¼" x 12" sticks.
Initiated by electric blasting caps 0 to 12 delay.
Inside Cross Section Area: 87.5 sq. ft.

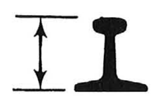
Main lines running from the orebody to the dumps are generally timbered. Ladder drifts are turnouts connecting panel drifts to the main haulage lines.

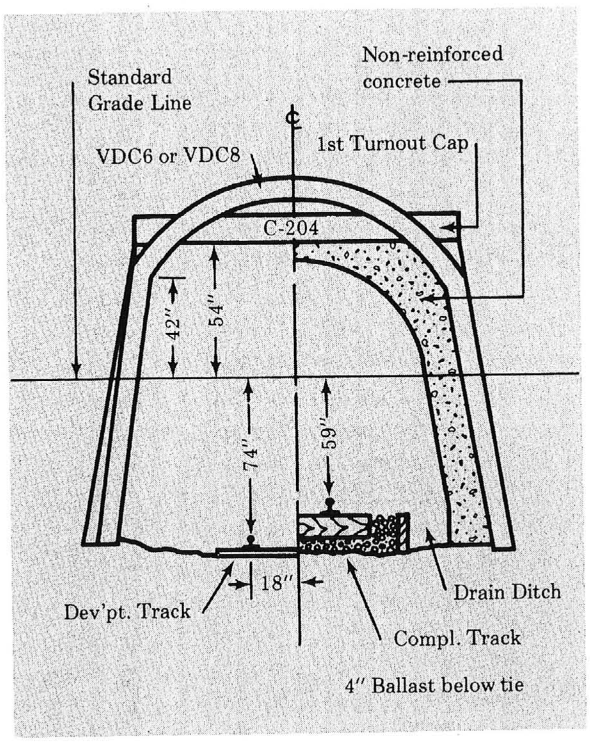
TRACK

Haulage Drift:
45# rail for Development.
90# rail finished track.

Ladder Drift:
If 75# rail is used, 65" is the grade.
45# rail for Development.
75# rail finished track.

Rail Measurements:
3¾" for 45# rail.
4-13/16" for 75# rail.
5⅝" for 90# rail.





Concrete

4″ or 6″ W.F. arch caps and 9′-6″ posts for initial ground support.
Sets on 5′ centers.
Crews same as Timber Haulage Drift.
Initial Ground Support: 6″ Steel Set VDC-6 or
8″ Steel Set VDC-8

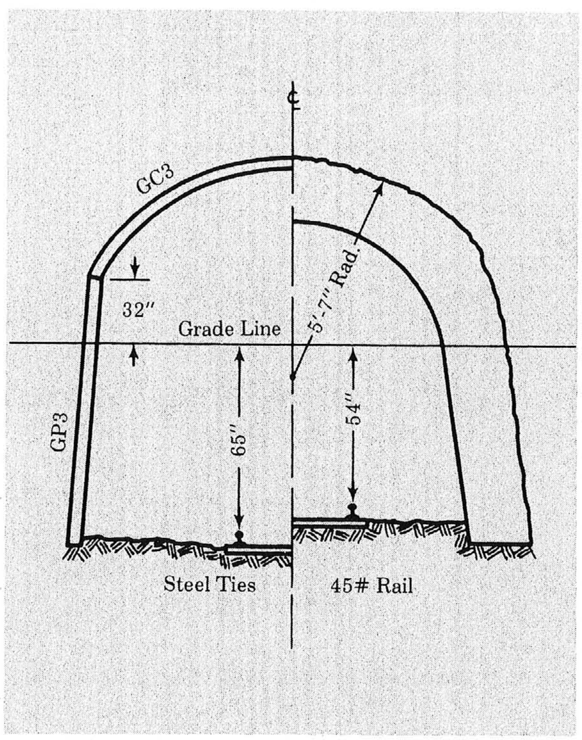
Cross Section Area
Inside Concrete: 84 sq. ft.

Drifts through less competent ground are concreted for additional support. Panel drifts, which run through the orebody, are concreted.

TRACK

Same as for timber drifts.

Grizzly Level Primary Development Drifts

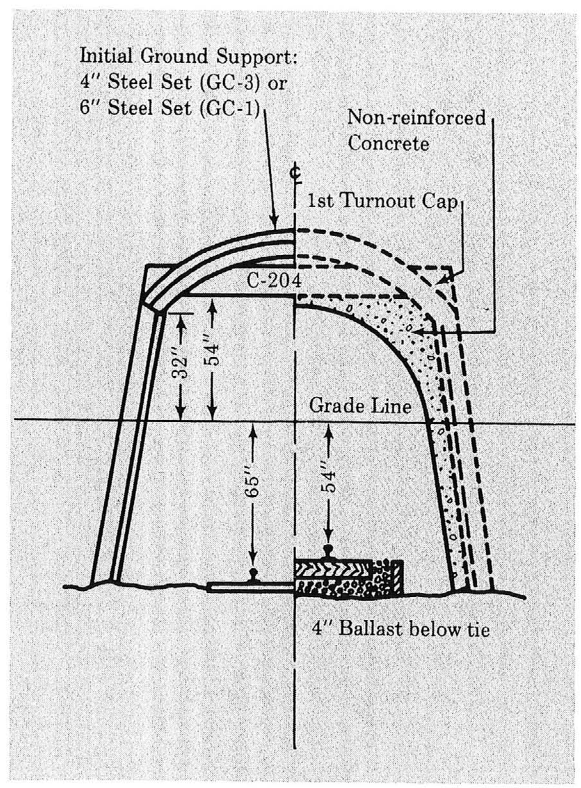


Concrete Panel Drift

Excavation only:
Rock bolts and steel straps GC-3, GP-3 are used as pre-concrete support.
Size: 10′-3″ x 9′-1″.
Each round marked on face by Boss.

Cross Section Area
Inside Concrete: 62 sq. ft.

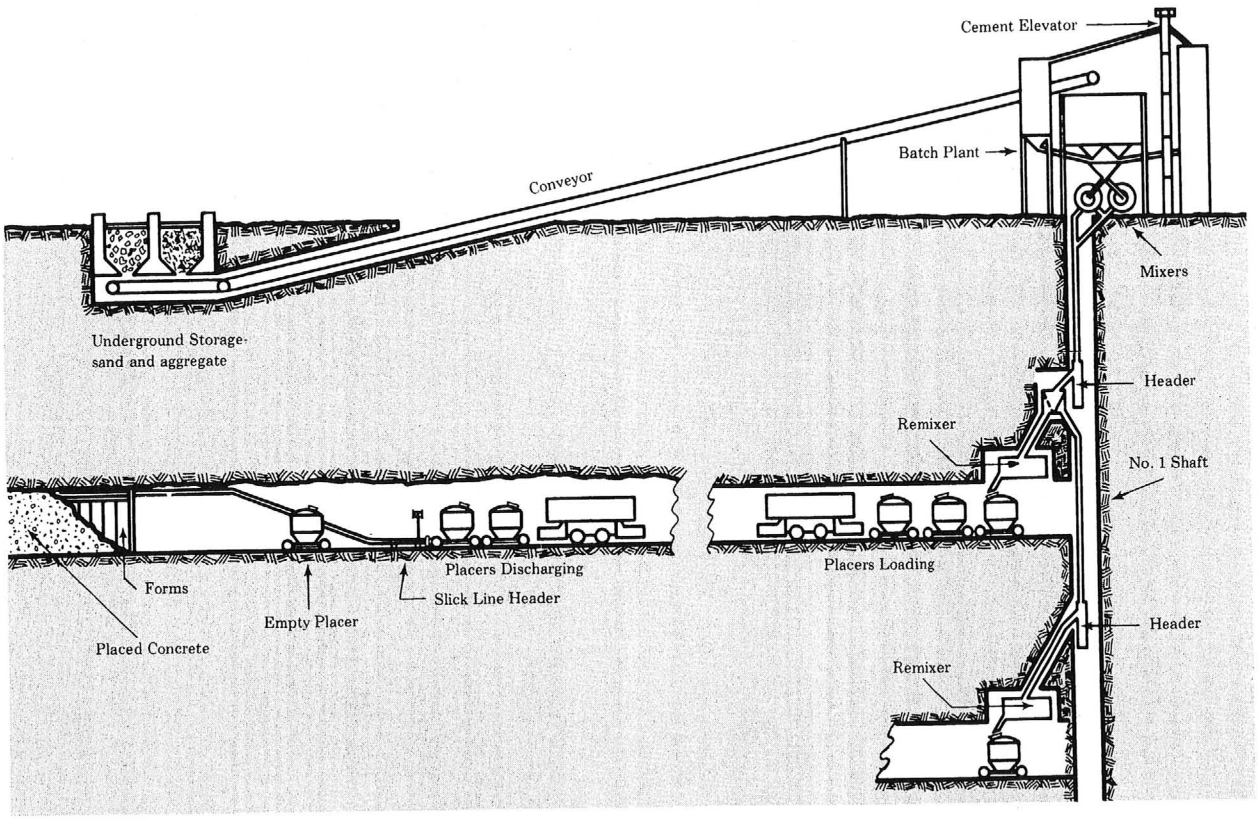
Two-Man crews, or 4 men in two headings.
44-48 holes drilled 6′ deep.
50 lbs. Aquagel per round. Initiated by electric blasting caps 0 to 12 delay.
Ventilation with fans and tubing.



Concrete Fringe Drift

45# rail and steel ties for Development and Finished Track.

Cross Section Area
Inside Concrete: 72.5 sq. ft.



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Concrete

In November, 1964, the surface mixing and underground distribution operations were automated. The operation of the batch plant, including the diversion of the concrete to the various levels, is entirely controlled by one man located in a central monitoring station on the surface. The aggregate is moved from underground storage bins to the batch plant by conveyor belt. Truck-delivered bulk air-entraining cement is transferred from the truck by pneumatic elevator into either the 500-bbl. or 800-bbl. cement silo. Mixers are 1¼ cubic yard double compartment. Mixwater is chilled to 48°-55° by a refrigeration plant in the summer. Dispersing and retarding agents are added with the mix water. Mixers discharge through a screened hopper into 8″ heavy-duty pipes suspended in No. 1 Shaft. Concrete discharges through a header into remixers on the various levels, which fill 2.5-cubic yard portable placers. The placers discharge pneumatically through a header and 6″ slick line behind plywood or steel forms.

From 6,000 to 8,000 cubic yards of concrete per month are poured on a three-shift-per-day, seven-day-per-week basis. Forming is also done on three shifts, seven days per week.

Transfer Raises

4′ x 4′ inside.

Lining: 6″ x 8″ cribbing, armored with 3″ x 4″ x 3/16″ steel angles and "T"-irons.

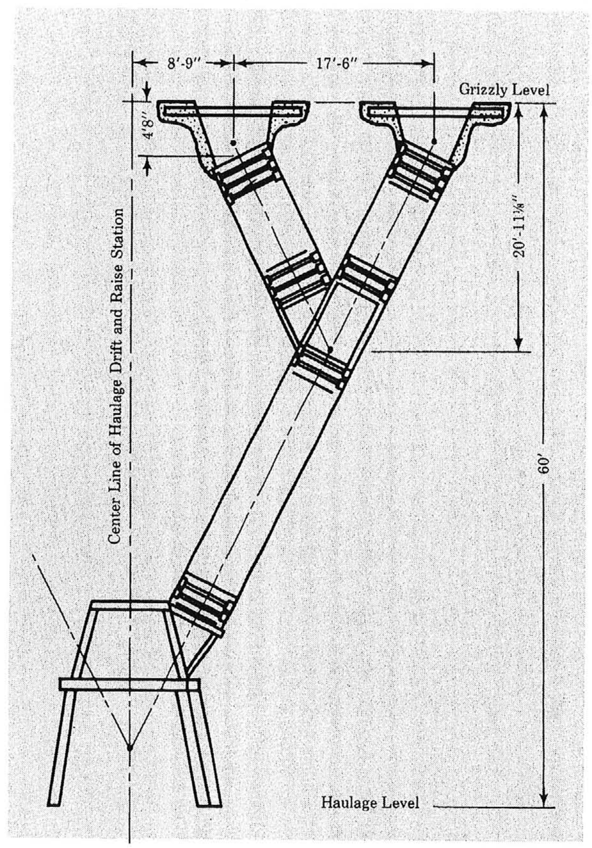
Inclination: 63°

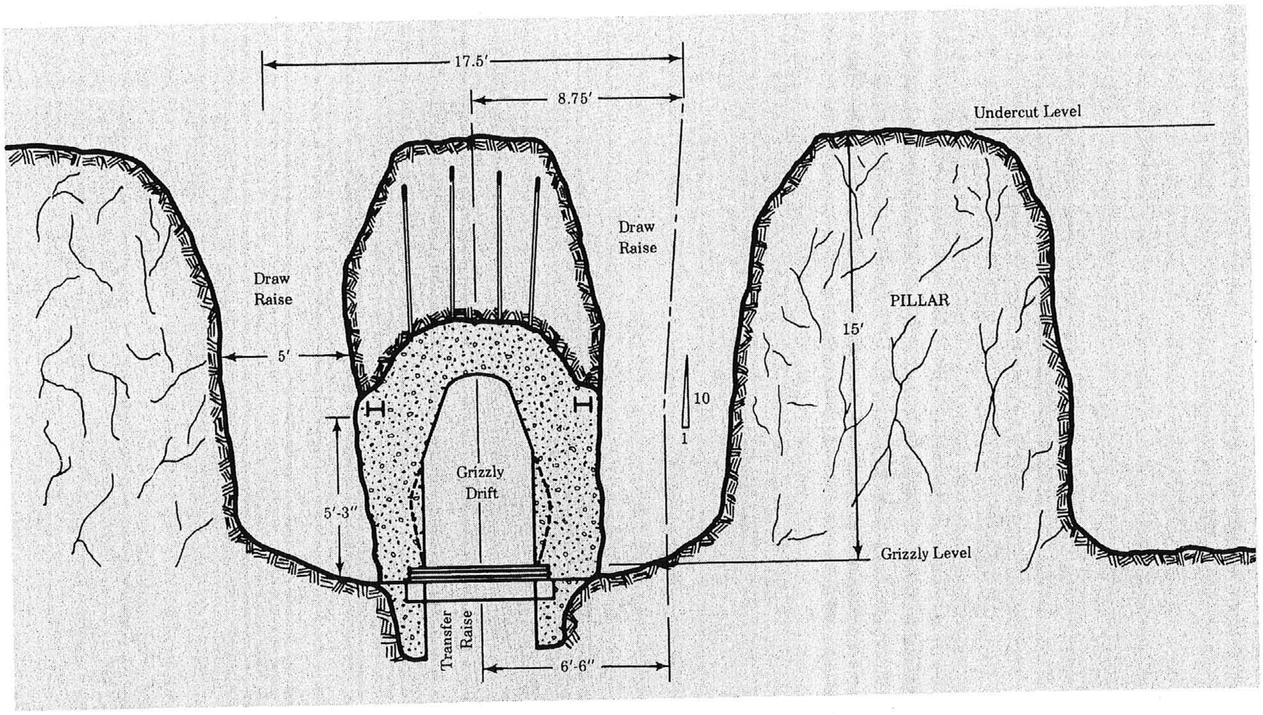
Length: 48′

Crews: 2-man crews advance two raises at once, using 3″ stopers. 14 holes drilled 5′ deep; 25 lbs. 1¼″ x 12″ sticks of Aquagel, detonated with electric caps. Ventilation with compressed air.

Transfer raise stations are cut by a special raise station crew using the same equipment listed for primary development headings.

Raise stations are steel pony sets on top of special drift sets. They are installed after the drift is concreted.





Grizzly Drifts

Excavation only; 8'-4" x 8'-0" between draw points: 9'-6" x 8'-0" at draw points.

