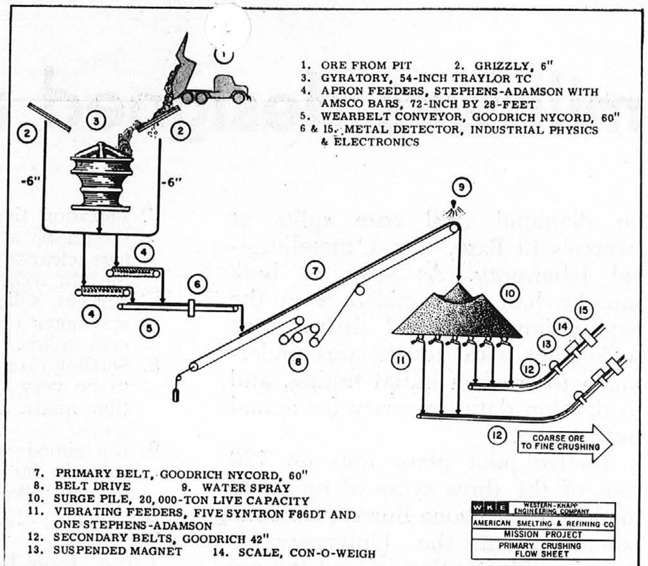
PRIMARY crusher dump. Passenger car gives scale for 60-ton Euclid. The 54-inch Traylor TC gyratory is installed below ground level. Service is by 75-ton P&H bridge crane.



PRIMARY crushing plant flowsheet—pit to fine crushing.

Three-stage, open-circuit crushing:

Primary crushing is done in a high capacity underground crushing plant housing a 54-inch Traylor gyratory. Secondary and tertiary crushing is done by two 7-foot Symons standard cone crushers and two 7-foot Symons short heads.

In no instance is the crushing circuit closed. A recirculating load is never returned to the same crushers. Fresh feed goes to each crusher, and it is carefully sized feed in the two final stages. This is an important factor in low operating cost with high capacity.

The marvel of the crushing circuits is the secondary and tertiary building. With all crushers operating at capacity there is little vibration, even on the top floor, 85 feet above the ground. There's lots of weight hung high in the air too. The four crushers weigh 322 tons and are mounted 20.3 feet above ground level. The top of the 1,000 ton tertiary bin is 75 feet above ground.

In no instance does all of the ore enter even one of the five crushers. In fact, theoretically and to a large degree in actual operation, all minus-¾-inch ore from the pit never passes through a single crusher. It is grizzlied and screened out of ore stream to bypass all crushers, a most important factor contributing to overall crushing efficiency. Some ore is crushed only once and thus reduced to final size, the greatest portion twice, and a considerable portion three times.

Then 15 percent of ore, crushed to minus-¾-inch, bypasses the secondary crushers, and in turn only 47.8 percent of mined ore reaches the tertiary circuit. Provisions have been made, and necessary space left, for quick installation of two screens to close the tertiary stage at any time in the future if, and when, finer crushing becomes desirable.

The accompanying flowsheets and equipment legends accurately depict ore flow from trucks to fine ore bin. Study them carefully. Construction details and operational highlights are described below for a more complete understanding of Mission crushing.

It has one of the highest throughput rates per operating crusher-hour of any plant having a comparable feed size, range of size reduction, and ore hardness. Crushing horsepower per ton in also among the lowest, if not the lowest, for comparable ores in the industry. Each of the two standards and short heads is driven by a 300 horsepower motor.

Circuit Flexibility

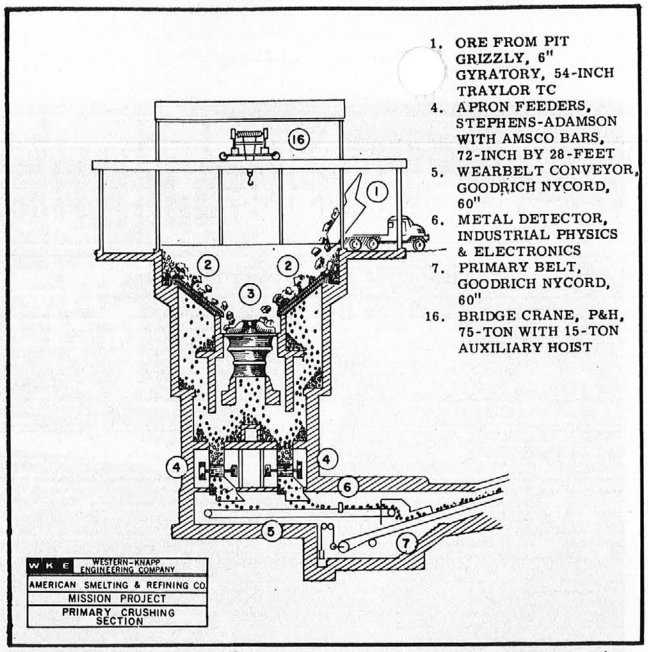
Three features make this possible. The first is to take off the finished undersize (minus-¾-inch) from primary screen ahead of the secondary crushers. This undersize is delivered to the fine ore belt without going through the secondary and tertiary circuits. With the undersize and the wet gummy fines out of the circuit the cone crushers can be effectively operated at fine settings.

The second feature is the flexible tertiary circuit arranged so that both or either one of the two tertiary cone crushers are running. When the oversize product from the secondaries is low, one crusher is sufficient. This makes an important power and crushing-steel saving. When visitors from many parts of the world are guided through this crushing plant they are continually amazed to see only one of the two tertiary crusher operating while the two secondaries are both operating.

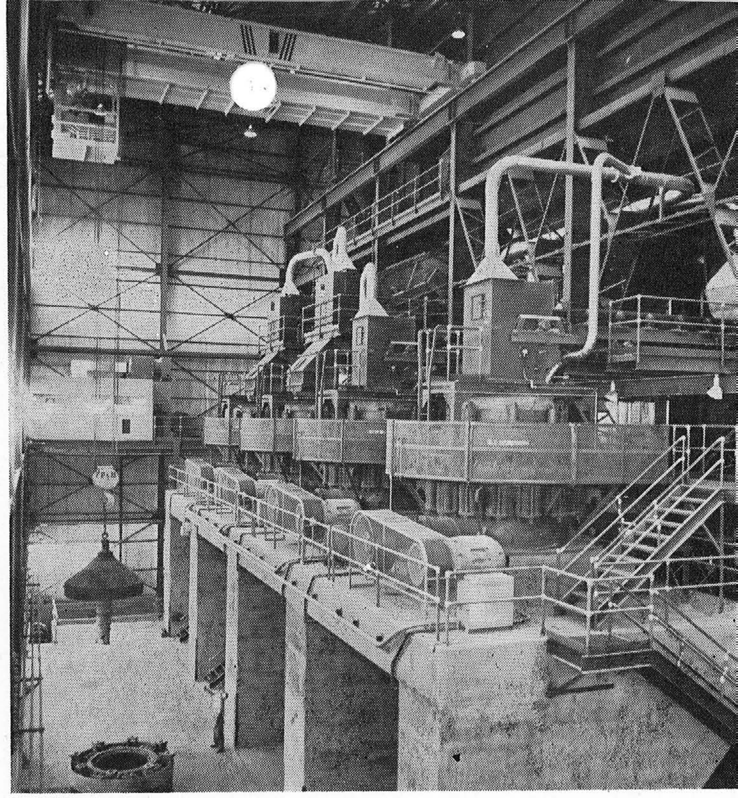
Flexibility in the tertiary circuit is made possible by the use of two 500-ton surge bins (actually one bin with two draw off points) built at the top of the crushing building. Each draw point has its own vibrating feeder and belt to a separate tertiary crusher. Use of a shuttle belt tripper on top of this bin, actuated by ore-level controls, insures a continuing feed to refill bins to replenish the draw off. Thus, the feed conveyor shuttles back and forth when the two tertiary crushers are operating, or continously discharges into the bin feeding one operating crusher.

The third point in operating flexibility is the separate use of twin feed belts from the surge pile.

This means that the secondary plant will operate at half capacity in the event of conveyor trouble cr periods when one crusher is being relined. The use of two belts 22 feet apart under the surge pile is most important to increasing the number



EAST-WEST section (west at left) through primary crusher.



INSIDE the fine crushing plant. Two Symons 7-foot short heads in foreground (tertiary circuit); two 7-foot standards behind.

3,200 tons per hour in primary, 1,400 tons in secondary

of draw points without having the expense and problems of installing a series of short right angle conveyors feeding to one main conveyor.

Designed capacity of the primary crusher is 3,200 tons per hour to minus-5½-inches. So the goal is one shift operation when the mine has been fully developed. Actually, this plant has crushed as high as 4,000 tons per hour for short periods.

The fine crushing plant is built to deliver 1,400 tons of minus-¾-inch mill feed per hour. It has already exceeded this tonnage with a very high proportion well below the ¾-inch top size.

The twin belts each feed 700 tons per hour from surge pile to the double deck primary screens. Here 114 tons of undersize is removed to the fine ore belt. High capacity is attained by removing plus-1½-inch oversize on the top deck and the plus-¾-inch on the lower deck, to feed only 590 tons to the secondary circuit. Screening of secondary product removes 220 tons ahead of the third stage.

Primary Crushing

The high capacity of the primary crusher is due, in part, to the use of the facing inclined twin grizzlies, which remove minus-5½-inch ore, bypassing the crusher. Two dumping points mean a faster ore-truck haulage schedule. A central control panel above the center of the crusher permits the operator continuously to monitor all equipment. He waits for all ore from each load to drop into top of crusher before he signals the next truck to dump.

A series of inclined grizzly fingers below each of the twin apron feeders breaks the impact of large rock on the wearbelt conveyor. Good design at this point made it possible to incorporate a gravity take-up on this 65-foot long conveyor. A tramp iron detector on the wearbelt protects the primary belt. This primary belt is also protected at the loading point with a cut, or pierced, belt-stop switch. It is also equipped with a solenoid brake for quick stops to prevent any run back.