Rock bolts and wire mesh used for pre-concrete support.

Size: 5' wide, 6¾' high finished drift with concrete reinforced at the draw points only.

2-man crews used. 13 to 21 holes drilled 6' deep. 50 lbs. 1" x 12" Amogel per round; electric primer blasted. Drilling is done with Jackleg. Ventilation with air mover.

Draw Raises

Size: 5' minimum diameter, unlined.

Length: 15'-0" above grizzly. Driven after grizzly drift is concreted.

Crews: 2-man crew drives several raises at once. 11 to 24 holes drilled 4' to 6' deep. 50 lbs. explosive; electric caps; electrically blasted.

Undercut Procedure

Undercut drifts are 5′ x 7′ timbered with 6″ round posts and 6″ x 8″ caps. These drifts are driven over the tops of all the draw raises, 15 ft. above the grizzly drift floor at right angles to the grizzly drifts. Access undercut drifts are driven parallel to the grizzly drifts over the tops of the northernmost and southernmost draw raises. Undercut pillar work usually begins before the drifts are all completed to prevent excessive drift repair and maintenance.

Undercutting can start at any position in the block, but usually is begun against an older caved block and retreats to a solid corner or corners.

Undercut pillar crews start the cave by drilling and blasting out a pillar between drifts or at a boundary of the block. The pillar crews retreat away from this initial cave, breaking the ground into the caved area. Before each pillar is blasted, the drift is widened on one side about four ft. and timbered if necessary. The remaining pillar, about 8 ft. thick, is drilled out to a height of 13 ft. above the floor of the undercut, and the pillar and widened drift are shot.

The timber is drilled with wood augers and shot with the undercut round. Generally, a 15 ft. section along the drift length is taken with each blast (from one draw raise to the next). Care is taken to insure that the pillar is completely broken by drawing off sufficient broken muck to observe the effect of the blast before the next adjoining pillar is shot. Millisecond delay electric caps are used in pillar blasting, and are wired in series—parallel, with not more than 25 primers in any one series. Circuits are tested with a galvanometer before being connected to the power source. All blasting lines go through an interrupter switch and from this switch to the main pillar blasting switch, which is a completely independent circuit.

Timber:

- Round posts and 6″ x 8″ caps with 6″ x 8″ stringers or sills over raise tops.
- 2″ x 12″ side and back lagging.
- Raise tops temporarily covered with 2″ lagging.

Crews:

- 2-man crews drill 10 to 18 jackleg holes, and 20 to 30 stoper holes per shift, depending on draw raise spacing and ground condition. Undercutting proceeds on a 3-shift, 6-day per week basis.
- In blasting 60% Amogel Explosive in 1″ x 12″ stick is used with millisecond electric blasting.

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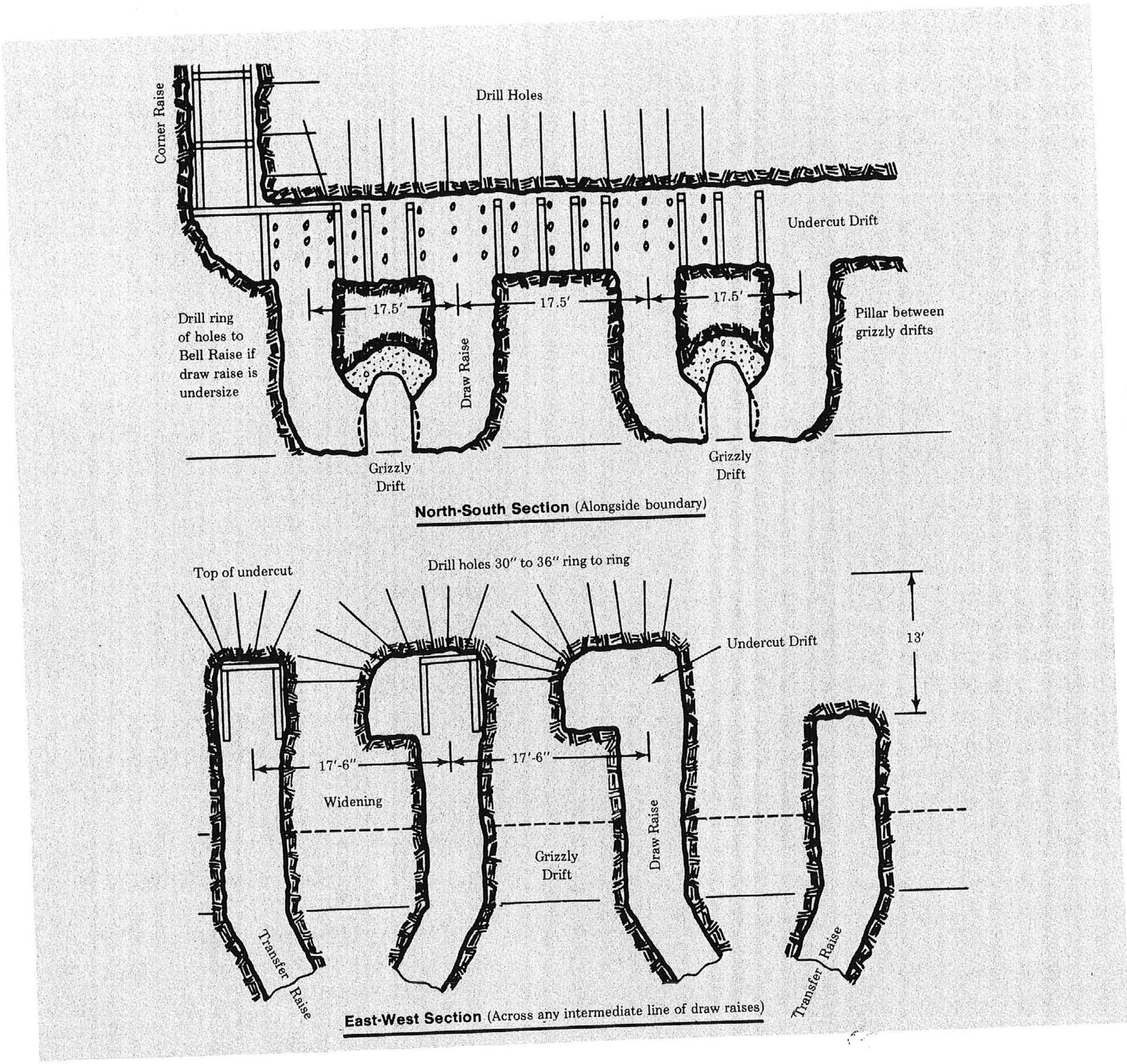
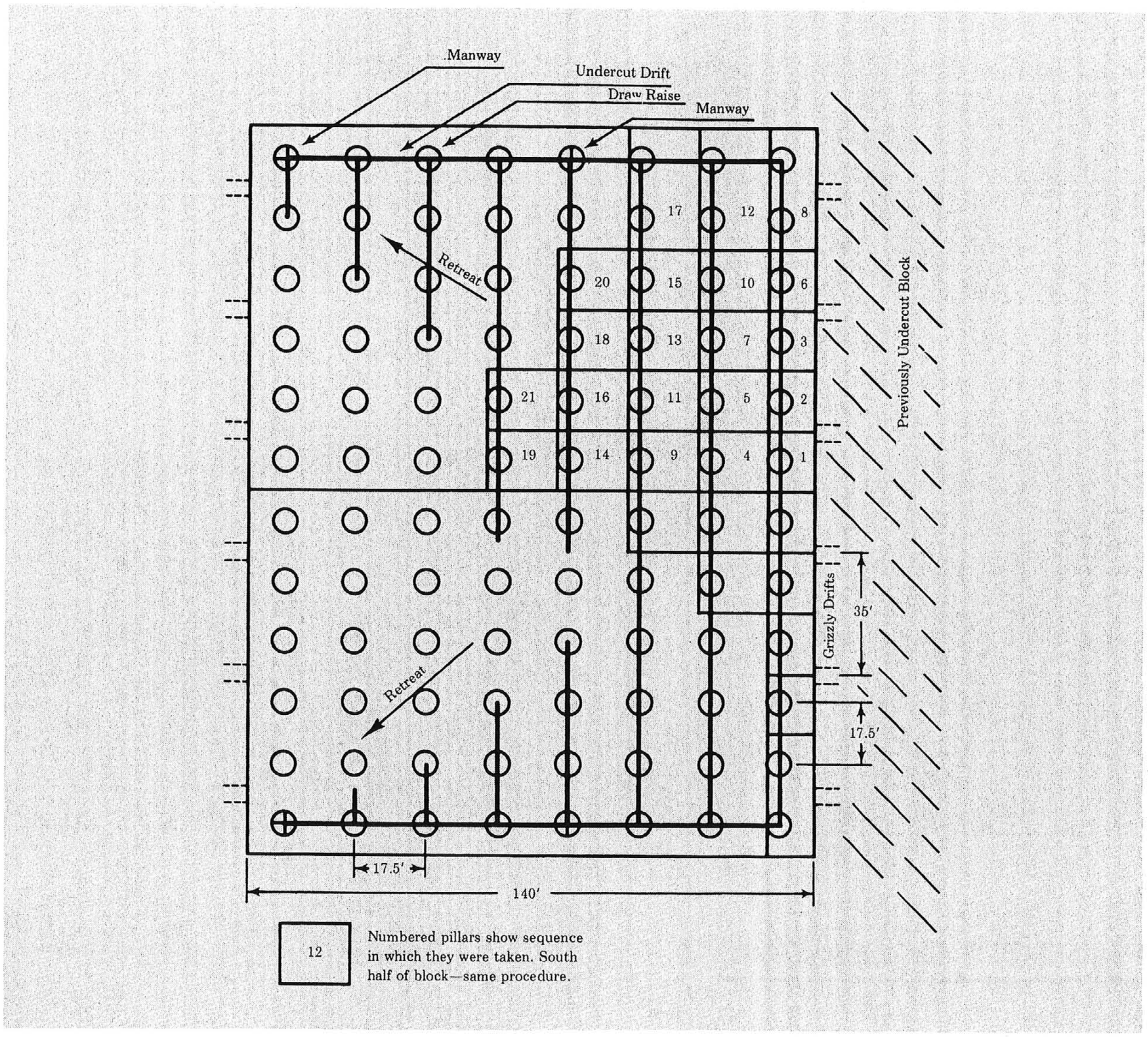


Undercut Procedure



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Progression of Undercutting

Typical Block

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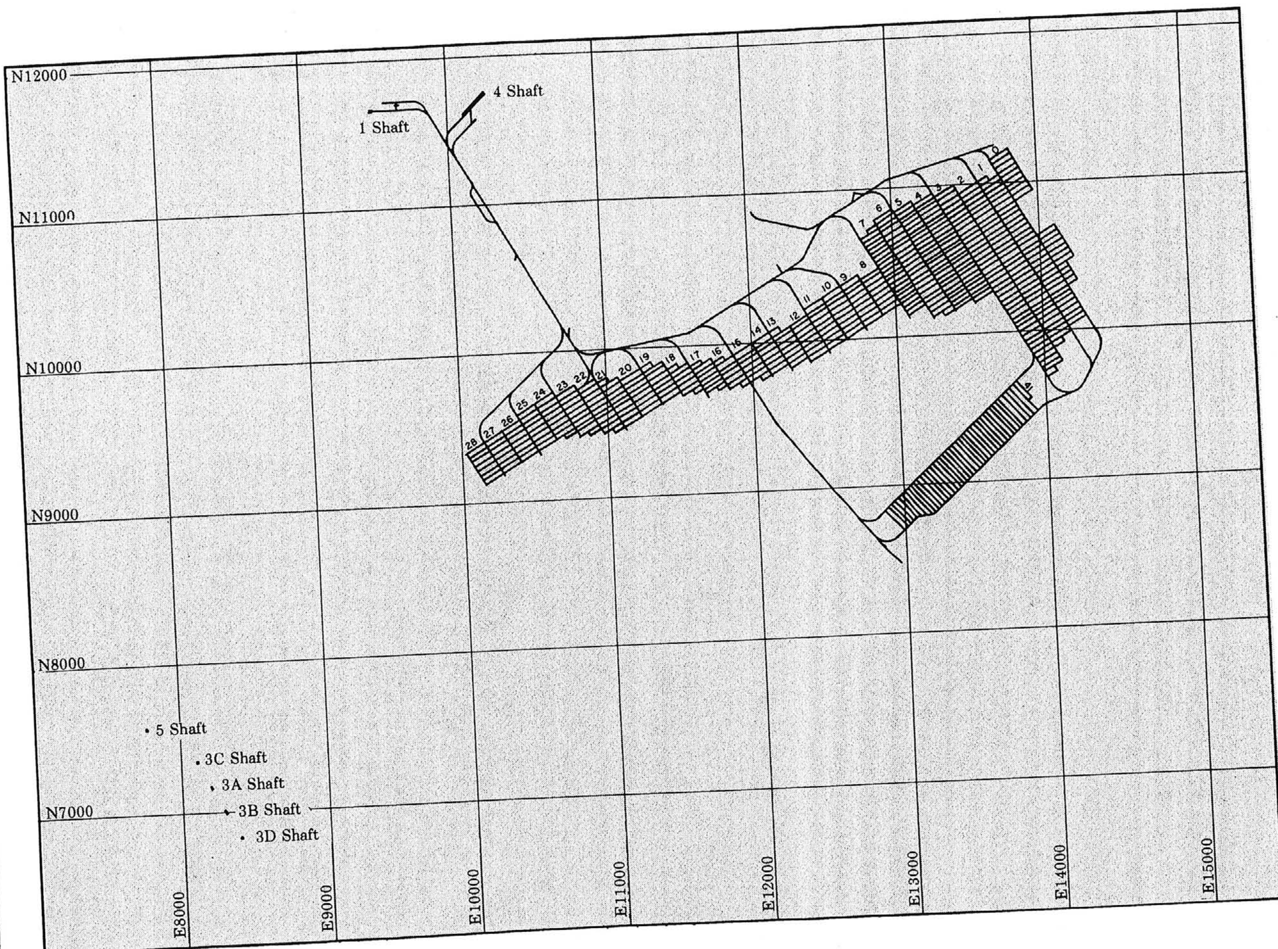
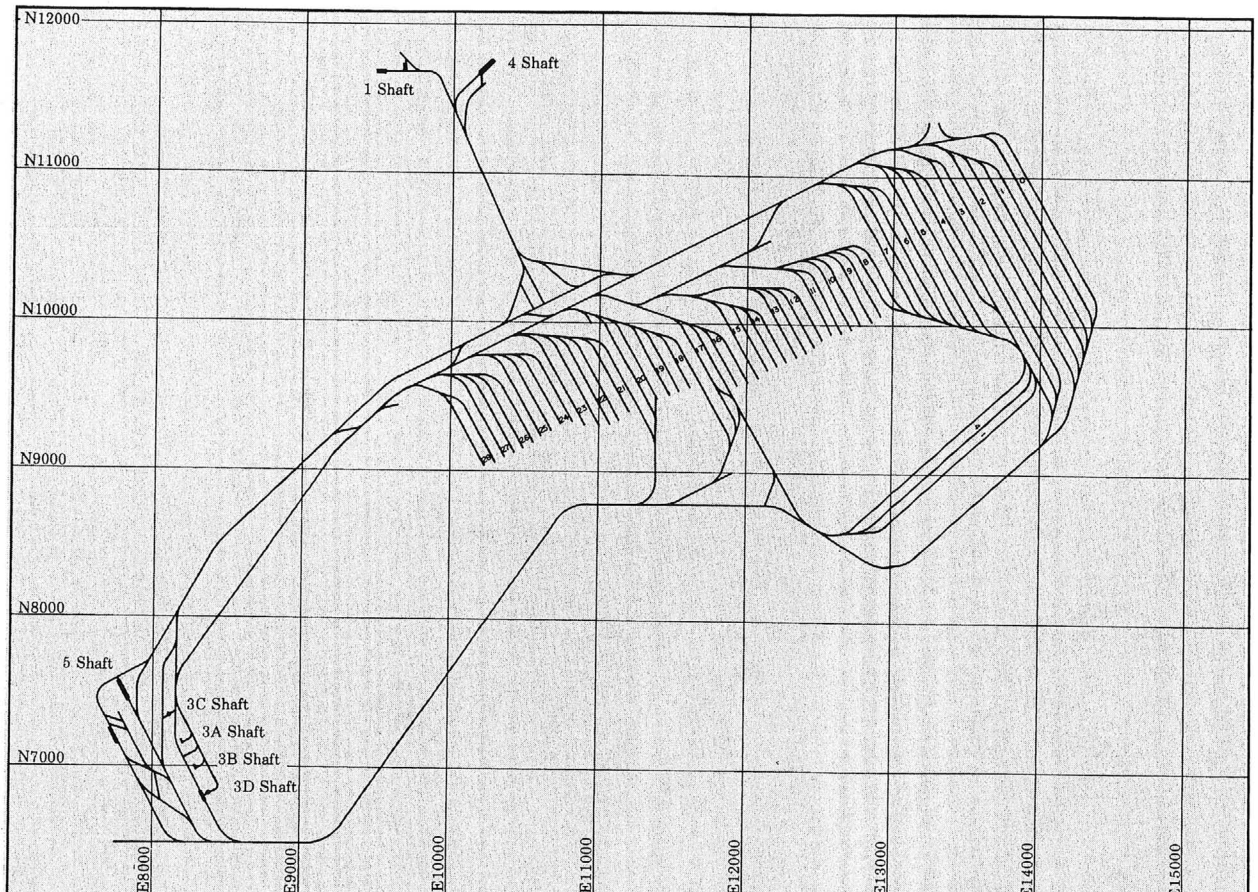


Plan-2315 Grizzly Level

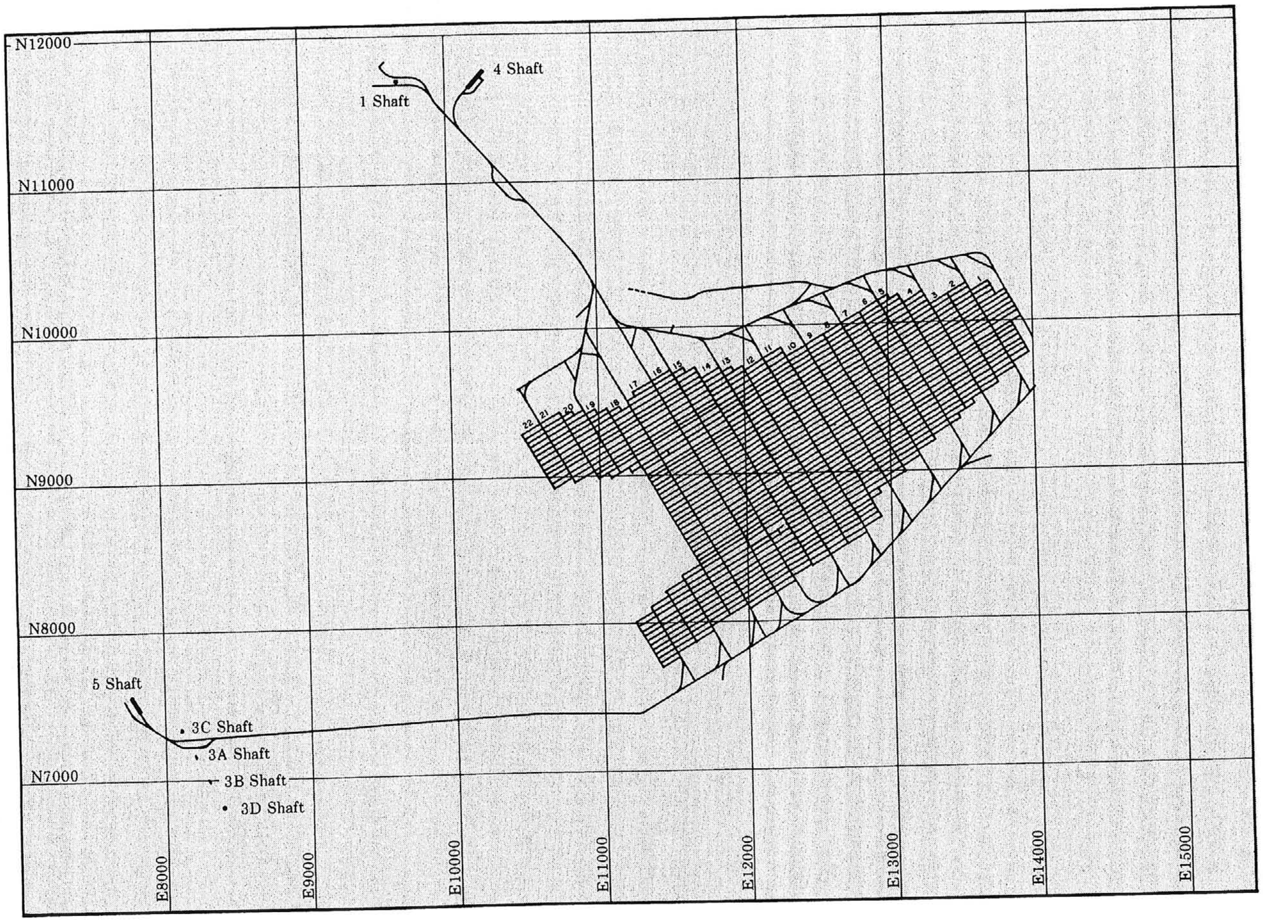
1″ = 1200′



Plan-2375 Haulage Level

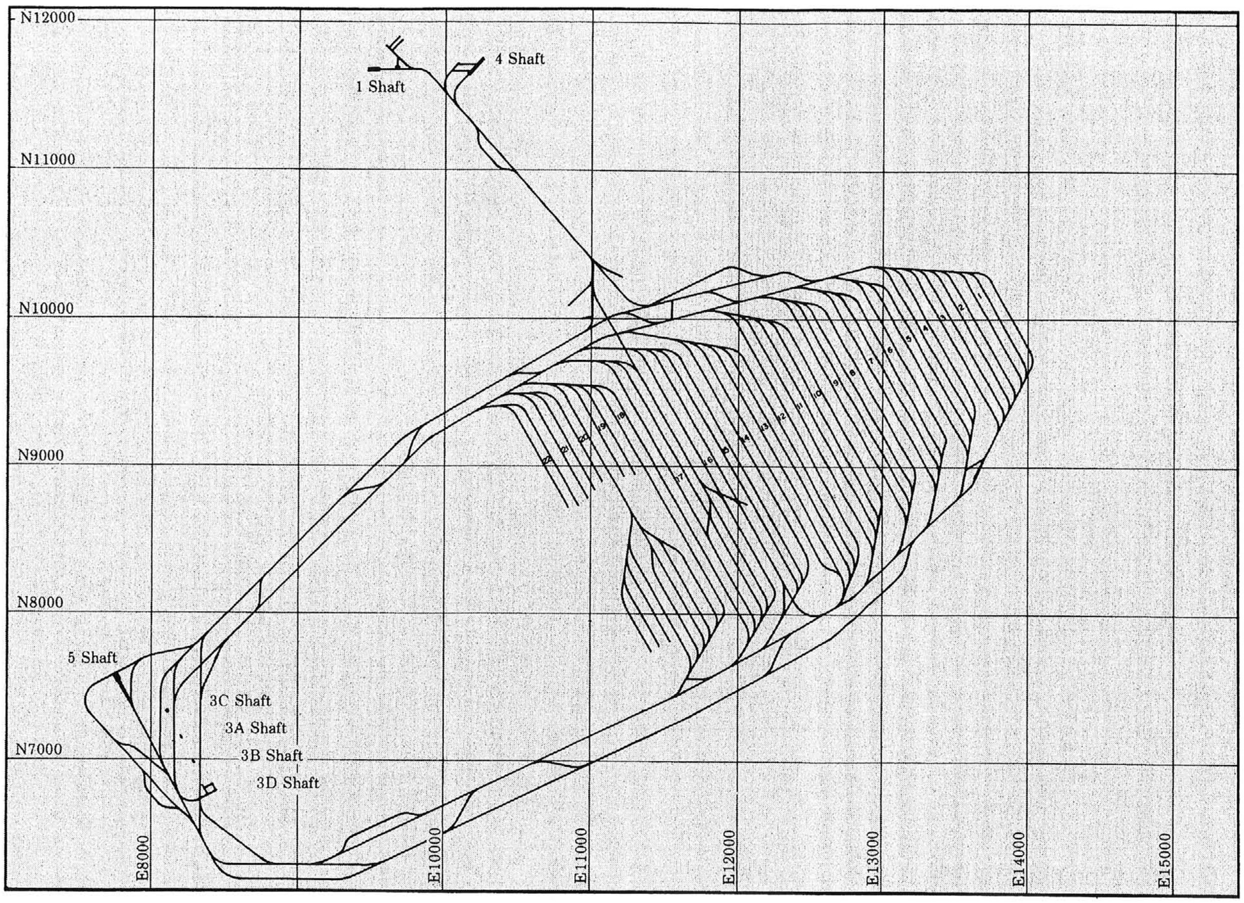
1″ = 1200′

26



Plan-2615 Grizzly Level

1″ = 1200′



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Plan-2675 Haulage Level

1″ = 1200′

28

General Mine Operating Data

Operating Shifts per Day	3
Operating Days per Week	7
Operating Days per Year (9 holidays)	356
Production per Day, Tons	64,000
Production per Year, Tons	22,784,000
Active Undercut Area, Sq. Ft.	446,000
Draw Point Spacing: 17.5′ East-West x 17.5′ North-South	
Block Dimensional Data:	
Block Width	140′ or 210′
Block Length	105′-385′
Present Average Block 140′ wide x 210′ long	
Ore Height above Undercut Floor	100′-700′
Draw Points (Average per Month):	
Active	1,775
High Pack	50
Held for Repair	150
Held for Grade	70
Total Draw Points	2,045

Mining Equipment

Big drifts utilize 2 and 3-boom remote control jumbos. The jumbos are outfitted with 8′ booms and 3′ pneumatically powered drifters with 6′ feed shells. The booms are hydraulically operated and are powered by two 1¾ gpm, 11,000 psi hydro-pumps that feed into a hydraulic manifold.

Mucking is done by an overshot rocker shovel with a steel flight conveyor dumping into 10-ton development cars. The cars are trammed to and from the work area by 8-ton, 40-hp (or 9-ton, 40-hp) storage battery locomotives.

Smaller headings use muffled feedleg drills mounted on 2′ or 4′ telescopic air legs. Vertical and inclined raise excavations utilize stoper drills. Mucking in smaller headings is done by a rubber tired 1-yd. hopper type pneumatically powered mucker.

Explosives Used

Primary Blasting (Development)

Carbamite P: For dry headings, blown in hole. One stick of powder in hole bottom or booster on electric blasting cap ensures detonation, 0-12 delay.

Aquagel: 1¼" x 12" with primer initiated by electric blasting caps 0-12 delay. Used in dry headings.

Amogel: For hard ground, wet headings. Stick form, initiated by e.b.c. 0-12 delay.

Detagel: Stick form, used in transfer raises. Less gas produced. Initiated by e.b.c.

Blasting in large headings is unscheduled. All other development blasting is done at the middle and end of each shift.

Secondary Blasting (Production)

On the draw level ½-lb. bags of Kinepac or Nipack are initiated with zero delay blasting caps. These are connected by a trunk line to a central underground location where blasting switches are located. Blasting is done at the middle and end of each shift.

Transfer raise hangups are blasted with stick powder during the shift. Detonating cord, laced through the powder, is placed up the raise and initiated with a safety fuse.

Rotary Car Dumps

In the dumping cycle the motorman pulls through the dump and spots three cars in the dumper without uncoupling. Car stops raise and lock the train in position. The motorman activates the dumper which rotates 180° and returns to the upright position. Three cars are dumped in about one minute, or five minutes per train of 15 cars. Development cars are designed to fit the dumper, but because of their length and type of coupling, they must be uncoupled to dump. Traffic can flow in both directions through a rotary dump, but dumping is done in one direction only.

ASEA Car Dumps

ASEA cars dump while in motion over the ore pocket. The locomotive and cars are designed to ride along the rollers of the unloading station while the opening of the car bottoms is controlled by a stationary guide bar. ASEA trains can be dumped in either direction in the time it takes to ride through the dump (approximately one minute).

General Mine Operating Data continued

Development Car Dumps

Two types of development car dumps are presently in use at the mine: (1) Welkom cars dump automatically while in motion by means of an inverted camel-back which tips the cars, allowing rock to be discharged; (2) bottom dump cars are parked over the dump and emptied by a tripper mechanism which opens the doors.

Underground Haulage Data

Haulage locomotives are 23-ton, 4-wheel trolley type, powered by two 125-hp, 275-volt DC motors. ASEA locos haul ten 15-17 ton working load cars while rotary dump locos haul fifteen 12-13 ton working load cars.

Rotary ore cars are 300 cu. ft., 15-ton box-type with one stationary and one rotating coupling.

ASEA cars are 350 cu. ft. 18-ton box-type. A fifth wheel on the car rides along the guide bar during dumping. Lips of adjacent cars are designed to overlap. This helps prevent spillage during loading.

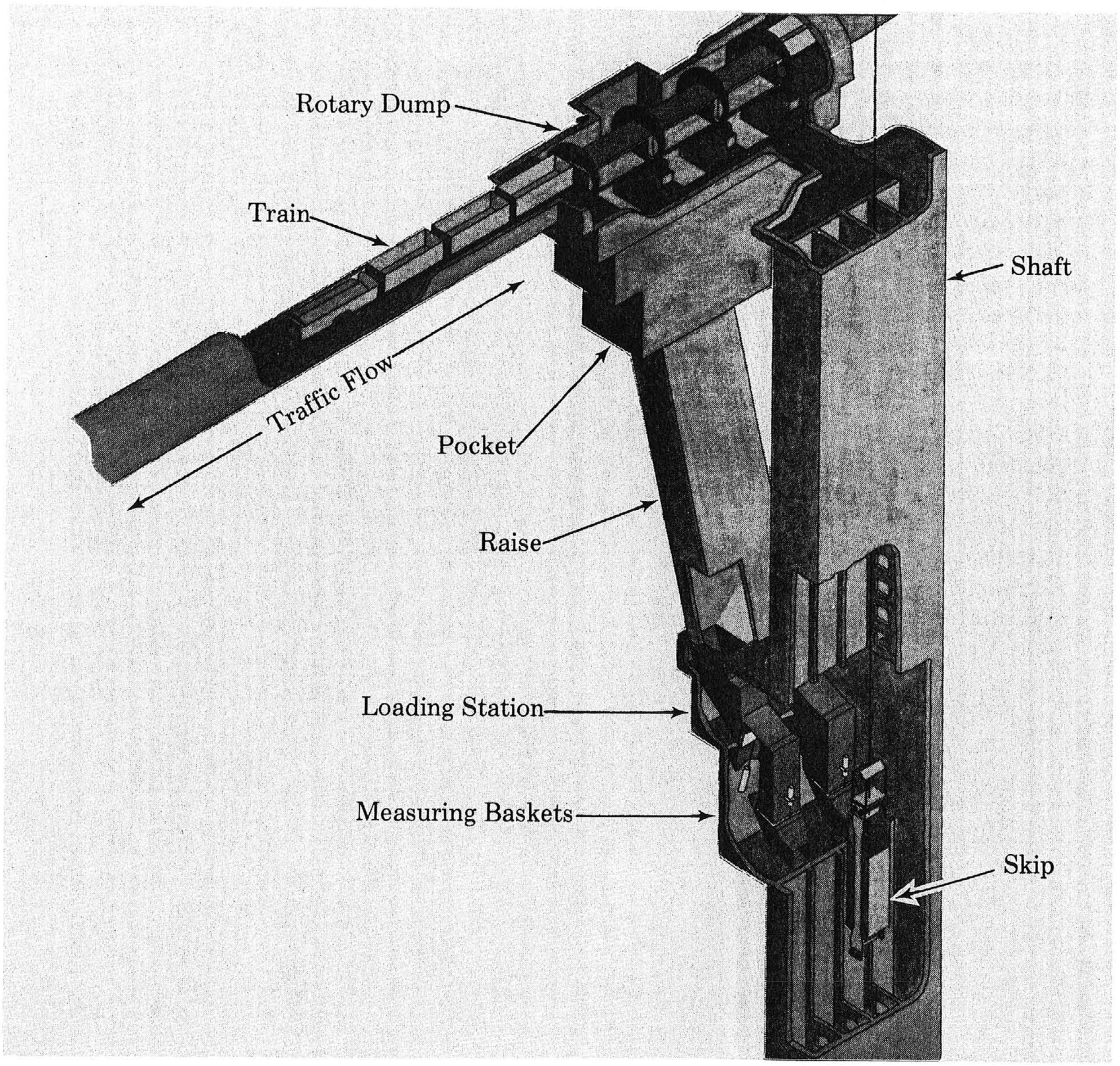
Length center to center of coupling:
- Rotary—17′-6″
- ASEA—17′-9″

Width, overall:
- Rotary—6′0″
- ASEA—6′7″

Height above track:
- Rotary—5′6″
- ASEA—6′2″

Couplers:
- Rotary—rotary and non-rotary coupler equipped with rubber cushioned draft gear.
- ASEA—couplers are self-centering spherical horn type, rubber cushioned.