The crusher, wearbelt, and main belt run continuously, while the apron feeders operate only when ore is being crushed. To make this intermittent feeder operation feasible the feeder must be stopped with a protective load of ore to cushion rock falls and to prevent continuing grate breakage when another truck load is dumped above. A photo electric eye set in the throat of the feed chute, about 3½ feet above the bed of each apron feeder, controls the feeder travel. When the light path is blocked by descending ore, the feeder travels. As soon as ore column is dropped below eye level the feeder stops before its cushioning ore load is fed to wearbelt.

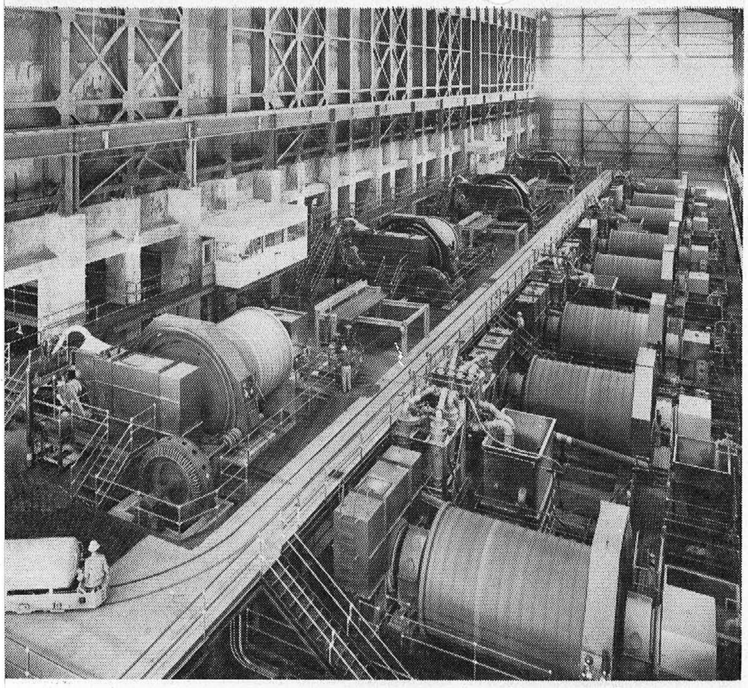
Mission is also experimenting with probes and high frequency sonnar devices for this application.

The six draw points under surge pile each have 4 by 4 foot tapered throats and are so positioned that each throat draws ore from a 1,188 square foot area. Each throat can be quickly blocked off by driving nine pipe spilling across the opening. These pipes can be pulled free to open throat with chain hoist, anchored to a special bar cast into the concrete roof. Blasting plug holes with screw caps extend through the concrete roof to the bottom of the pile.

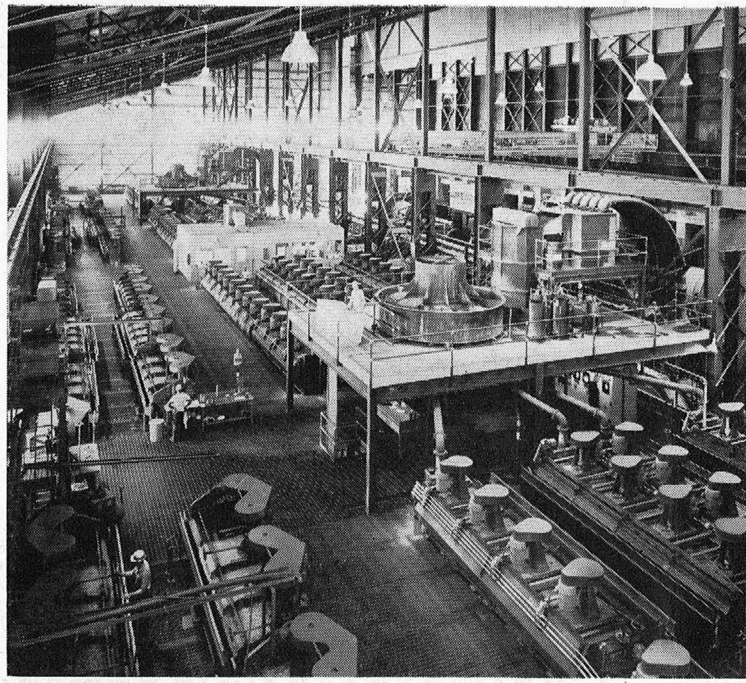
Electric magnets above the twin belts from the surge pile to secondary crushing are suspended on trolleys that can be rolled away from the belt. The current is then cut, and the trapped tramp iron dropped free.

During the crushing plant engineering period a model was built in San Francisco, California to test chute design and location. Because of the use of massive concrete foundations and heavy steel columns, the long-fall and lateral-transfer of the final undersize from the primary screen to the fine ore transfer belt presented difficult problems in chute location. This belt runs parallel to the line of four crushers and very close to their concrete foundations. Parallel to this belt, but operating in the opposite direction, is the tertiary

continued on page 42



GRINDING: 4 rod mills and 8 ball mills



FLOTATION: 328 cells in 36 banks

Two stage grinding with cyclone classification and

Mill circuit flexibility with

Designed capacity of the Mission mill is 15,000 tons per day of ore which is of average grade and hardness to produce 165,000 annual tons of concentrate containing 45,000 tons of copper.

There are two identical 7,500 ton units (north and south) which can be further subdivided into two twin grinding and classification circuits.

Concentrate is pumped to a separate building for thickening, filtering, and shipment. Reagents are received in bulk and are stored, mixed, and continuously recirculated to points of use. Water reclamation and recirculation is important, and is accomplished by two tailing thickeners and decant recovery from tailing pond.

The mill is equipped with all necessary auxiliary facilities, including a variety of circulating liquids and gases, a complete process metallurgical laboratory, a mill office, and large and well planned equipment repair bays.

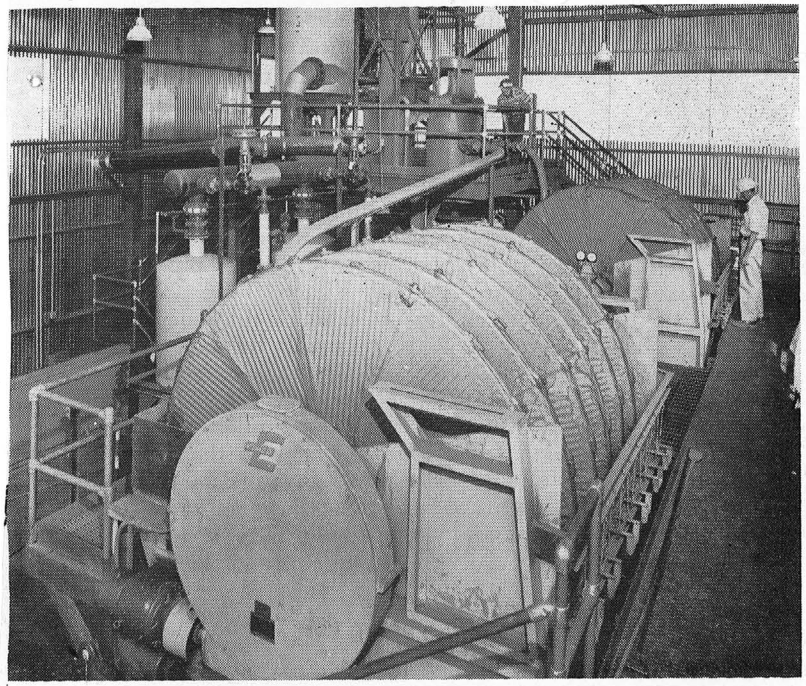
The steel-framed mill building is covered with corrugated, galvanized sheating and is built with one long roof line (384 feet) to minimize construction costs. The crane height 32 feet over the rod mill floor and approximately the same at the lowest point beneath the service crane over the flotation cells assures adequate room for crane operation, ventilation, and adequate lighting.

Ventilation with its inherent cooling—so important in the desert southwest—is materially increased by the use of a continuous ventilator along the ridge. The building proper has only two bays, an 80.5-foot span over the grinding and classification section, and a 70.3-foot span over the flotation section. The relatively short span over the grinding section is made possible by the arrangement of the rod and ball mills and by the use of cyclones for classification which require very small floor area. A P&H 50-ton bridge cranes with a 10-ton auxiliary hook, travels the full length of the grinding bay including the 72 foot long service and repair section on the south end. A second P&H 5-ton bridge crane, services the flotation section. Removable steel grate flooring makes it possible for this crane to service part of the hydroseparators and regrind ball mills, located directly underneath the flotation floor. Each regrind mill has its own 10-ton P&H bridge crane for repairs and service.

The 312-foot long, 43-foot wide, and 50-foot high fine ore bin has a live capacity of 15,000 tons.It is elevated 32 feet above the ground level, and the reinforced concrete piers are so positioned that a truck can be driven the full length of the mill to deliver supplies, or a front end loader can be used to clean up any possible spills.

Grinding Section

Fine ore to feed each of the four rod mills is drawn from the flat-bottom bin by six belts. Four fixed speed, and two variable speed, 36-inch wide flat rubber belts move horizontally across the mouth of tapered slots, extending through the flat bin bottom. These form modified Pioche type feeders, so that area of feed to each rod mill represents four percent of the total bottom area of the bin. The slots are Linatex lined to prevent wear. Flat steel sheets can be driven across the slot to block off



FILTERING: 2 six-disc units

regrinding of rougher concentrate assures

automatic density control

ore flow, to make belt or conveyor repairs.