Track gauge: 36″



Rotary Dump
Train
Shaft
Traffic Flow
Pocket
Raise
Loading Station
Measuring Baskets
Skip

Car Dumps

Monitoring System

Because of the extent of the underground operation, vital remote equipment which cannot be effectively tended are monitored from one central location. This will allow developing problems to be detected quickly so that corrective action can be taken.

The system displays the continuing status of all major switchgear, rectifiers, pumps and ventilation fans. Underground air flows and gas level monitoring provides information for fire prevention. Data on compressed air pressures and water flows helps in regulation and efficient use of these systems.

The monitoring system is computerized. Equipment status is displayed by indicating lights on a 288 ft.^{2} graphic panel.

Ventilation and Cooling

In general, air is brought in on grizzly levels, drawn down transfer raises and exhausted from haulage levels.

Intakes:	#1 Shaft	165,000 cfm
	#4 Shaft	425,000 cfm
	#5 Shaft	625,000 cfm
	Compressed Air	40,000 cfm
Exhausts:	#3A Shaft	265,000 cfm
	#3B Shaft	110,000 cfm
	#3C Shaft	470,000 cfm
	#3D Shaft	410,000 cfm
Level Intakes:	2015-2075	410,000 cfm
	2315-2375	350,000 cfm
	2615-2675	260,000 cfm
	Sublevels and Compressed Air	135,000 cfm

Main Fans: 2015-450 hp, Vent Crosscut supplying 2315; 1-450 hp at 5 Shaft; 2-60 hp, Main Crosscut (MXC)
2315-200 hp, MXC
2615-200 hp, MXC
2675-450 hp, MXC supplying 2615.200-hp fans are 60″, 1,160 rpm. 450 hp fans are 72″, 1,160 rpm.

Auxiliary Ventilation

Block ventilation is handled by 20-hp, large-volume, low-pressure, low-speed fans. Individual working places and development headings are supplied with 10 hp and 20 hp high-pressure, high-speed fans. Individual ventilation is provided by venturi type air movers. 60 hp fans are used to supplement the main fans in problem areas.

Cooling for specific development headings is provided by 50-ton spot coolers. The production areas on the 2615 level are cooled by a refrigeration system in which chilled water is circulated to a coil drift. There, air is pushed through coils and cooled before being sent into the working areas.

Drainage

Newly opened areas show an appreciable flow of water which is carried out of the working area by air-operated sump pumps, with a capacity of 150 gpm at 100′ head. Mine underground was planned so that water drains either to No. 1 Shaft or to 3A and 3B Shafts.

Mine Water = 7,000 gpm, principally from the shaft bottoms and the third lift.

Mine water is pumped approximately eight miles to the Plant site for use as Mill water.

Potable water is pumped from San Pedro wells to the Mine for domestic use.

Mine Power

Power is supplied to the Mine No. 3 Hoist Area Substation at 115 Kv from the Plant Substation over a feeder approximately 6.5 miles long. The Mine feeder conductors are 795 MCM ACSR with a current carrying capacity of 900 amps.

The No. 3 Hoist Area Substation Main Transformer is rated at 50/66.5 MVA, 115/46 Kv, 3-phase. This transformer supplies the 46 Kv bus at the Substation and the feeder to the No. 1 and No. 4 Shaft Area located approximately one mile away. The 46 Kv bus at the No. 3 Hoist Area Substation supplies several banks of single phase 46/2.4 Kv., 2,500 Kva and 7,500 Kva transformers for all surface and underground power requirements in this area.

The 46 Kv feeder to the No. 1 and 4 Shaft Area feeds three secondary substations supplying all surface and underground requirements. These include No. 1 and No. 4 hoists, compressor building and all service requirements.

Compressed Air

Delivering 110 lbs. air pressure for approximately 100 psi mine working pressure.

No. 4 Compressor House:

- Five 3,500 cfm compressors, delivering at 100 lbs. air pressure, each equipped with 600-hp synchronous motor.
- One 1,936 cfm—350-hp synchronous motor.
- One 1,596 cfm—300-hp synchronous motor.
- Total—21,032 cfm, delivering at 110 lbs. air pressure for approximately 100 lbs. mine working pressure.

Three natural gas powered compressors each having a 3,200 cfm capacity. "Outdoor" type.

No. 3 Shaft Hoist House:

- Three 7,000-cfm centrifugal compressors, each equipped with 1,500-hp motor, delivering at 110 lbs. air pressure.

Chiller/Compressor Building:

- Two 3,500 cfm centrifugal compressors, each equipped with a 700-hp motor, delivering at 110 lbs. air pressure.

Total compressed air—58,632 cfm.

Communications

A dispatcher, located on the surface, coordinates draw and haulage operations by means of an audio paging system.

Radio phones, on a different circuit from the audios, allow communication between haulage level ore and supply trains and the dispatcher. Trains move only on direct order of the dispatcher.

Each shaft has its own paging system for coordination of shaft operations.

A dial telephone system aids in communication between hoisting, maintenance and service facilities between the surface and the mine underground.

Surface Ore Transportation

Cars: 100 tons capacity, 35 to 40 per train.

Locomotive: 125-ton, 1,600-hp, diesel-electric.

Trackage: 132-lb. rail, 7-mile haul to receiving bin at reduction plant, level track.

No. 1 and No. 4 Yards

Surface installations in this area include a machine shop (including car repairs), electric shop, drill repair shop, a blacksmith shop, truck maintenance shop, framing shed, carpenter shop, warehouse facilities, timber-treating plant, salvage area, pipe shop, cylinder repair shed, sand-blasting shed, paint shed, fire marshal shed, mine rescue training center, fuse and cap storage tunnel, batch plant (including mix water cooling plant and additive storage tanks), compressor house, No. 1 and No. 4 hoisthouses, potable water treating plant, and changerooms.

There are storage areas for all material used in the mining operation.

Steel: Variety of structural shapes for shop fabrication jobs and mine ground support.

Timber: 12″ x 12″ drift timber.
2″ and 3″ lagging, various lengths.
6″ and 8″ cribbing, pre-framed.
Pole posts—Texas pine for undercut timber.

A large explosives magazine is maintained to supply the mining operation.

A planned maintenance and lubrication schedule is followed for all surface and underground operating equipment.

Change Room No. 4

Accommodates 1,900 employees with lockers, showers, and toilet facilities. Heated with gas space heaters.

In the same building are the foreman's office, time office, mine survey office, industrial hygiene office, dispensary, lamp room, and incentive bonus office.

Change Room No. 3

Accommodates 1,000 employees and has office facilities similar to #4 change room. This change room is located in the #3 Shaft Area near #5 Shaft.

Training Center

The Minesite Training Department conducts classes in safety and first aid for all Mine Division surface and underground employees. Training is required for newly hired employees and those changing job assignments. Employees also spend one day per year in annual refresher training.

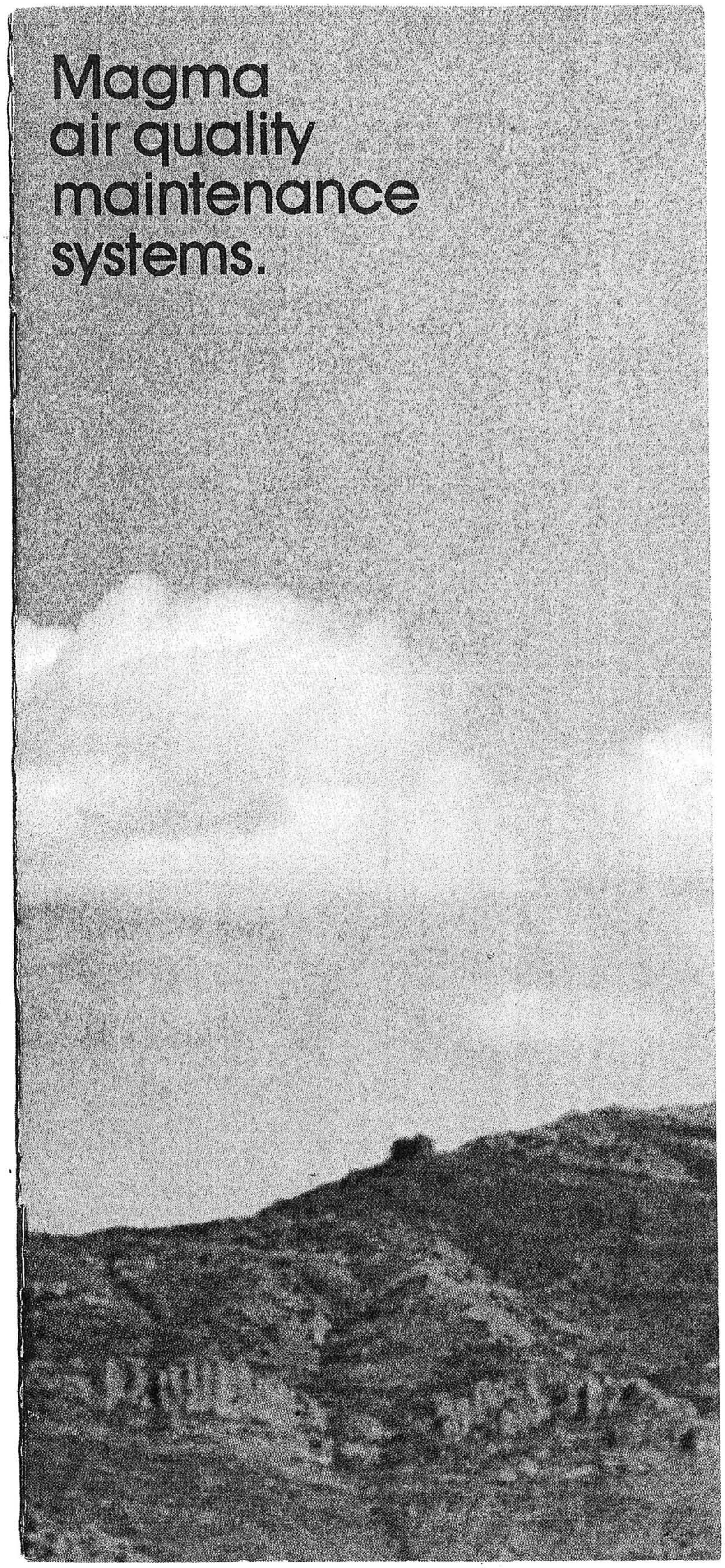
The department conducts an electrical helpers' training program and the miner trainee school. New hire and refresher training is also provided for other mine and plant employees.

Miscellaneous

1979—12 months of operation:	
Average Daily Mine Production, Dry Tons	61,005
Tons of Ore Mined	21,828,705
Copper Contained in Concentrates Produced, Tons	120,862
1980—8 months of operation:	
Average Daily Mine Production, Dry Tons	62,177
Tons of Ore Mined	13,803,276
Copper Contained in Concentrates Produced, Tons	79,231
Number of Mine Employees, 12/31/80	2,476

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

Magma air quality maintenance systems.



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.

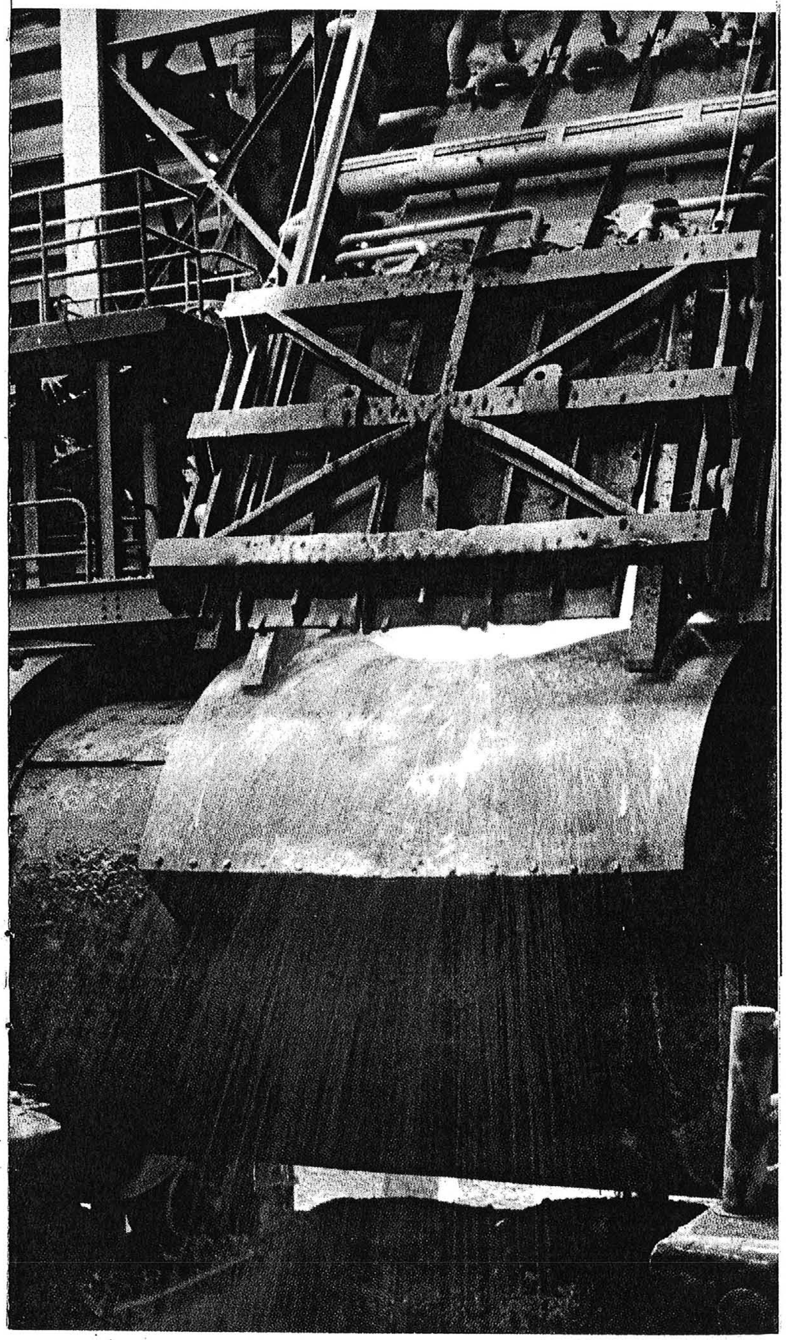
- Cooperated fully with and contributed information and experience to State and Federal agencies in the promulgation and administration of air quality standards.

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.

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

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



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.

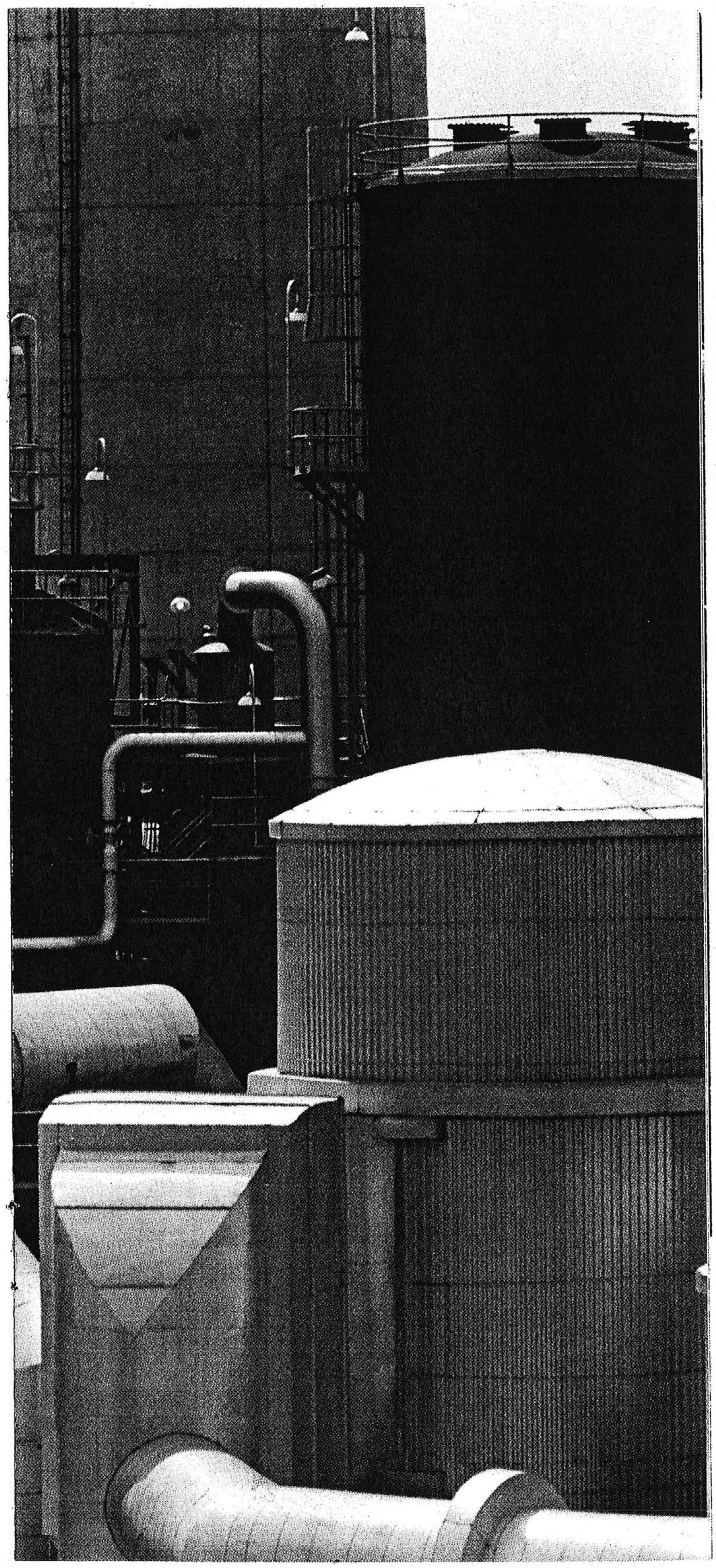
Sulfur is released by oxidization in both the reverberatory furnaces and converters. The major oxidization, which produces sulfur dioxide, occurs in the converting process, while only weak gases are released from the reverberatory furnaces.

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.

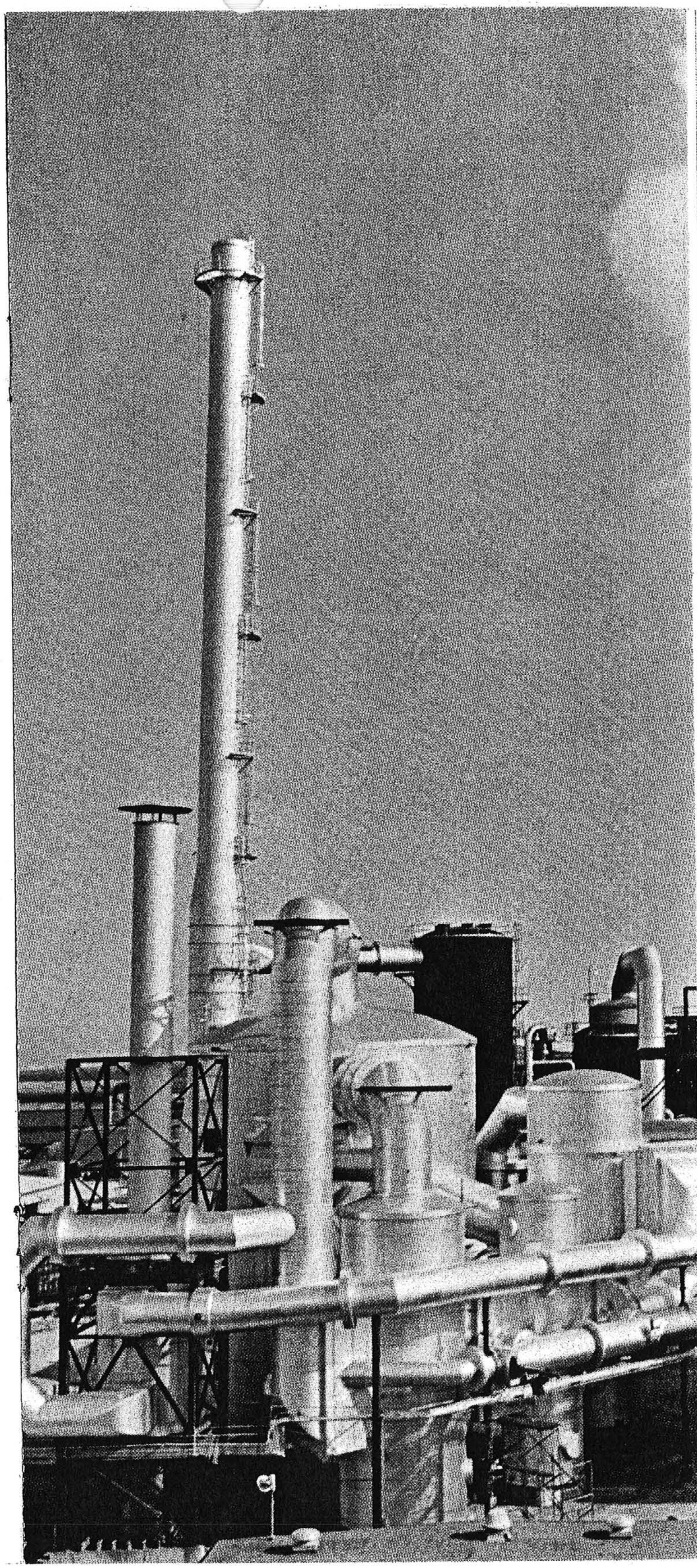
The contact sulfuric acid process.

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.

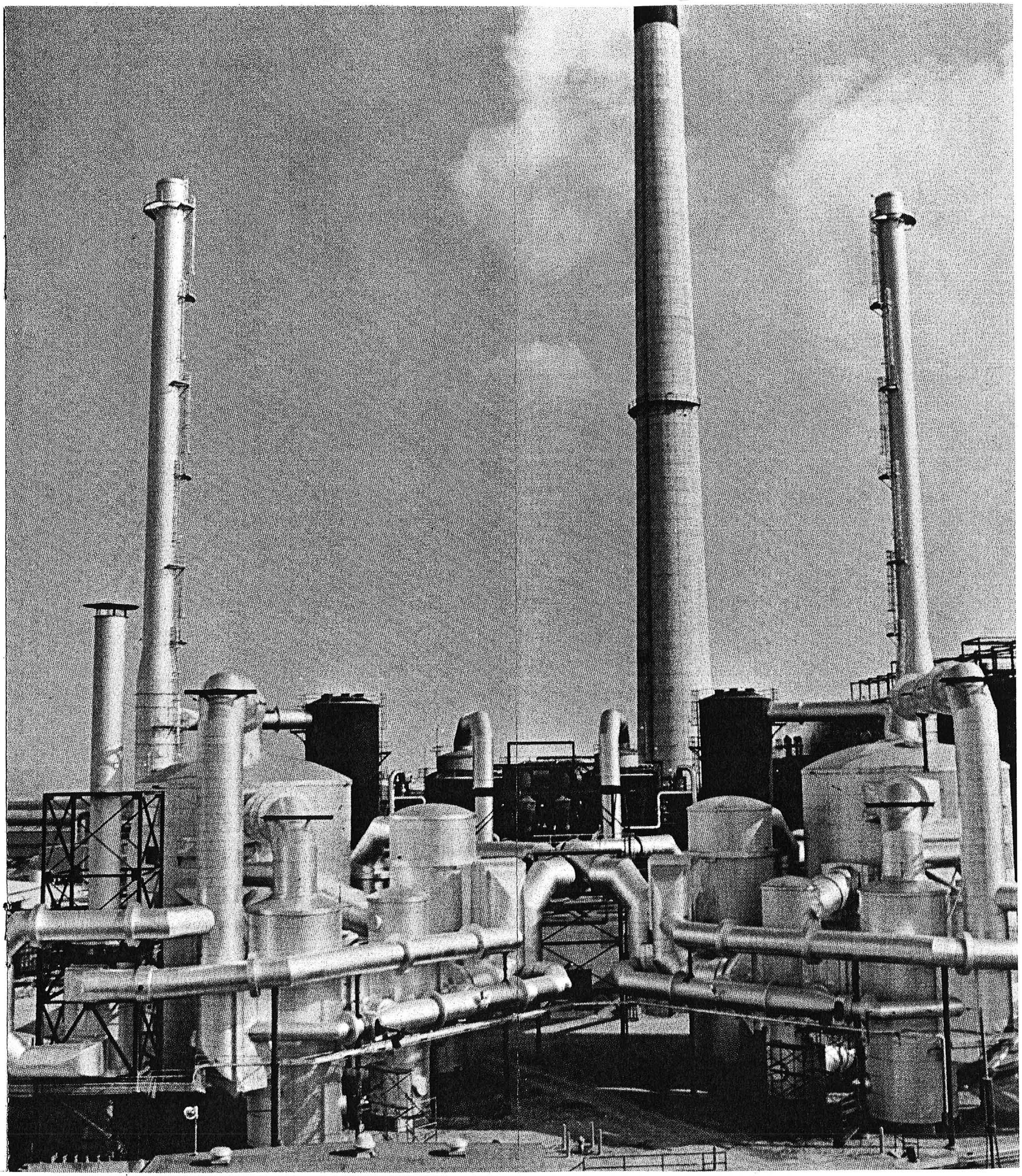
Upon leaving the high velocity flues, the sulfur laden gases, principally sulfur dioxide, are pulled through a large electrostatic precipitator to remove dust and particulate matter, then through cooling and humidifying towers, and finally through a bank of eight electrostatic mist precipitators to remove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