The six draw-off belts feed a common 30-inch wide gathering belt running along the center line of the bin and parallel to long axis. This belt then feeds a 30-inch rod mill feed belt extending at right angles from under the bin to the rod mill scoop box. Feed is weighed on each belt by a Con-O-Weigh scale. All transfer points between belts and discharge to scoop box are fitted with dust collection hoods and air suction lines.

Each of the four rod mills is a 10.5 by 15 foot Allis-Chalmers high-overflow type mill. Water and milk of lime are fed to the scoop box in proportion to weight of ore being fed. Water is rationed to the mill by an automatic control tied in with the feed belt scale to maintain mill density of 73 percent.

Use of a scoop to feed the mill is very important because it permits a very high overflow discharge level, it performs some initial pulping, and there is no problem in forcing a large volume of dry feed through a feed trunnion.

The discharge end of the mill is equipped with a grate-box and trash-catcher. A Reserve Mining Company type rod charger is used to load 3-inch rods through the discharge end of the mill. Charging of rods, liner bolt tightening, relining and other work on the rod (ball) mills necessitates accurate positioning. This spotting presents a problem because of cascading of grinding charge, off-center mounting of scoop feeder, etc. (To accurately position its Silver Bell ball-mills, Asarco helped develop and install an "E - M Incher".) The Mission mill corporates this equipment, which was described by Norman Weiss, milling engineer, at the Fall Meeting of the Minerals Benefication Division, AIME, in San Francisco, California, on September 24, 1954, as follows:

"Inching by electrical means is accomplished by transferring the mill-power motor-feed from the normal 4,160-volt bus bar to the inching bus, by a double-throw disconnect switch. The inching bus carries a simulated low-frequency 3-phase power which operates the mill motor at one to two percent of normal operating speed. A direct current generator is used, the current being altered by direct current, motor-driven, commutator-controlled contactors to furnish the simulated 3-phase low-frequency power. The inching rotation of the large motor can be reversed, and inching speed increased or decreased."

Rod mill overflow is diluted to 53 percent and split in half with each flowing to a pump sump box. A 40 horsepower, slow speed (360 revolutions per minute) 12 by 14 Allen Sherman Hoff Hydroseal pump elevates the pulp to the top of a four way splitter, feeding four Model D 20 B Krebs cyclones. This pump operates against a total head of only 25 feet, so that operating pressure of the cyclones is only five pounds per square inch. By keeping head low and both the inlet and outlet velocities low, the pump and cyclone life is greatly extended. The cyclone overflow, rougher flotation feed, is pumped to flotation distributor, being sampled en route, by a 10 by 10 inch ASH Hydroseal driven by a 75 horsepower motor.

The cyclones have been set high enough between the feed ends of each pair of ball mills that the underflow gravitates through a short pipe directly into the bottom of the ball mill scoop box. At first it seems surprising that the ball mills have scoops, in so much, as all feed is a well mixed, relatively fine pulp, which could be fed to the mill through a six inch diameter pipe. However, it makes good sense to use a scoop. Otherwise the cyclones would have to be mounted at least 25 percent higher than at present, to have underflow reach mill through a feed trunnion without a second pump. The extra height that all feed would have to be pumped if no scoops were used makes their use mandatory in this circuit.

Ball mills are Allis-Chalmers 10.5 by 15 foot overflow type. Mill overflow joins the rod mill overflow in the cyclone pump feed sump box. Thus the rod mill circuit is open and the ball mill closed. Two-inch diameter balls are used. They are charged by gravity through the ball charging drum of the scoop feeder.

Both rods and balls are received in railroad car lots, unloaded right in the mill building, and distributed to mills each day. Charges are weighed as they are loaded into cars which operate on the 18-inch gauge mill track extending from storage bin to each of the mills.

Grinding Control

Ore is weighed on the belt as it is fed to the rod mill. All rod mill

Mission Grinding Circuit

Item	*Each of Four Rod Mills*	*Each of Eight Ball Mills*	*Each of Two Concentrate Regrind Ball Mills*
Feed	92% minus-3/4-inch, 20% minus-8-mesh	25% plus-28-mesh, 10% minus-200-mesh	10% plus-100-mesh 30% minus-325 mesh
Product	92% minus-8-mesh 24% minus-200-mesh	60% minus-200-mesh, 5% plus-65-mesh in cyclone overflow	85% minus-325 mesh
Operating density	73%	68%-mills 28—31%-cyclone overflow	60—65% in mill 25—27% cyclone overflow
Dimensions	10.5 by 15 foot Allis-Chalmers, overflow	10.5 by 15 foot Allis-Chalmers, overflow	7-foot 7-inch by 13-foot Marcy, overflow
Capacity	160 tons per hour	60 tons per hour	15—20 tons per hour
Speed	15.8 RPM (65.5% of critical)	16.7 RPM (69.3% of critical)	15.5 to 20 RPM (60 to 70% of critical)
Drive motor	900 horsepower, synchrondus, 257 RPM	900 horsepower, synchrondus, 257 RPM	Wound rotor 300 horsepower at 1,200 RPM with belt drive
Steel charge	3-inch rods 65—70 tons	2-inch balls 77 tons	3/4-inch balls variable, 27 to 34.5 tons
Steel make-up, Pounds per ton	0.5	1.2—1.5	0.05 per ton of original feed 0.80 per ton actually ground

water is added to the scoop box through a 3-inch diameter line. The mill operator selects density of the grinding pulp. With a set density, and known weight of ore, the one variable is the amount of water to be added to the mill to maintain this density. A Fisher Porter valve is opened and closed to control water addition, acting on signal from the belt scale.

Rod mill pulp overflow is diluted at splitter box before reaching cyclone feed pumps. Density of cyclone overflow flotation feed is the key item in this circuit and it is measured and controlled by a Halliburton Model D.I.A. densometer. The instrument is mounted on the structure holding the cyclones, and receives a small fraction of the overflow pulp cut out of the discharge line. Halliburton has long used this meter for controlling viscosity of heavy oil-well drilling mud. Asarco was the first to use it in a non-ferrous grinding circuit.

PH of the flotation circuit is automatically controlled by addition of milk of lime to rod mill scoop box. Lime control is regulated by a Fisher Porter valve which regulates flow from the circulating milk of lime feed line.

Rougher Flotation

Key to flotation is the rougher circuit which makes a high-grade concentrate when milling clean ore. In this instance the concentrate can or cannot be reground before cleaning. Roughing is done in 192 Wemco Fagregren flotation cells.

Thus, the concentrate from first one to four cells of the flotation rougher cells in each bank can be sent directly to the second cleaner bypassing the hydroseparator, regrind mill, and first cleaner. The other eight cells of the rougher bank or, as is usually the case, all cells go through preliminary classification in the hydroseparators and the hydroseparator underflow is reground. The hydroseparator overflow is thickened and is rejoined with the regrind cyclone overflow for feed to the first cleaner machines. The first cleaner tailing is scavenged. The scavenger concentrate returns to the hydroseparator and the scavenger tailing joins the rougher tailing to become a final mill tailing. The first cleaner concentrate is cleaned in the second cleaner along with any rougher concentrate that has been sent directly to these machines to make the final concentrate. The second cleaner tailing joins the first cleaner feed at the head of the first cleaner flotation banks.

Details and sizes of the flotation machines and pulp densities are shown in accompanying table. Flow of pulp is shown in the Flotation Flowsheet.

Flotation feed flows directly from the distributor through an eight-inch diameter pipe to the first of four rougher cells. The distributor is so positioned in the center of identical flotation sections that short feed flows reach all banks. Concentrate from these four cells, or any combination of them, can be sent directly to the hydroseparator. Tailing from first four cells drop over a 12-inch high step to the final eight cells. This drop gives greater flexibility in sampling and reagent feeding, and increases the slope of the concentrate launder, which is made from heavy rubber sheeting to assure long life and good concentrate velocity and flow, because of its rounded rather than flat bottom.

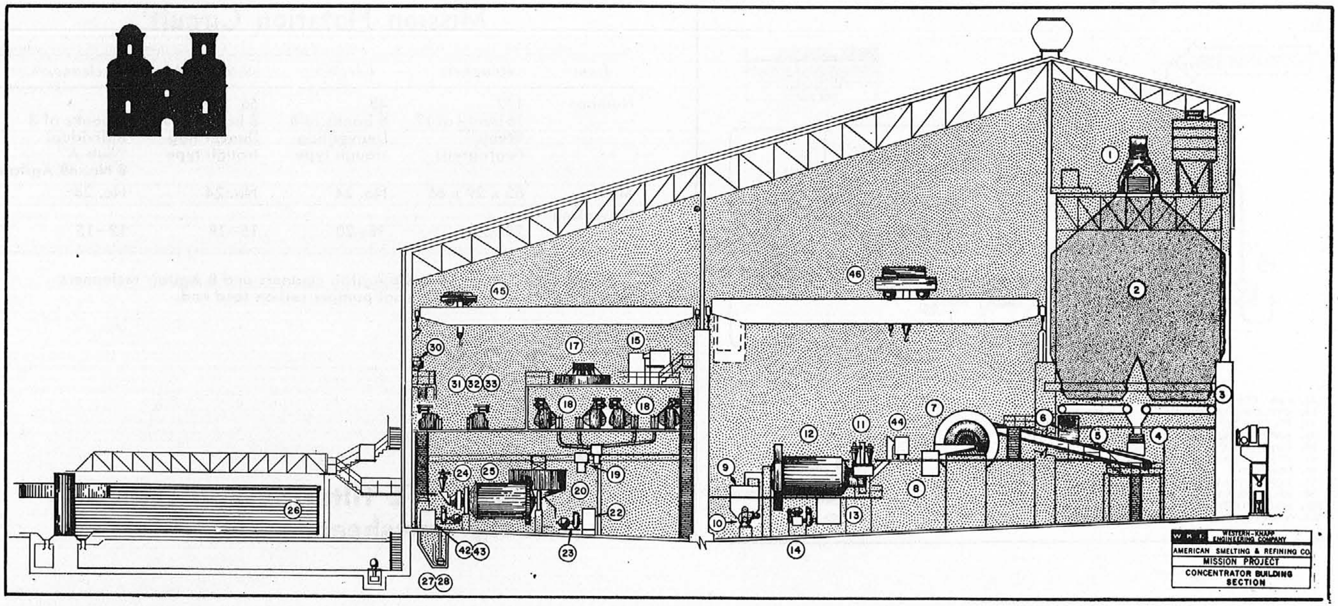
Rougher concentrate flows by gravity direct to the Eimco type BX hydroseparator located under the flotation floor. It can be directed either through a direct line or through a sampler. The rougher tailing plus the scavenger tailing is mill tailing. See section below for the disposition.

Hydroseparator overflow is piped to the 125-foot Eimco Type CX heavy duty middling thickeners. Underflow is pumped through a Krebs model D 10 B cyclone, operating in closed circuit with a Marcy regrind ball mill. Reground cyclone overflow is pumped back to the flotation floor, where it is joined by the rougher concentrate thickener overflow and sampled to feed a four way pulp distributor proportioning feed to the four banks of Denver Sub A cleaners. First cleaner tailing is scavenged in No. 24 Denver "Climax" rougher cells. Scavenger concentrate flows by gravity to the hydroseparator and tailing is sampled en route to join final mill tailing. Recleaner concentrate is final concentrate and is sampled and pumped to the concentrate thickener.

A special feature of the cleaning section is the straight line flow of the second cleaner or recleaner tailing to the first cleaners, and finally to the scavenger cells. Four Denver Special pumper cells at the feed end of the recleaner banks make this possible.

The 7-foot 7-inch by 13-foot Marcy overflow type ball mill with a drum feeder, in concentrate regrind circuit, is designed to operate at variable speeds. A wound rotor electrical motor makes possible some speed changes and the V belt drive makes greater changes possible by varying size of motor pulley. By changing mill speed, both the grinding rate and fineness of grind can be regulated to best accommodate type of concentrate (degree of mineral interlocking) and feed tonnage to the mill.

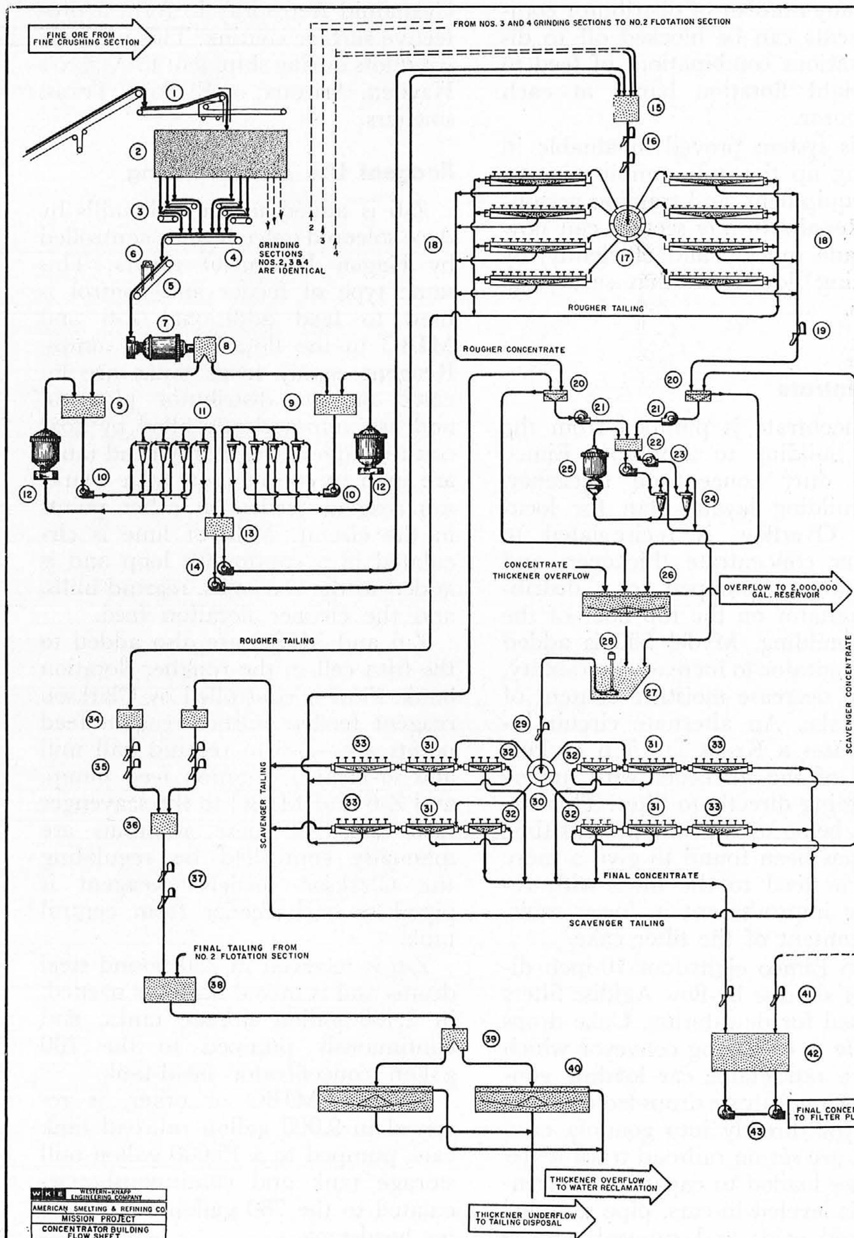
Flow sheets flexibility is only one of the high lights of the Mission mill. It is, however, an important one because it permits diversion of the pulp in most of the mill flows to parallel or identical circuits. For example, the two middle grinding sections, rod mill Nos. 2 and 3, ball mill Nos. 4, 5, 6 and 7 can be sent to either the north or south distributors, i.e., all of the cyclone overflow from ball mill Nos. 4 and 5 can go to the south or 4 can go to the south and 5 to the north. Likewise, ball mill Nos. 6 and 7 cyclone overflows can be divided or both can be sent to either the north or south distributors. At the distrib-



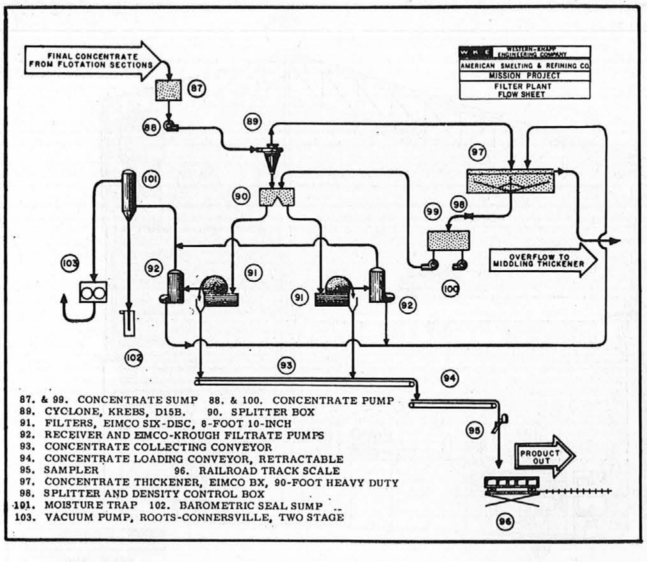
EQUIPMENT LAYOUT in main concentrator building. You are looking south in east-west section.

LEGEND

1. Tripper conveyor, 48-inch belt
2. Fine ore bin, 20,000 tons
3. Belt feeders, 36-inch
4. Gathering belt, 30-inch
5. Belt, 30-inch
6. Con-O-Weigh scale
7. Rod mill, 10.5 by 15 foot Allis-Chalmers overflow type
8. 39. Splitter box
9. 13. 22. 27. Pump sump
10. Hydroseal pumps, 10 by 14, Allen-Sherman Hoff
11. Cyclones, Krebs, model D20B
12. Ball mills, 10.5 by 15 foot Allis-Chalmers overflow type
14. Hydroseal pumps, 10 by 10 Allen-Sherman Hoff
15. 24. 36. 38. Junction box
16. 19. 29. 35. 37. 41. Samplers
17. Distributor, 8-way
18. Rougher flotation, 192 Wenco Fagregren machines, 66 by 60 by 29 inches
20. Hydroseparator, Eimco 14-foot
21. and 23. Hydroseal pumps, ASH
24. Cyclones, Krebs, model D10B
25. Ball mill, 7-foot 7-inch by 13-foot, Marcy overflow type
26. Rougher concentrate thickener, Eimco, 125-foot
28. Sump pump
30. Distributor, 4-way
31. Cleaner flotation, 42 Denver No. 24 Sub A "hog trough" and six Agitair No. 48
32. Recleaner flotation, 24 Denver No. 24 Sub A individual cells and eight Agitair No. 48
33. Scavenger flotation, 56 Denver No. 24 Sub A "hog trough"
40. Tailing thickener, 275-foot, Dorr type
42. Concentrate sump
43. Concentrate pumps
44. Ball charging car
45. Bridge crane, 10-ton P&H with 10-ton auxiliary
46. Bridge crane, 50-ton P&H with 10-ton auxiliary



FLOWSHEET for the milling equipment in main building.



← **CONCENTRATE filtering and railroad car loading flowsheet**

Mission Flotation Circuit[1]

Item	*Roughers*	*Cleaners*	*Scavengers*	*Recleaners*[2]
Number	192 16 banks of 12 Wemco Fagragrens	48 8 banks of 6 Denver hog-trough type	56 8 banks of 7 Denver hog-trough type	32 8 banks of 3 individual "Sub-A" 8 No. 48 Agitair
Size	60 x 29 x 66	No. 24	No. 24	No. 24
Operating density	28–32	18–20	15–18	12–15

1. Note the south section has 6 Agitair cleaners and 8 Agitair recleaners.
2. Each bank has Denver special pumper cell on feed end.

utors any number of distributor compartments can be blocked off to divert various combinations of feed to the eight flotation banks at each distributor.