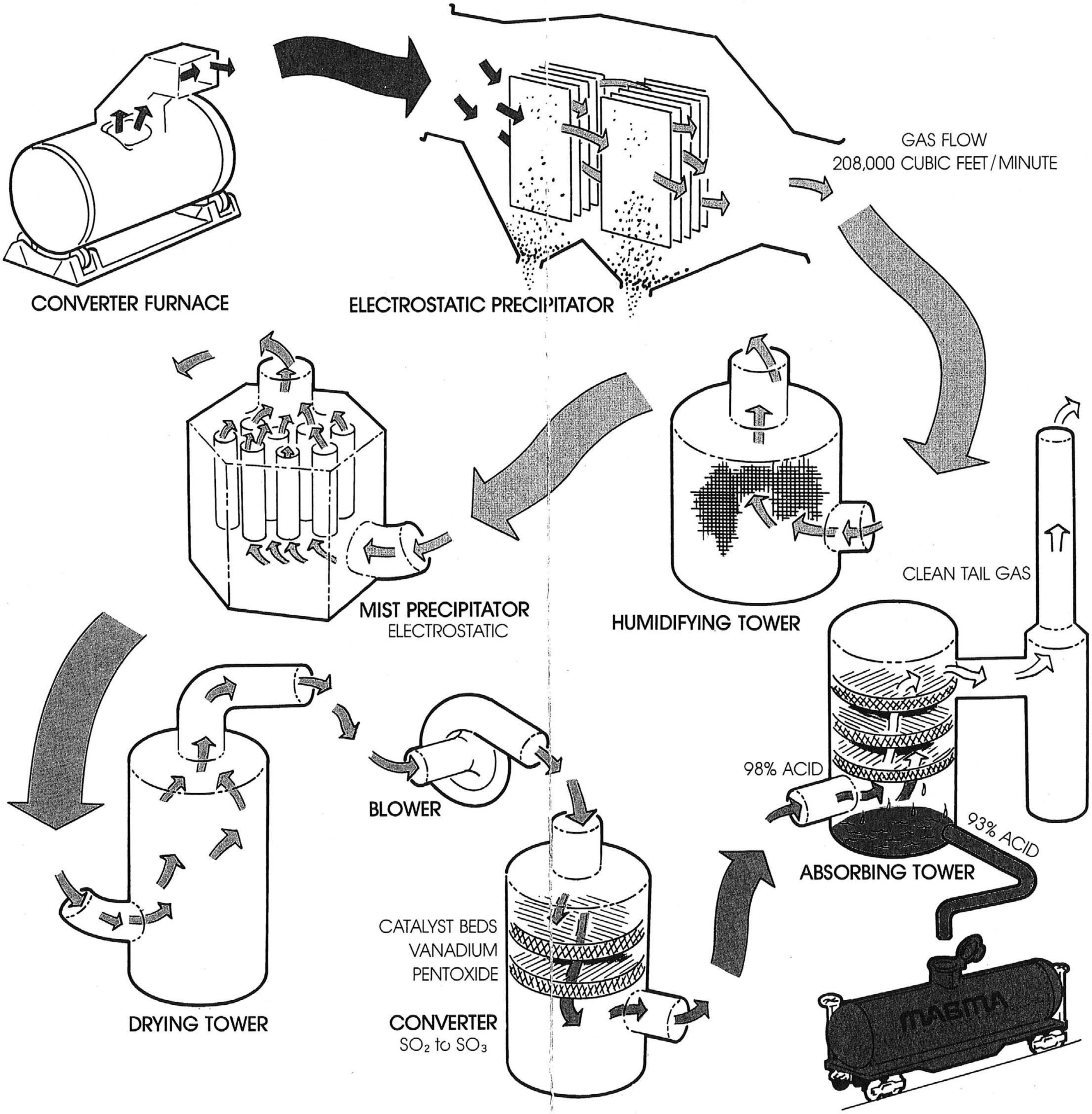


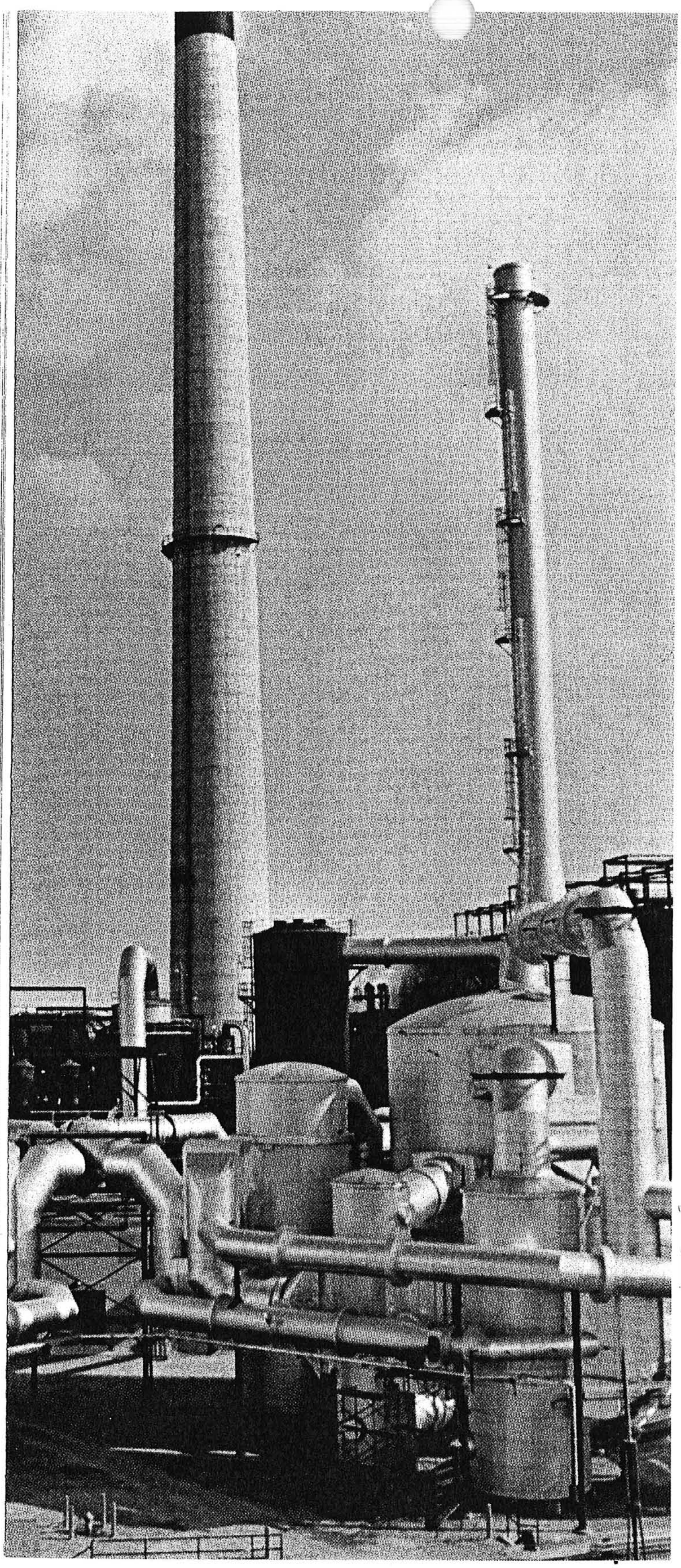
Magma Copper Company's San Manuel, Arizona, Sulfuric Acid Plant.



San Manuel Sulfuric Acid Plant

Sulfur dioxide conversion process.





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.

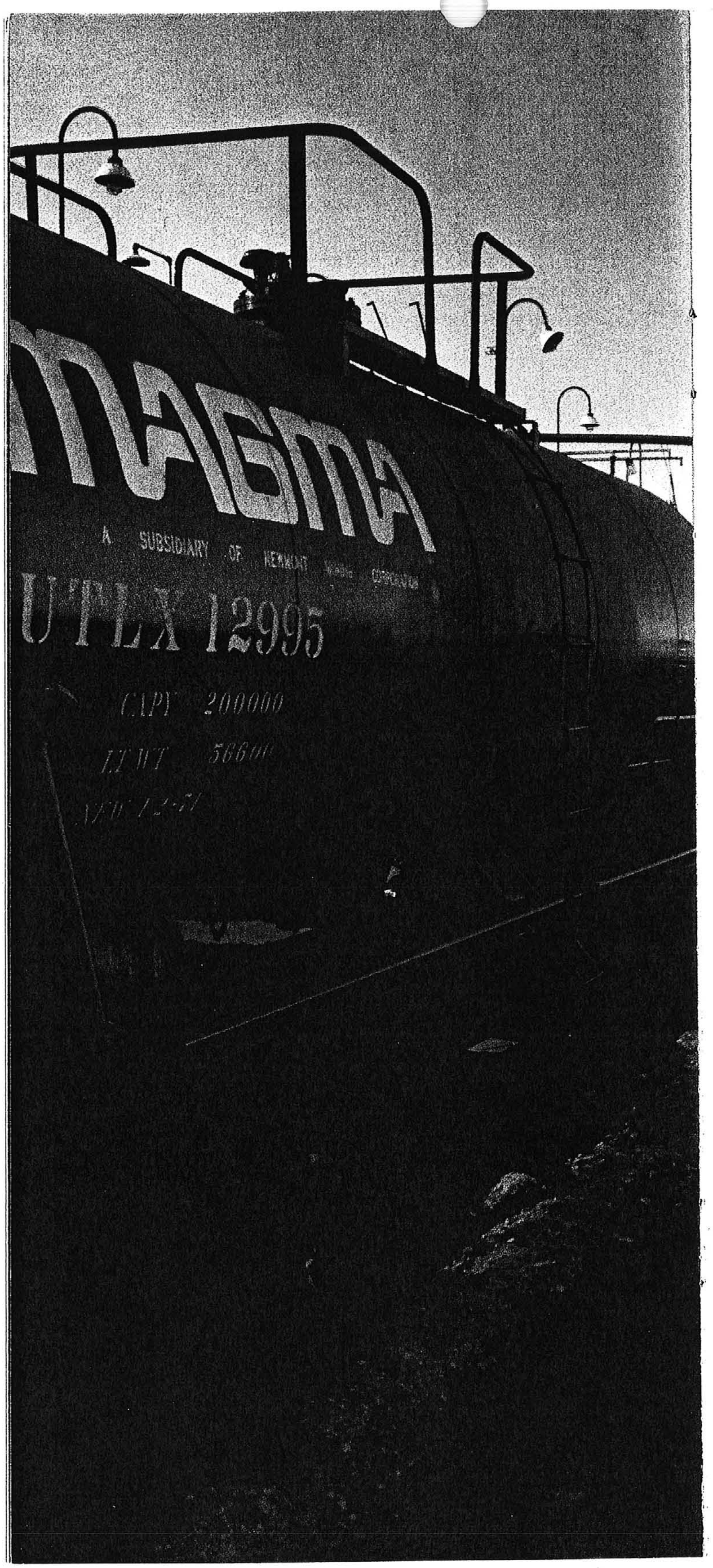
The San Manuel plant has a designed production capacity of up to 2,000 tons per day of sulfuric acid.

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.



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.

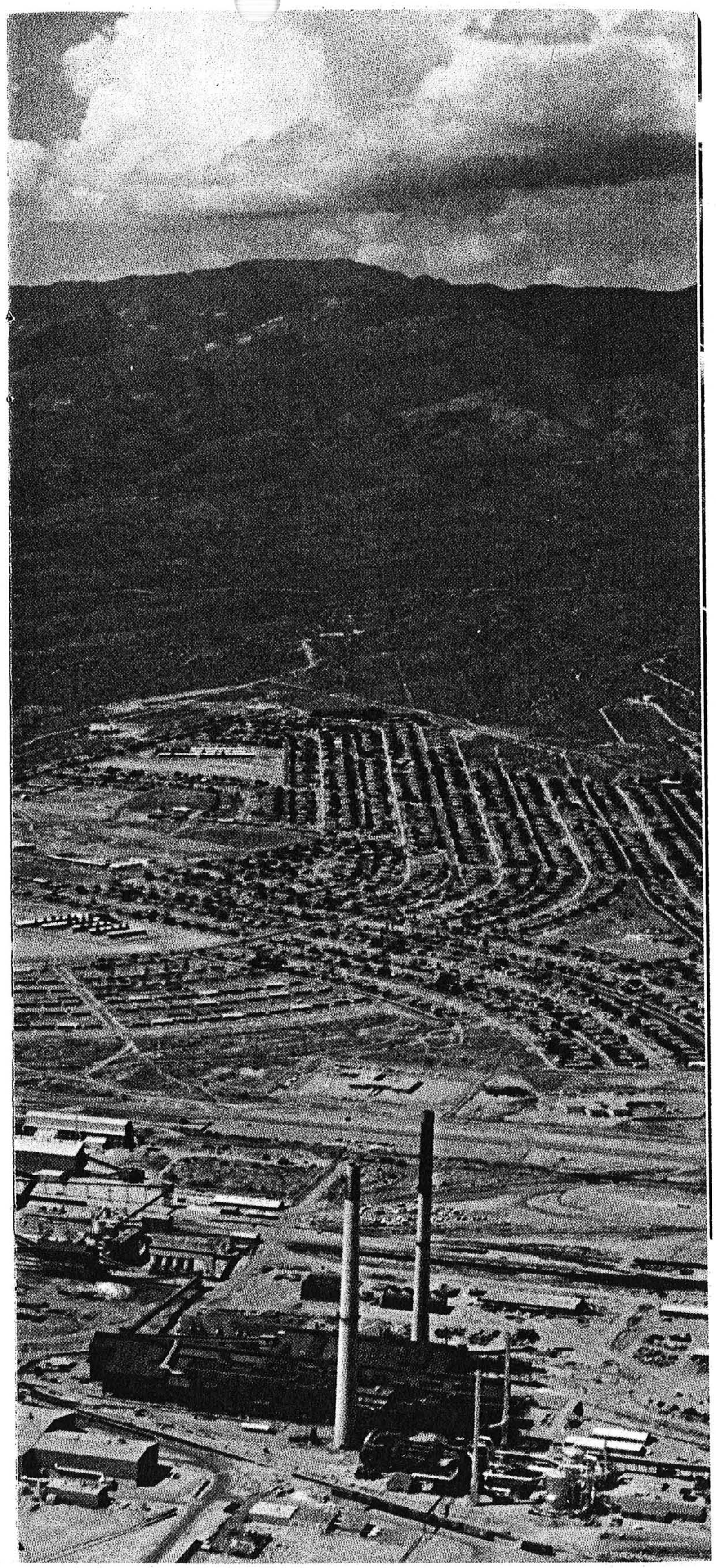
To avoid possible land and water contamination, Magma's acid neutralization system has the capacity to process the full production of the San Manuel acid plant, if necessary.

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.

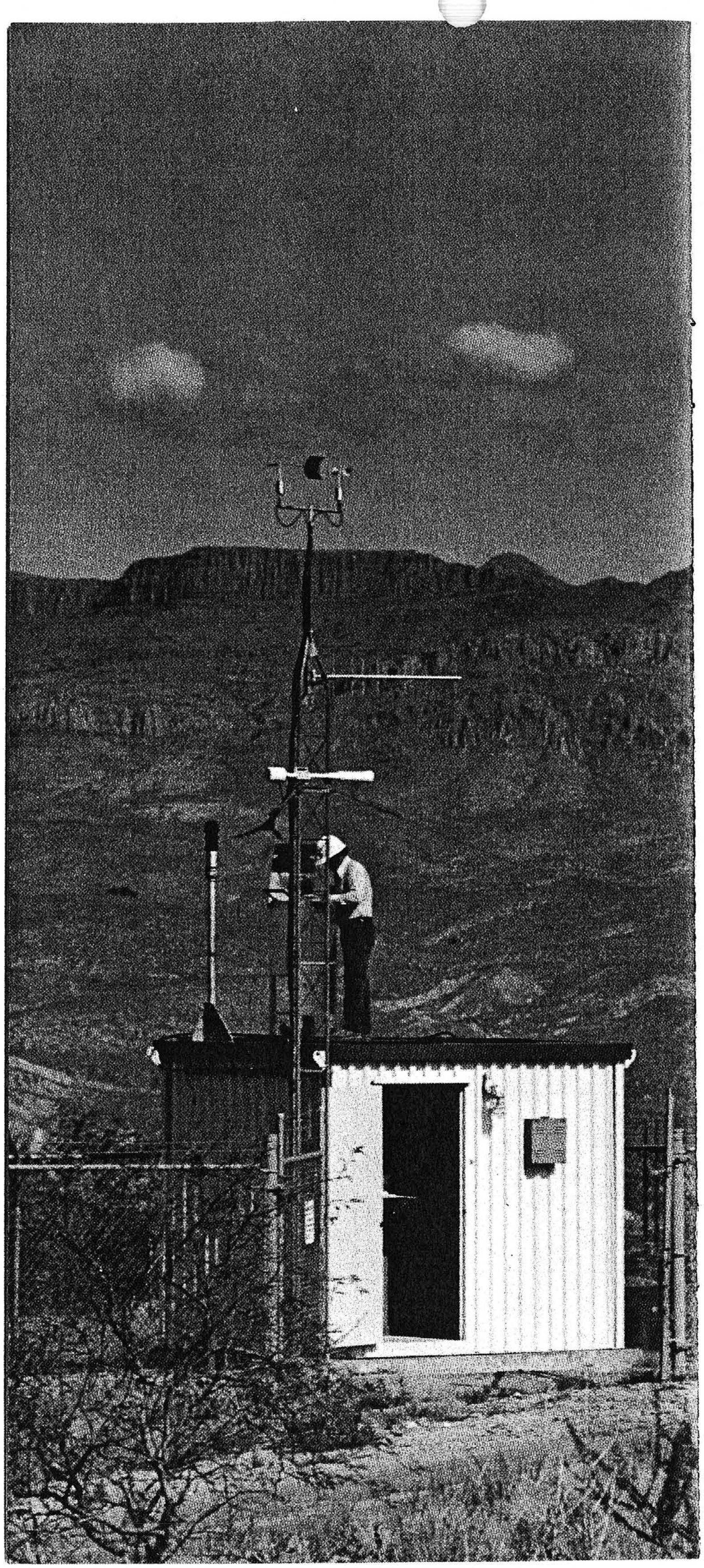
To obtain this limestone, a quarry was located seven miles south of San Manuel and several small limestone hills must be excavated. A road was built for haulage and additional water wells were developed.

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.