This system proved invaluable in starting up the mill, running in the new equipment, and training personnel. Repairs to any section can now be made quickly and efficiently, by diverting flow from that section to others.

Concentrate

Concentrate is pumped from the main building to a 90-foot Eimco heavy duty concentrate thickener. See building layout plan for locations. Overflow is recirculated to rougher concentrate thickener, and underflow is pumped to a distributor-agitator on the top floor of the filter building. Mydel 550 is added to the agitator to increase filterability, and to decrease moisture content of final cake. An alternate circuit incorporates a Krebs D 15 B cyclone ahead of the thickener with underflow going directly to filter. This circuit is being used at the present time as it has been found to give a more uniform feed to the filter with resulting improvement in lower moisture content of the filter cake.

Two Eimco eight-foot 10-inch diameter six-disc hy-flow Agidisc filters are used for dewatering. Cake drops directly to collecting conveyor which feeds a retractable car loading conveyor. Concentrate drops from second conveyor directly into gondola cars, which are set on railroad track scales and are loaded to capacity. Concentrate is leveled in cars, pipe sampled on fixed grid, and sprayed with a four percent solution of American Cyanamid Aerospray to form a protective surface coating. This prevents wind loss during shipment to Asarco's Hayden, Arizona, or El Paso, Texas, smelters.

Reagent Use and Handling

Z-6 is added to the ball mills by Asco solenoid valve feeders controlled by Hagen Percent-O timers. This same type of feeder and control is used to feed additional Z-6 and MIBC to the flotation feed sumps. Reagent steady head tanks are located on the distributor platform and are automatically filled by float control valves. The steady head tanks are used in conjunction with Clarkson reagent feeders at other points in the circuit. Milk of lime is circulated in a continuous loop and is added to the rod mills, regrind mills, and the cleaner flotation feed.

Z-6 and MIBC are also added to the fifth cell in the rougher flotation bank. Flow is controlled by Clarkson reagent feeders. Other reagent feed points are—Z-6 to regrind ball mill and to cleaner flotation feed pump, and Z-6 and MIBC to the scavenger feed box. All these additions are manually controlled by regulating the Clarkson feeders. Reagent is piped to each feeder from central tank.

Z-6 is received in 250 pound steel drums and is mixed daily, as needed, in 2,400 gallon storage tanks, and continuously pumped to the 780 gallon concentrator head-tank.

Frother, MIBC or other, is received in 9,000 gallon railroad tank cars, pumped to a 15,000 gallon mill storage tank and continuously circulated to the 780 gallon concentrator head-tank.

Burnt lime is received in 50-ton covered hopper cars, unloaded and elevated to a 270 ton storage bin. A separate milling circuit is operated intermittently to produce milk of lime by grinding and hydrating burnt lime in a 7-foot by 48-inch Hardinge ball mill in closed circuit with a Krebs cyclone. Cyclone overflow is pumped to two 73,000 gallon storage tanks from which the milk of lime is continuously pumped through the mill to distribution points.

Tailing System

Flotation tailing is continuously sampled by a two stage sampler, installed just outside the mill building, as it flows to two 275-foot Dorr type tailing thickeners with a sand bottom and steel wall.

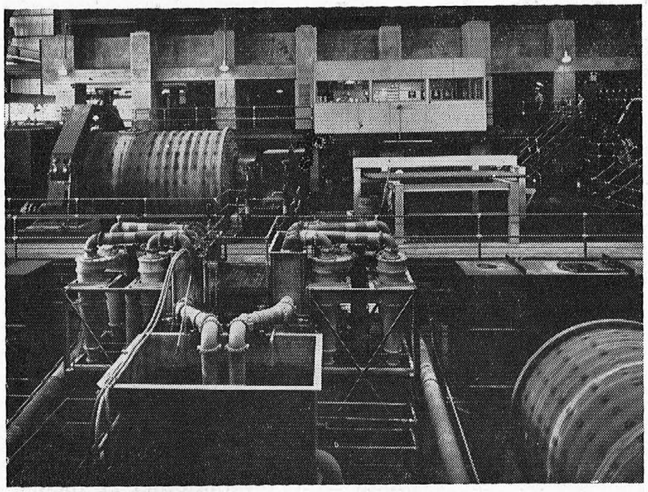
The bottom of both tailing thickeners was treated with SS-13 to form an impervious bottom to reduce water loss by percolation. After treating with 3,500 gallons of the SS-13, the water loss was reduced approximately 1,200 per minute.

Thickener overflow is collected in a 2,000,000 gallon reservoir and pumped to 600,000 gallon mill water tank. Overflow from middling thickeners is also collected in this reservoir.

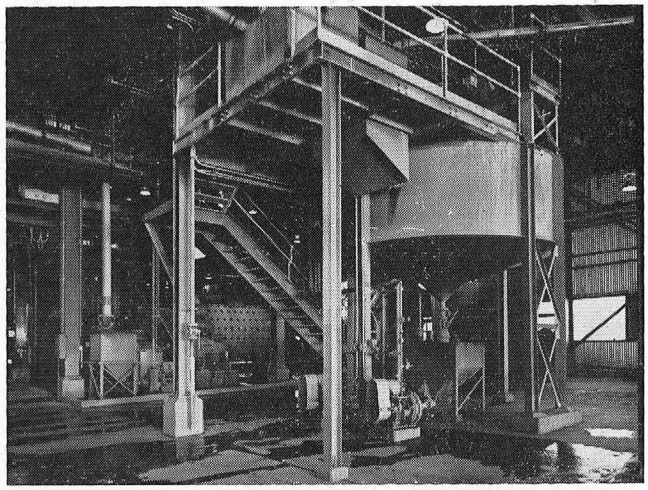
Three 7,000 gallon per minute single stage vertical mine type VS Barrett Haentjens pumps with a 14-inch discharge pump from reservoir to tank.

Sodium polyphosphate (Moberg Laboratories), a chelating compound, is metered into the pump discharge line only during time the pump is operating. This prevents lime from precipitating in the tank and pipes.

With a use of about 20 gallons



CLASSIFICATION: 32 cyclones



REGRINDING: two ball mills

per minute of fresh water per ton of ore, the Mission Plant is currently reclaiming 70 to 80 percent of the total water used. The major portion is reclaimed from the overflows of the two 125-foot middling thickeners and the two 275-foot tailing thickeners. However, an appreciable return of water is being made from the tailing dam.

Fresh water, about 2,700 gallons per minute, is obtained from three 500-foot deep wells drilled two miles east of the mill on the west side of the Sahuarita Valley. This water is pumped directly to a 600,000 gallon fresh water tank and is used for mill water fire protection, pump seal water, domestic needs, for slurrying dust in collectors, and the metallurgical and assay laboratories.

The ground surface has a natural slope averaging 2.7 percent away from the mill so the flow to tailing pond (50 percent solids) is by gravity. A 24-inch J-M Transite line with tilted circular concrete drop boxes forms the main line. Horizontal runs between drop boxes maintain an average slope of 0.5 percent and the distance between vertical drops depends on ground slope as the natural grade varies from 0.5 to 3.0 percent. This line is split into two 20-inch distribution lines which completely circle the pond area on a natural gradient from the last drop box to build up head. The lines are carried flat around the berm being continuously built up to what will be a 300-acre pond.

Four-inch take-off pipes each with a plug valve are spaced every 52 feet on the top of the main line. Bank is built by sand underflow from a series of cyclones mounted in portable steel frames which are moved along crest as it is raised behind them.

As reported in the chapter on construction methods, "dust control is well designed and adequate". Water sprays are used at major transfer points such as the truck dump and belt discharge point to surge pile.

Dust hoods and exhaust lines are installed at every dry ore transfer point and feeder from the primary crusher to the rod mill scoop boxes.

The primary crusher, the secondary and tertiary crushers, the fine ore bins, and fine ore handling in the mill proper, all have separate systems incorporating hoods, exhaust lines, cyclones, wet collectors, and dust slurry pumps to the main mill building.

Electric power, 8,500,000 kilowatts per month for the 27,000 horsepower connected, supplied by Tucson Gas, Electric Light, and Power Company reaches the plant area over a new 138,000 volt transmission line from the Tucson generating plant. At the Mission transformer station voltage is reduced to 4,160 volts for the mill and 13,800 volts for the mine. Underground leads carry power to pit rim and to mill transformer station, to keep the entire mill and service area free from dangerous and unsightly overhead distribution lines.

The mill electrical station is located in an air cooled and pressurized room under the fire ore bins. Here voltage is further stepped down to 4,160 and 440 volts to correspond with motor sizes. Battle lamps with dry batteries are located throughout the mill and crushing plant for emergency use in event of a power failure.

Control assays are made in the mill which has a small assay and metallurgical laboratory right on the flotation floor. With samples of feed, final concentrate, rougher concentrate, scavenger tailing, rougher tailing, and final tailing taken every two hours and assayed immediately the necessary reagent changes to take care of grade fluctuations are made.

A complete assay office equipped to make all fire and wet determinations is housed in a separate building; one section of which contains the metallurgical laboratory.

The assay office has three double-hooded hot plates, three full and two short work benches with sinks installed perpendicular to titration bench. It is equipped with two colormetric analyzers—Bausch and Lomb Spectronic 20 and a Klett-Somerstrand. There is a fine balance room, and a bullion balance room. Pure water is produced by a Barnsted water de-ionizer instead of a still. Storage is provided for samples, and dry chemicals while a separate, vented, outdoor storage room is used for acid.

The sample preparation equipment includes three Koch thermostatically controlled electric pulp ovens, a 4 by 6 inch Marcy Laboratory jaw crusher and 10-inch gyracone, a 12-inch Denver wet pulp filter, six ventilated dust hoods for sample rolling and cutting, and four Braun pulverizers. The metallurgical laboratory has two enclosed ovens, a 12-inch Denver wet sample filter, two 15-inch Booth flotation cells, one each 2,000, 1,000, and 500 gram Denver laboratory flotation machines, and a Denver laboratory agitator.

Metallurgy—Mill Design

continued from page 31

is done continuously with weights automatically recorded on time charts.

Sampling is done exclusively on pulps. Samples are taken automatically with Denver samplers at rougher flotation feed, rougher concentrate, rougher tailing (two samplers in series), cleaner flotation feed, and final tailing. A pipe sample of concentrate is taken on a grid pattern from the top of the loaded railroad cars.

The mill building is 384 feet long. The other basic mill dimension—width of primary bay—was shortened by placing the four rod mills at right angles to the eight ball mills, with an important saving in overhead crane and span cost. Very efficient span utilization in this section prevented crowding of individual equipment.

Installation of overhead cranes to service all major equipment is outstanding. Special lifting wells, removable floor sections, and provision for lateral transit make possible fast and efficient servicing and repair of equipment. For example, in the tunnels housing the belts under the surge pile, there is plenty of room around the belts for normal repairs. A small overhead monorail crane, over each feeder, extends over the wide walk way alongside the conveyor. This horizontal walk way is large enough so that any part of the feeder or belt can be transported through it to a point beyond the outside limit of the pile. There a vertical shaft extends to the surface with a permanently mounted overhead crane at its top. A complete feeder can thus be quickly raised from the tunnel to the surface and loaded directly on a truck, for transport to the shop. Other crane and servicing facilities are equally complete and well designed.

The flotation floor is built high enough so that other process equipment is placed under it to take advantage of the space and is so located that short compact flow lines from other mill sections efficiently reach this equipment. Flotation feed pulp is elevated only once, importantly high enough, to feed mechanical distributor from which gravity flow reaches rougher flotation. Placing the floor high means that the mill has no low spot, sump, or below ground-level equipment. This height also insures gravity flow through tailing samples plant to thickeners and tailing pond.

Reagents Continuously Circulated

All reagents are continuously circulated in a closed loop from a separate reagent building. Feeding is by time-modulated valves.

Reagent building is alongside inbound railroad track so that car-load lots of drummed reagents can be unloaded quickly. Dry reagents are mixed with water in a 2,400 gallon tank and then pumped continuously to a 780 gallon concentrator feed reagent tank. Frother arrivers in 9,000 gallon railroad cars, is unloaded to a 15,000 gallon storage tank, and is pumped continuously to a 780 gallon mill feed tank.

A complete and separate milling unit is operated intermittently to provide milk of lime for the flotation circuit. Burnt lime is received in 50 ton, hopper-bottom railroad cars and unloaded to a 270 ton storage bin. Lime is ground in a 7 foot by 48 inch Harding ball mill in closed circuit with a Krebs cyclone. Cyclone overflow is pumped to two 73,000 gallon storage tanks. Milk of lime is continuously pumped through closed circuit to mill distribution points. The ball mill serves as a pulper and grinding unit to insure good mixing and elimination of coarse grit, inherent with pulping only.

Final concentrate is pumped out of main building to a separate concentrate thickening and filtering building. This reduced the necessary size of the main building, simplified railroad trackage, and segregated processes. No concentrate bin is needed or provided as all concentrate is conveyed directly to railroad cars as soon as filtered. However, provisions have been made for loading to trucks or for storage on the ground near mill if necessary.

Piping Layout for Flexibility

Flotation feed, overflow from four banks of cyclones in the four twin ball mill circuits, is pumped to two eight-way mechanical distributors. Normally, the two southern grinding sections feed the southern distributor. However, piping is so flexible that pulp from the two center sections can be sent, in any split, to either of the two distributors. Thus, flotation load can be balanced during a mill relining, or at any time when a bank of rougher flotation cells is being repaired. The flotation feed pulps are joined in a junction box above each distributor to insure adequate head for an underflow, or rising, feed into the center of the distributor. This insures both a better mixing and a more uniform overflow and resultant mechanical eight-way split to the rougher flotation banks. Both flotation floor space and distributor segments are available for possible expansion.

Mechanical Department

How maintenance running and spares

A regularly scheduled preventive maintenance program is the key to high equipment availability and operating schedules for Mission's mobile fleet. The Mission fleet, some 65 strong, from 280-ton, 9-cubic-yard electrical shovels to mechanic's service trucks has a service crew of 90 skilled mechanics with a wide variety of specialized skills. Crusher and mill repair crews total another 22 men.

The importance of keeping equipment running at peak capacity is most important in that it takes 130 men in the mine and 62 in the mill to operate it. Actually both operating and maintenance crews are small as they mine 90,000 tons of ore and waste six days a week and mill 15,000 tons of ore seven days a week.

An equipment availability sheet is completed every day for each of three shifts for every major fleet unit. Every unit is marked as to working, standby, preventive maintenance, repairs, and waiting parts. A separate equipment lubrication record with 21 entries is completed and filed by equipment number for each major unit lubricated.

A field lubrication summary is posted on a daily basis for each piece of equipment to record in gallons, quarts, cases, and pounds the amount of Diesel fuel added and the types of lubricants used.

A separate bulk tank station was one of the first things built after stripping started. Diesel fuel, gasoline, transmission oil, engine lubrication oil, and hydraulic oil are purchased in tank truck lots and de-

Complete mill

Mission mill construction was started and completed during a fortuitous period when real mill-wrights were locally available with experience on similar major construction projects for San Manuel Copper Corporation and Southern Peru Copper Company. Construction peaked ahead of the critical demand for men necessary to build major defense installations surrounding Tucson. There was no competition for men between Mission and missiles.

Equipment orders were given at a time when delivery could be made early, many months ahead of normal delivery in several instance. All shipments were accepted on a fast de-

keeps equipment always ready

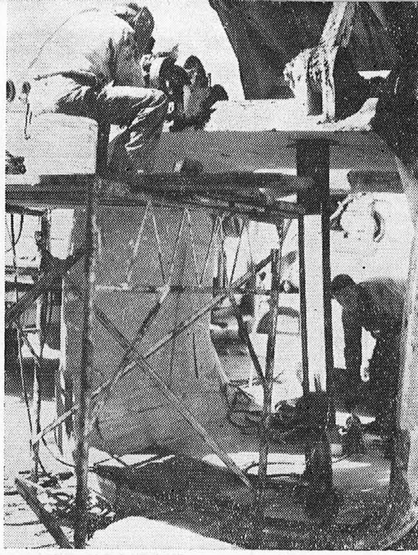
livered to the tank farm. These products are metered and delivered to internal combustion-powered units through underground lines extending to the grease buildings and fueling pumps.

With eight shovel shifts operating per day out of 15 available for six days each week a regular program of dipper and door welding is followed. Electrical motors are air cleaned and checked on a 15 point schedule. Brushes on generators and motors are given a 15 point inspection. Motors are greased every 1,000 hours, and tubes and control panels checked regularly. Twelve other inspections are regularly made and reported.

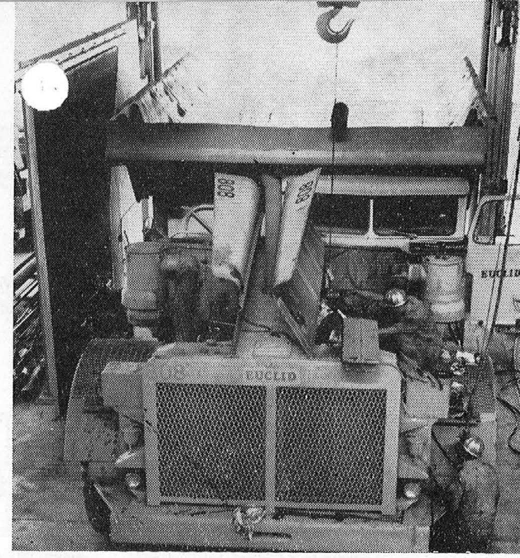
Diesel trucks are greased on a 15 hour maximum schedule. Oil is changed on a 125 to 175 hour basis. Air cleaners (dry filters) are changed when manifold pressure exceeds the set maximum allowable. Trucks are washed every week. This keeps the transmission clean, makes any oil leakage immediately apparent, facilitates inspection for structural damage, and makes cleaner working conditions for mechanics. Every Monday morning four men come to work two hours early and check air pressure in every tire. Pressure is again checked on the afternoon shift. The pit inspector drives every truck every day and checks each tire carefully. Tires are run to destruction as capping to date has not paid.

A lubrication check with minor cleaning and servicing is followed every 10 operating hours (40 checks); 100 hours (34 checks); and 1,000 hours (10 checks). Many of these are multi-checks such as drain, filter change, refill, drain and refill; or 12 brake shoe anchor pins, etc.

Similar lubrication schedules are followed for the D8 Caterpillars, and LeTourneau Westinghouse graders.



WELDING wear plates and hard facing of shovel buckets is on a regular maintenance schedule.



ENGINE REPAIRS and Diesel motor rebuilding are important to achieve high truck availability.

Complete Shop Facilities

The main shop building has complete repair equipment for the following separate shop departments: electric, shovel cables, carpenter, machine, rubber (lining belts, etc., not tires); welding and blacksmithing; truck; special rebuilding (hydraulic pumps, water pumps, differentials, transmissions; and sheet metal.

The steel building housing these shops has an overhead crane with two hooks, power operated doors, pressurized and air conditioned rooms for certain Diesel engine rebuilding, an office, clerk and record office, and rest rooms. The machine shop is equipped with lathes, power press, shaper, drill press, punch machines, cut-off press, bending rolls, etc.