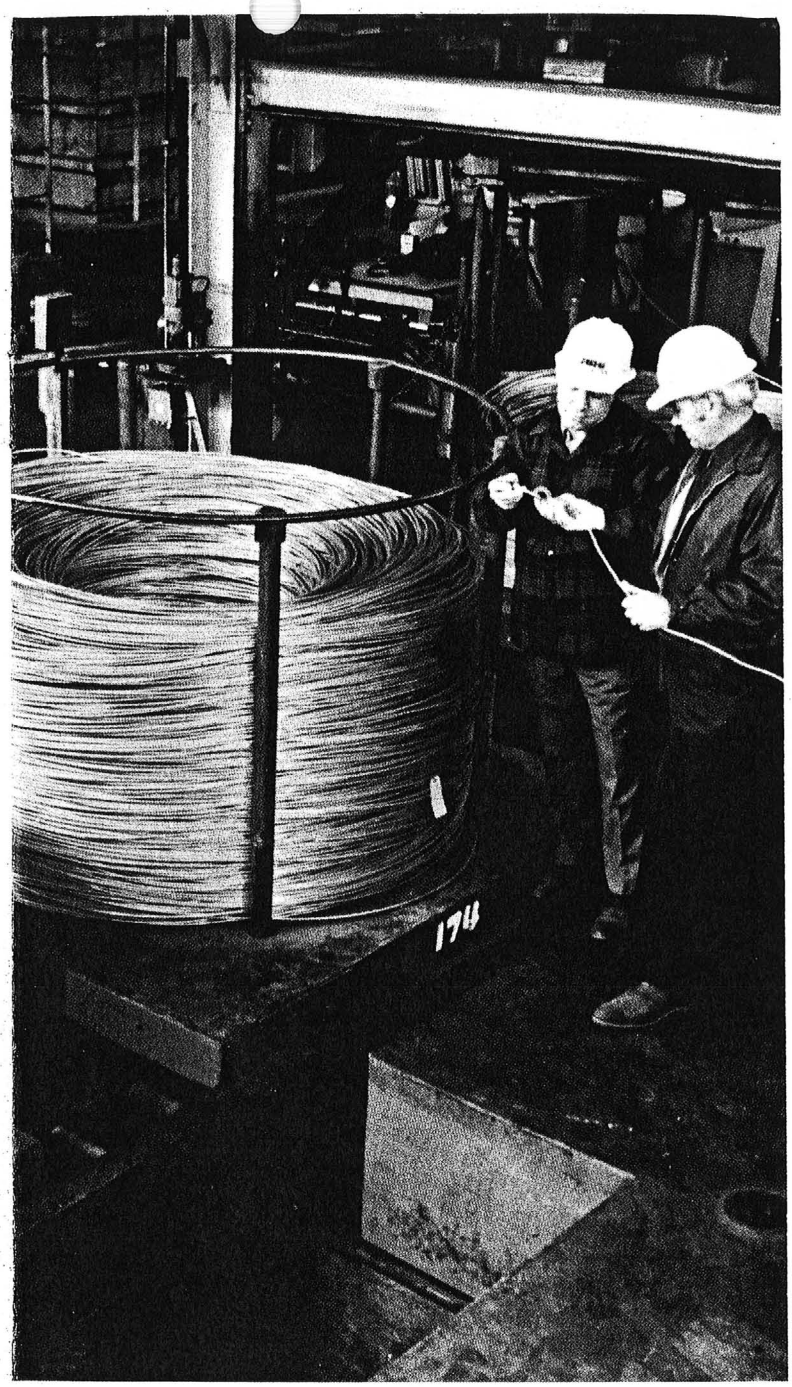
Magma Copper Company is a highly integrated producer of primary copper, controlling the entire process from underground ore bodies through refining and having a production capacity of 200,000 tons of metal per year.

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 $\frac{5}{16}$ inch copper rod of the highest purity is produced at San Manuel for the wire and cable industry.

MAGMA

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A Subsidiary of Newmont Mining Corporation
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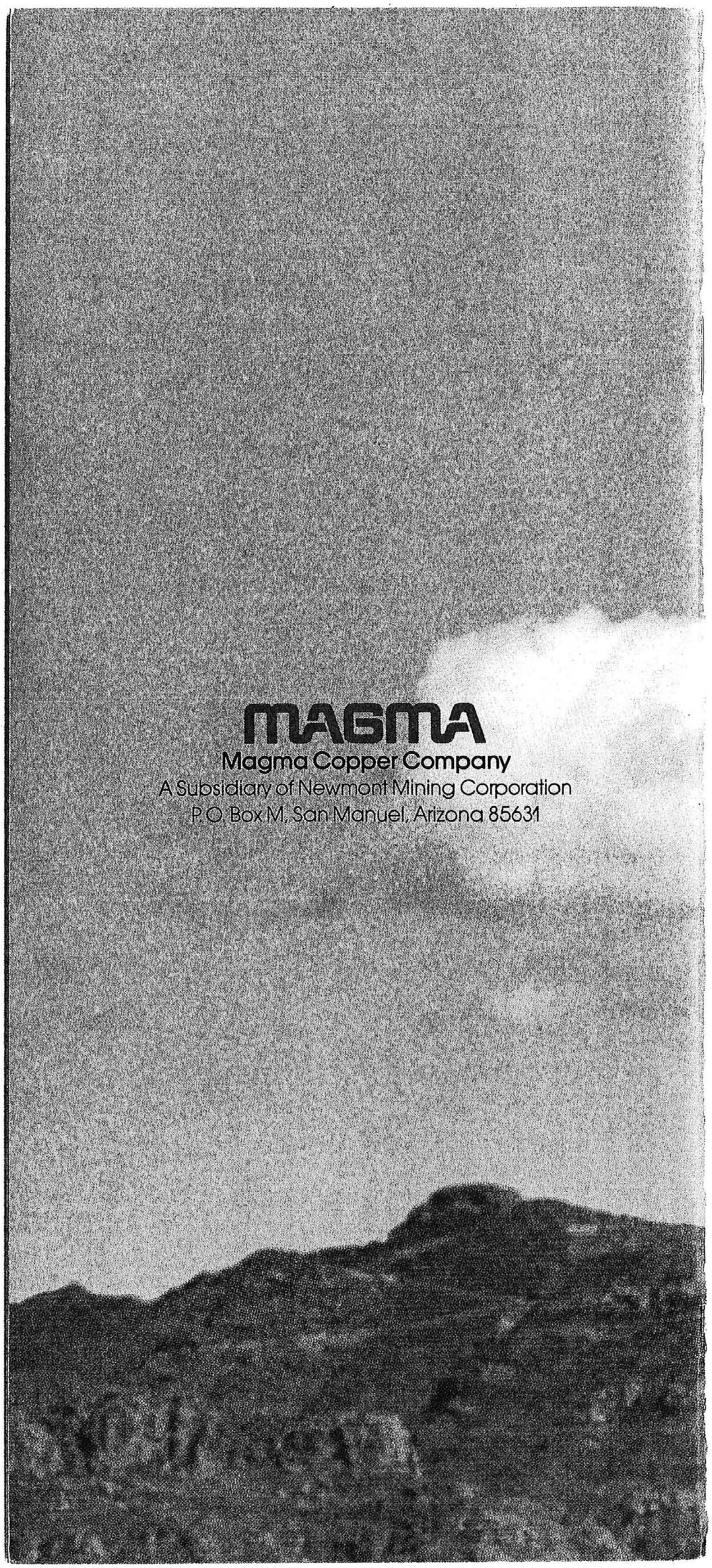
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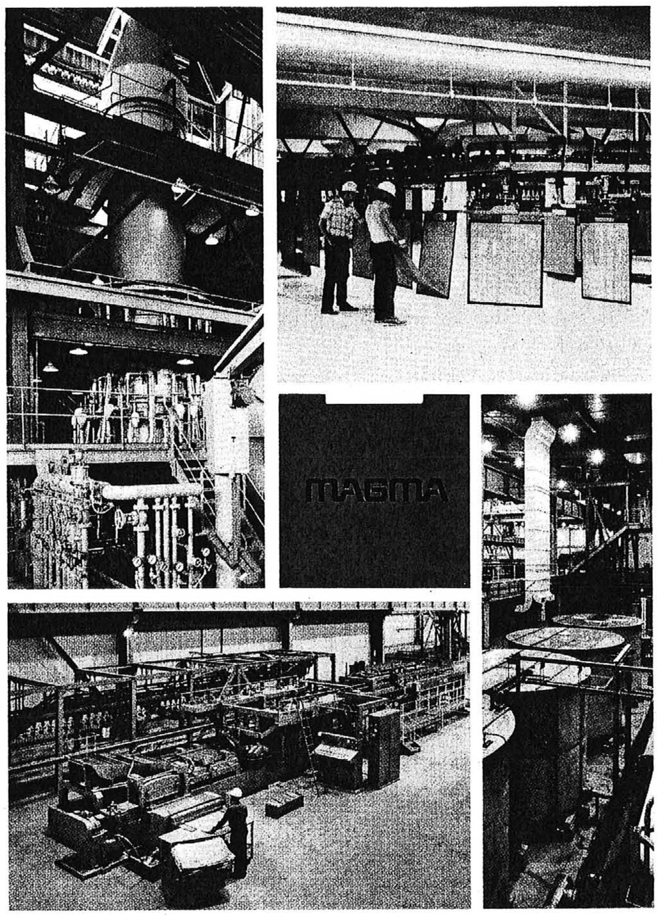


MAGMA

electrolytic copper

MAGMA
COPPER
COMPANY

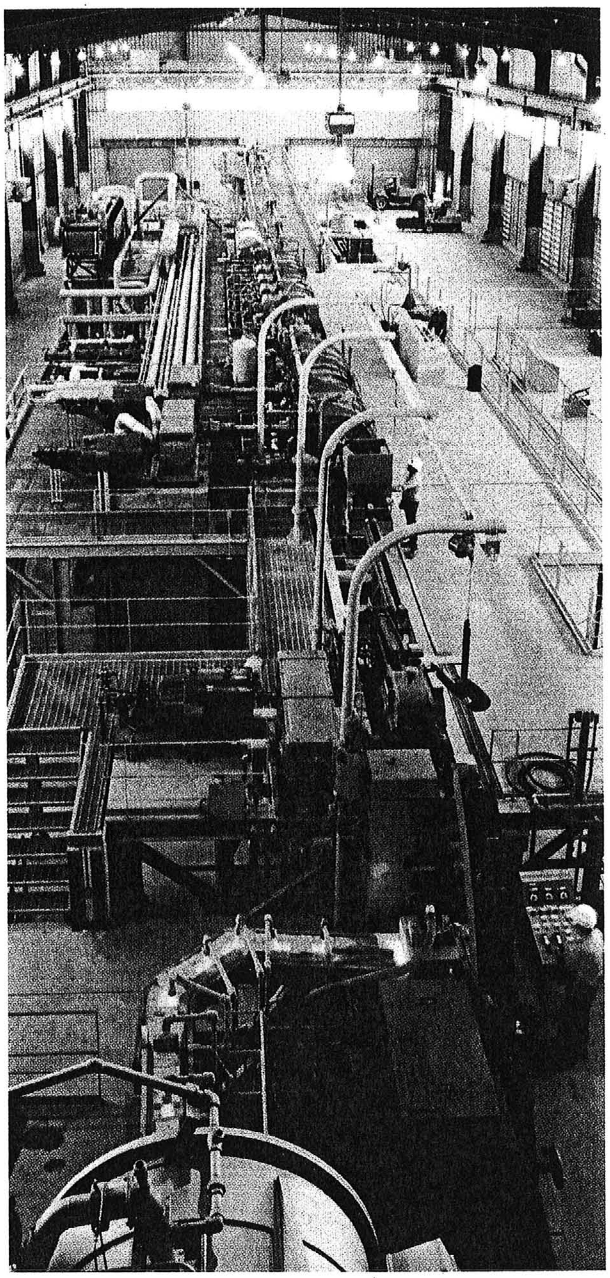
IN ARIZONA SINCE 1910

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.

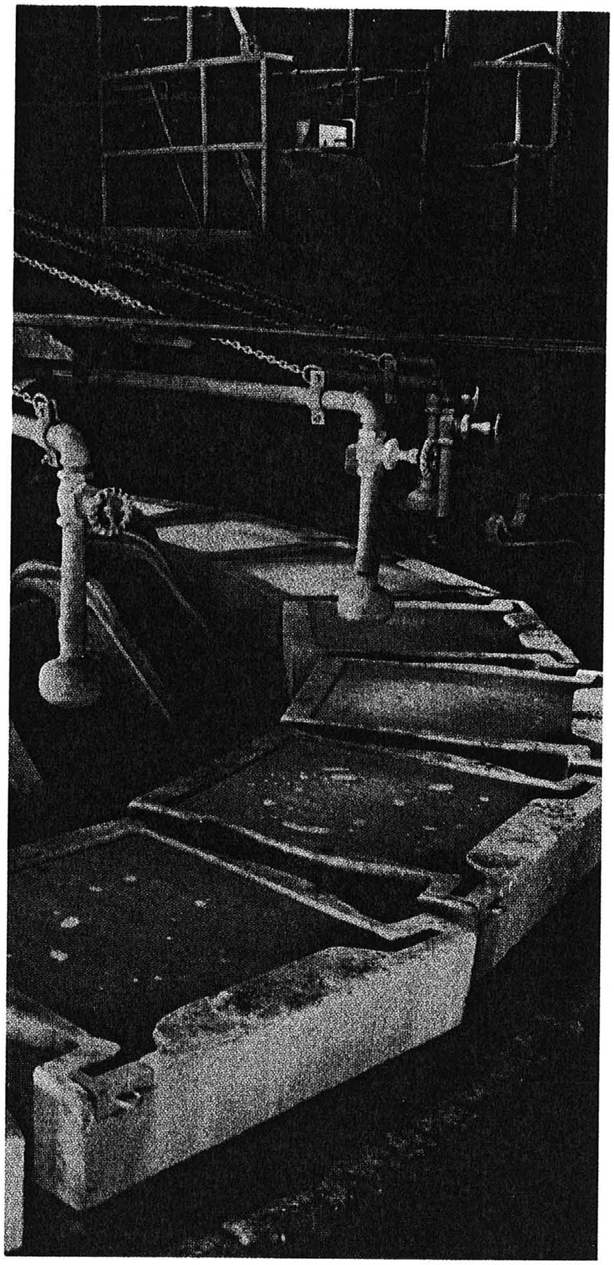
From the standpoint of practical economics, this new large copper refinery presents many new benefits to Arizona such as:

- 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



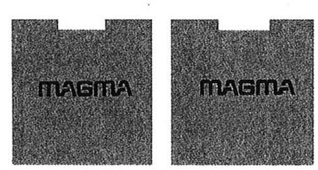
The end product of the San Manuel smelter has been and will continue to be the copper anode, a casting of approximately 99.6 percent purity measuring 37 in. x 42-3/16 in. x 1-7/8 in. with its characteristic suspension lugs and weighing about 785 pounds.

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.

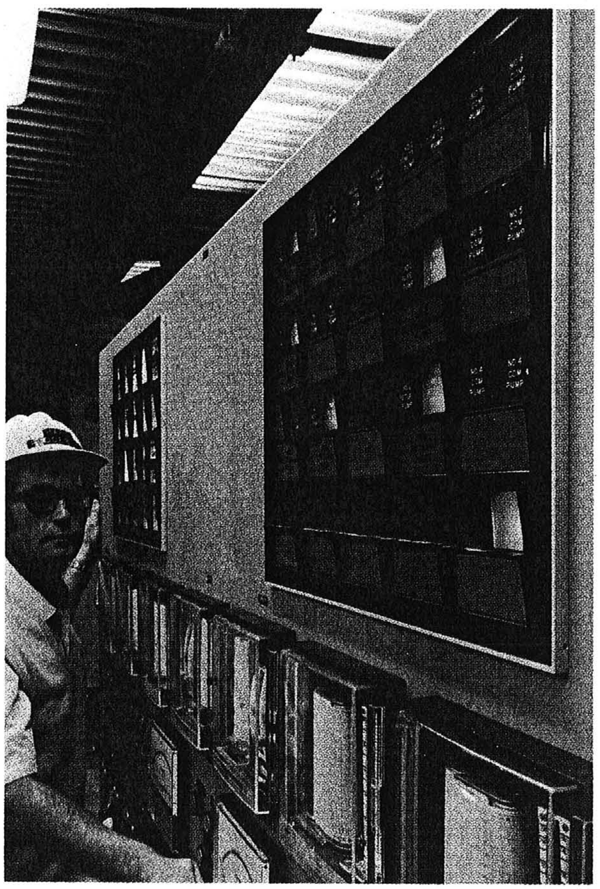
The molds are made of copper and weigh 5,730 pounds each. A mold wash of pulverized silica, obtained from concentrator tailings, prevents the molten copper from adhering to the molds.

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.



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.