There is a separate tire building for storage and changing. Also a separate two-truck grease building, and a steam cleaning and hot tank facility.

Crushing plant and mill repairs are facilitated by use of a wide variety of overhead cranes which can lift any component parts. A pipe and welding shop on the ground floor of the mill building is used for normal repair work.

Special mechanics grease and check all belts. Electricians, with special electronical experience, service control and recording panels.

Nearness to Tucson with its excellent transcontinental air and truck service minimizes the need for a large and extensive parts inventory. The warehouse carries, in regular stock, a wide variety of truck and engine parts, spare electric motors, etc. and other parts which are normal replacement items.

ahead of schedule by good organization and close supervision

livery schedule and stored at the job awaiting installation. There was no substitution of equipment for normal long-lead delivery items.

Western Knapp Engineering Company of San Francisco, California was responsible for detailed design and construction. E. M. Nicholson, general superintendent at the site, organized and supervised his construction crews in top form.

The mill was not built section by section. All areas were started simultaneously, with the object of having the maximum crew—650 men—for the longest time.

On-the-job pre-fabrication was important. A big carpenter shop was set up to make all concrete forms which were then trucked to the site and quickly erected. All piping was similarly fabricated and erected in final position. All reinforcing bar was bent and/or welded in central shop. A large iron worker and boiler maker crew was assembled early and kept busy fabricating tanks, thickeners, pump sumps, scoop boxes, etc.

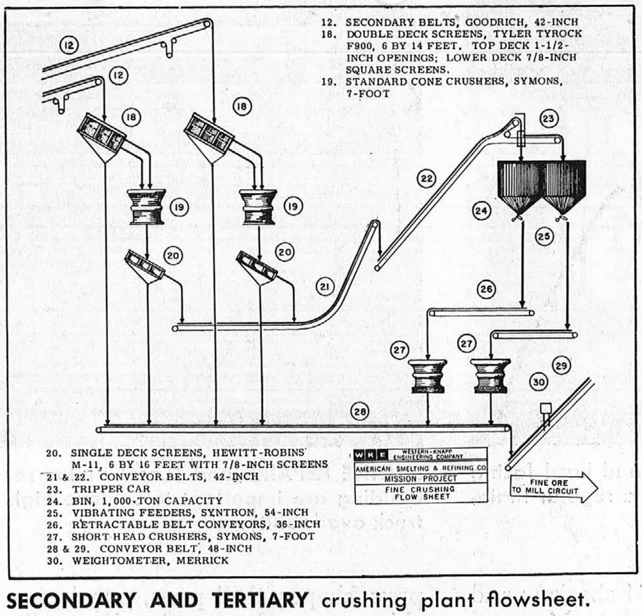
Equipment was available on the job to take care of any emergencies. There were very few change orders.

Construction materials were purchased closely with the result that the completed job inventory was held to a minimum.

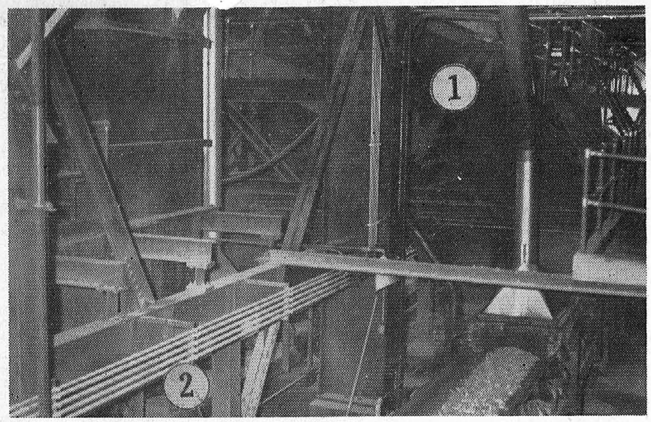
Early construction of the branch line of the Southern Pacific railroad assured delivery of nearly all equipment by rail to the job site. Two 60-ton mobile cranes and a 75-ton lowboy trailer proved invaluable for unloading, transfer to storage, and reloading and delivery to position.

The Tucson Gas Light and Electric Power Company expedited construction of a new 138,000 volt power line from Tucson to the mine, to deliver 27,000 connected horsepower when needed.

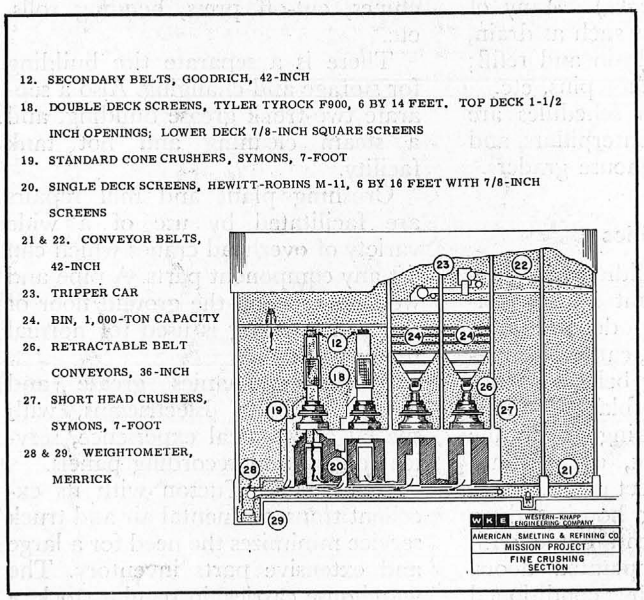
One unique feature is the casting of a special steel plate in concrete, to which Nelson studs are flash welded. Wear plates in bins and chutes are then bolted to the studs.



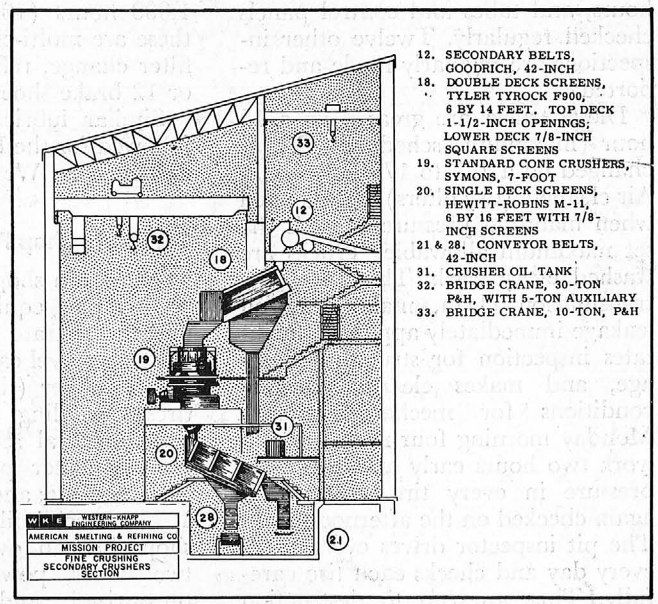
SECONDARY AND TERTIARY crushing plant flowsheet.



TERTIARY CRUSHER feed on belt in foreground travels toward camera. Vibrating screen (1) produce plus-7/8-inch feed to belt; undersize drops to belt (2) traveling away.



EAST-WEST section looking to the south through plant.



NORTH-SOUTH section looking east through plant.

crusher feed belt which receives its oversize load from the ends of the long (16-foot) screens positioned below the cone crushers.

Each screen below the standard crusher is mounted on a prefabricated steel structure which can be pulled quickly out from under the crusher into the repair section of the crushing plant. The bridge crane can pick the entire unit up, move it away, and place a new unit in position for easy lateral return under the crusher.

The 36-inch horizontal conveyors feeding the tertiary crushers are mounted as an integral unit so that they can readily be pulled back from the top of the crushers when they are being repaired. The feed bin and Syntron feeder to these conveyors are mounted high enough so that the conveyors slide under them easily.

Control Feed to Capacity

Crushed ore is elevated to the top of the mill bins on a single 48-inch wide belt. A Merrick Weightometer on this belt continuously records crushing plant output. Desired tonnage rate can be set by operator in the control room, and the Syntron feeders under the surge pile will control feed rate to conform with set figure. The operator observes the feed rate to the tertiary circuit, and switches from one to two crushers and back again as the ore hardness varies. He has the option, too, of increasing draw off rate from the surge pile when crushers are not operating at capacity. This happens, at certain periods, when ore is fine and soft despite the fact that normal tonnage is being sent to fine ore bin.

The bottom of the 20,000 ton fine ore bin is reinforced concrete supported by massive concrete pillars. Consequently the belled steel plate bin sides and supporting steel beams are bolted directly to bin foundation walls. The result is a high capacity single compartment bin, without internal supports or cross bracing.

A 48-inch tripper belt conveyor extends the full length on top of the bin. Positioning of the car is automatically controlled by Industrial Physics and Electronics bin level probes to insure systematic replacement of ore drawn off to the grinding circuit.

The tripper car, discharging on both sides, operates with continuous dust-sealing belts, to prevent dust from escaping from the bin. Four Wheelabrator dust collectors, set on the floor covering the bin, recover dust created when the ore drops into the bin and return it directly to the bin.

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For a free copy of our book, FLOTATION FUNDAMENTALS AND MINING CHEMICALS, or the digest, CHEMICALS FOR THE MINING INDUSTRY, write to: Abbott Road Buildings, Midland, Michigan, Attn: Chemicals Merchandising Dept.