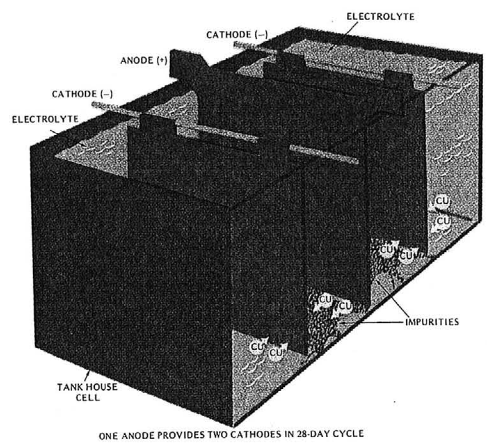
Copper is separated from any metals and impurities by electrolysis in a bath (electrolyte) which is a solution of copper sulfate and sulfuric acid. It is sufficiently electropositive to hydrogen in the solution to facilitate its deposition at relatively high current efficiency.

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.

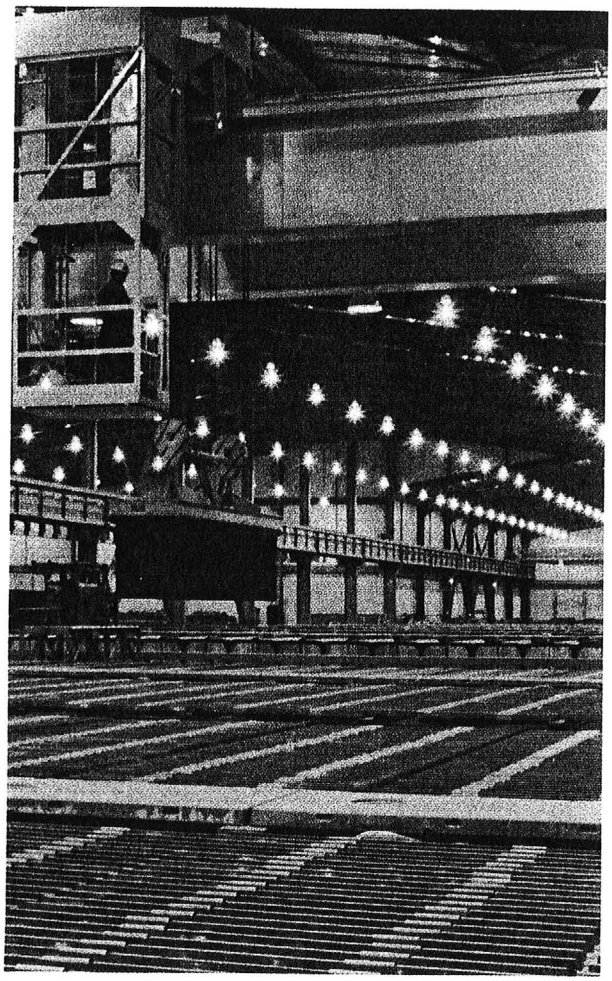
Each anode provides two cathodes in a 28-day cycle. The cathodes weigh 330 pounds, and the remaining 125 pounds of anode scrap is recycled to the smelter where it is melted and recast into anodes.



ONE ANODE PROVIDES TWO CATHODES IN 28-DAY CYCLE

Deposition of Refined Copper in Electrolytic Process

electrolytic copper produced in tankhouse cells



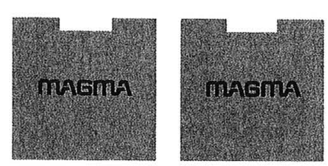
The Magma refinery has design capacity for producing 200,000 tons of electrolytic copper annually or about 650 tons per day.

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.

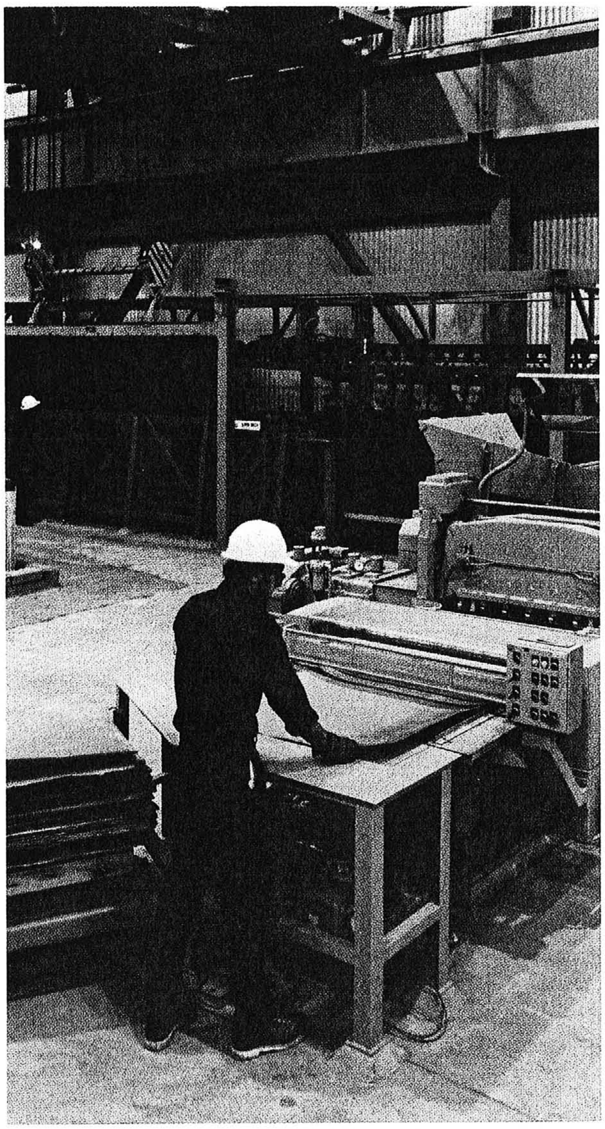
In order to maintain production rates and smooth operating schedules, the cycles are staggered so that 3948 cathodes are pulled daily from 84 cells during a 6-day production week.

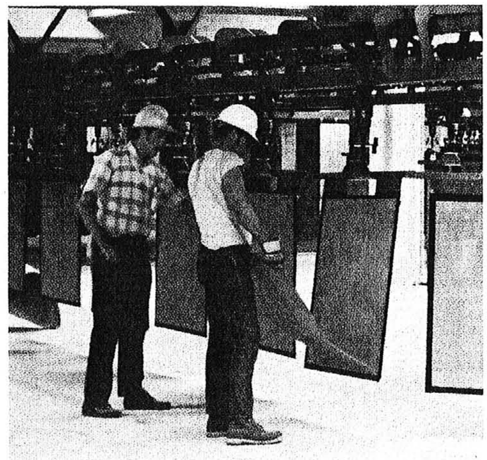


magma copper company
san manuel division

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.

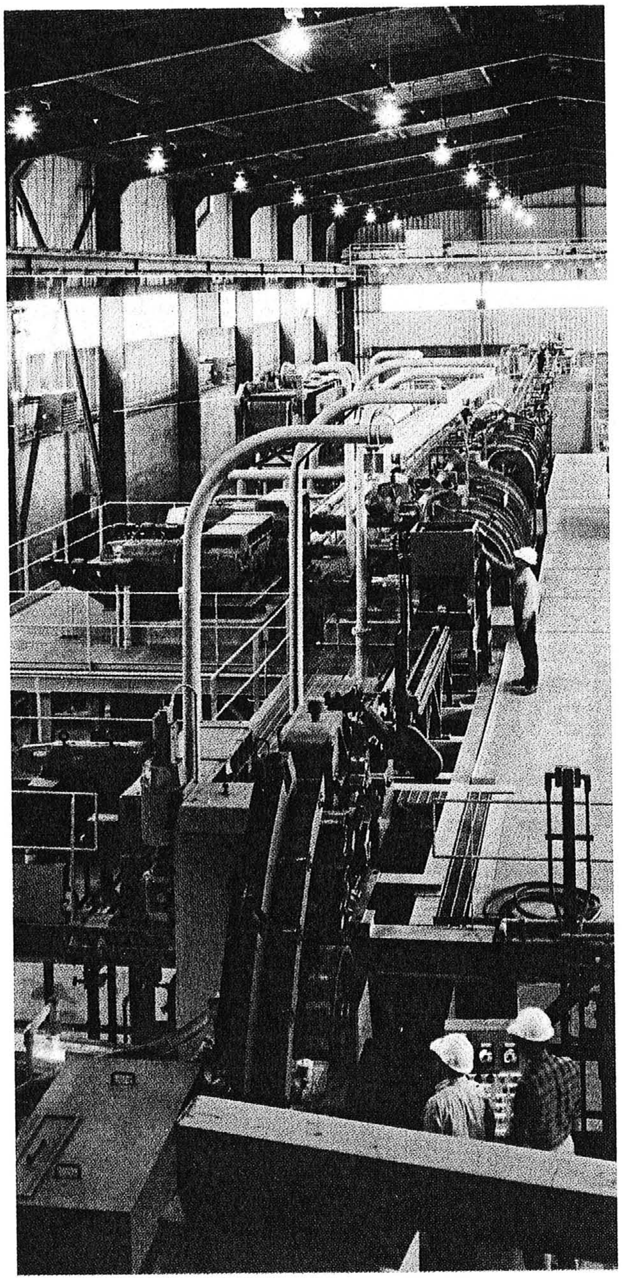
In the stripper section, some 2700 rolled copper blanks with specially treated surfaces are interspersed in tanks between anodes. Electrodeposition occurs in the same manner as in the commercial tank sections, but is halted after 24 hours.

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.

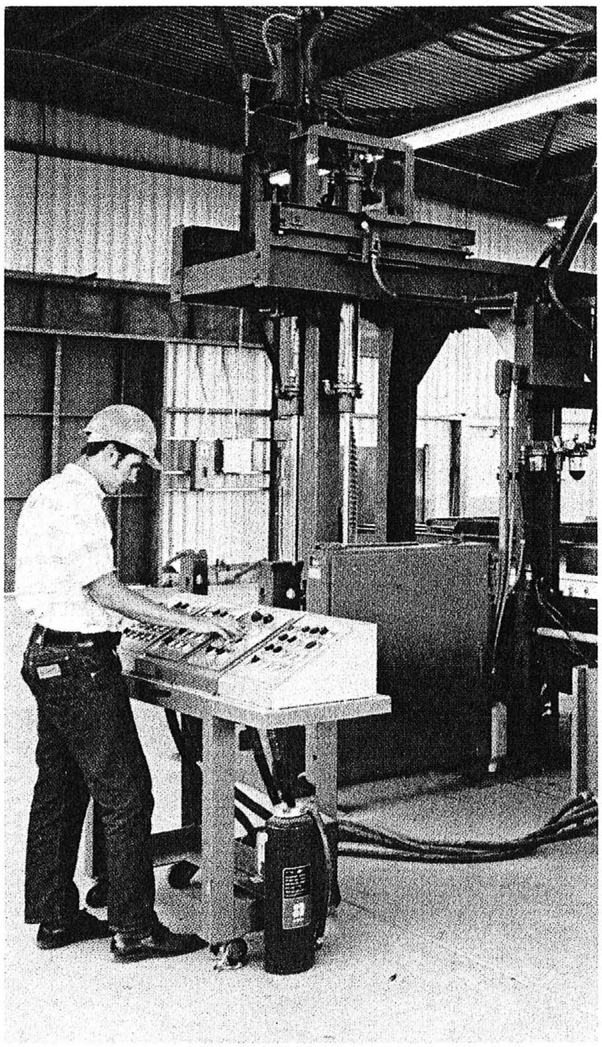
As the wheel turns, it continuously casts a 5-square-inch bar, which is fed to a rolling mill consisting of 12 stands. The casting is rolled into alternate oval and round shapes, progressively smaller down to five-sixteenth inch. The sequence takes place at rates up to 4000 feet per minute.

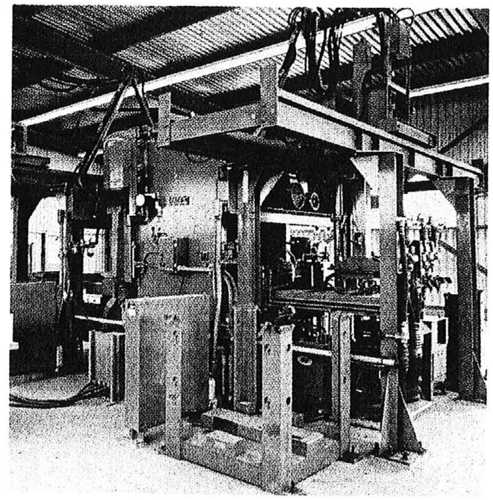
After leaving the rolling mill, the rod is pickled with dilute sulfuric acid, rinsed, coated, and finally wound into coils of various sizes specified by customers.

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.)

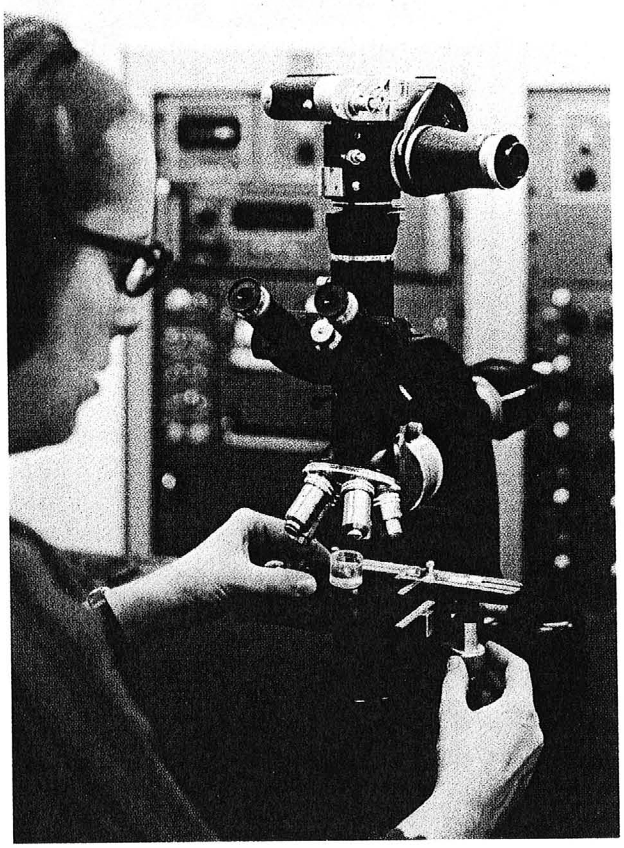
A vacuum mechanism lifts the 330-pound cathodes, feeds them to the shear blade, removes the cut, discards the scrap, and bundles the completed stack of sheared cathodes.

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.

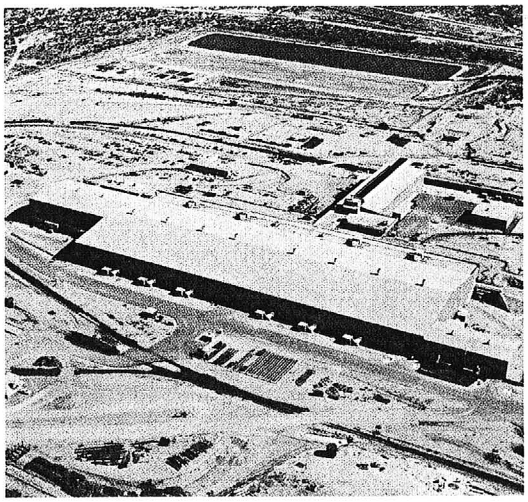
In 1969, Magma became a wholly owned subsidiary of Newmont Mining Corporation, an international firm specializing in the development and production of diversified mineral resources.

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 copper company

THE SAN MANUEL DIVISION

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A Subsidiary of Newmont Mining Corporation

magma copper company
san manuel division
electrolytic refinery