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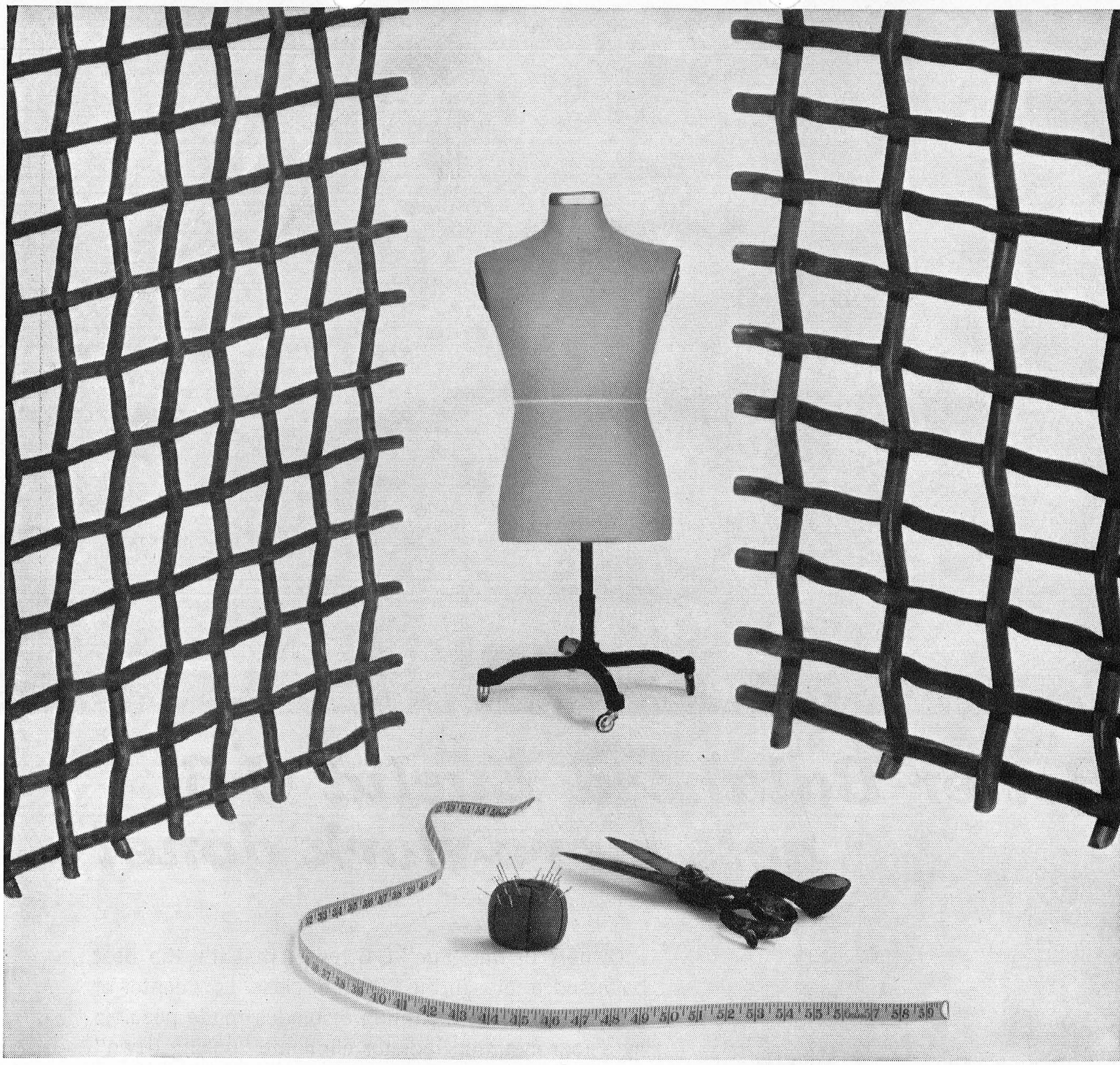

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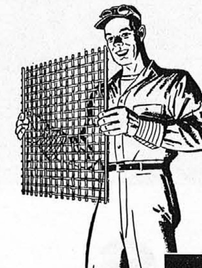

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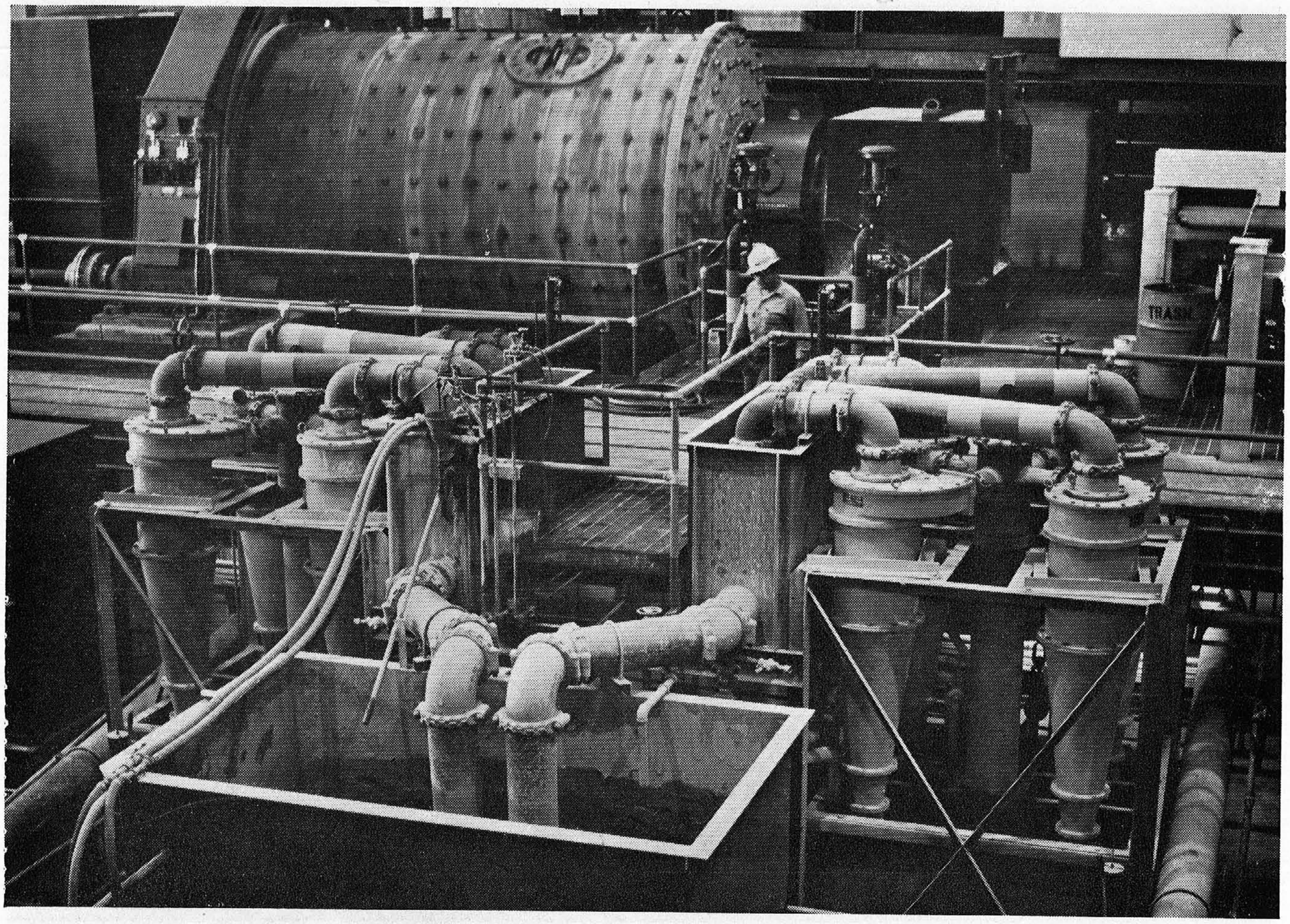

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MINING WORLD

VOL. 24, No. 1 January 1962

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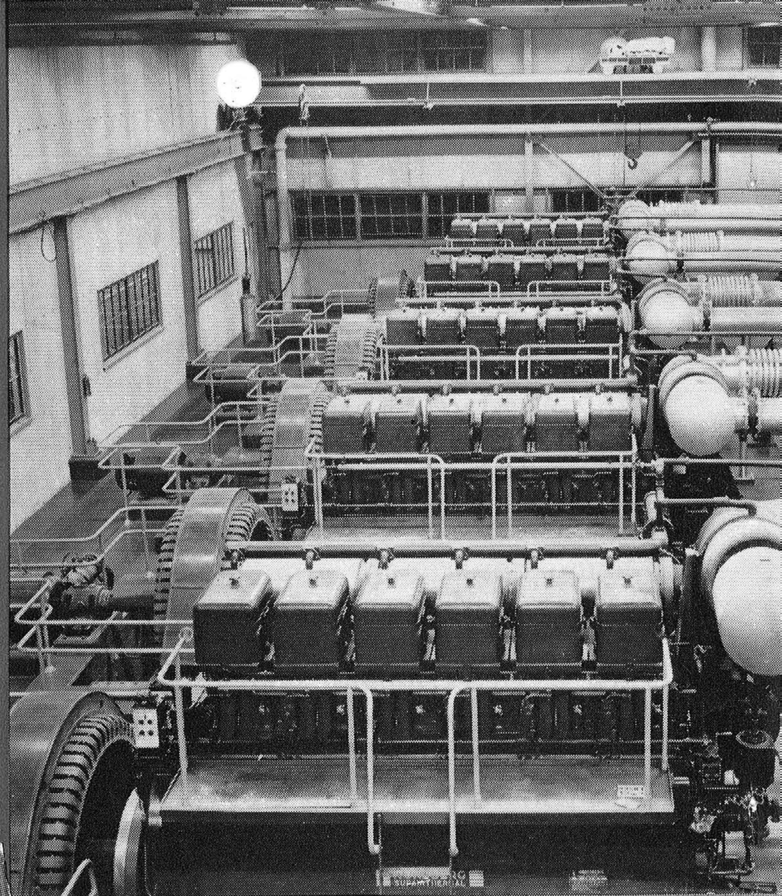

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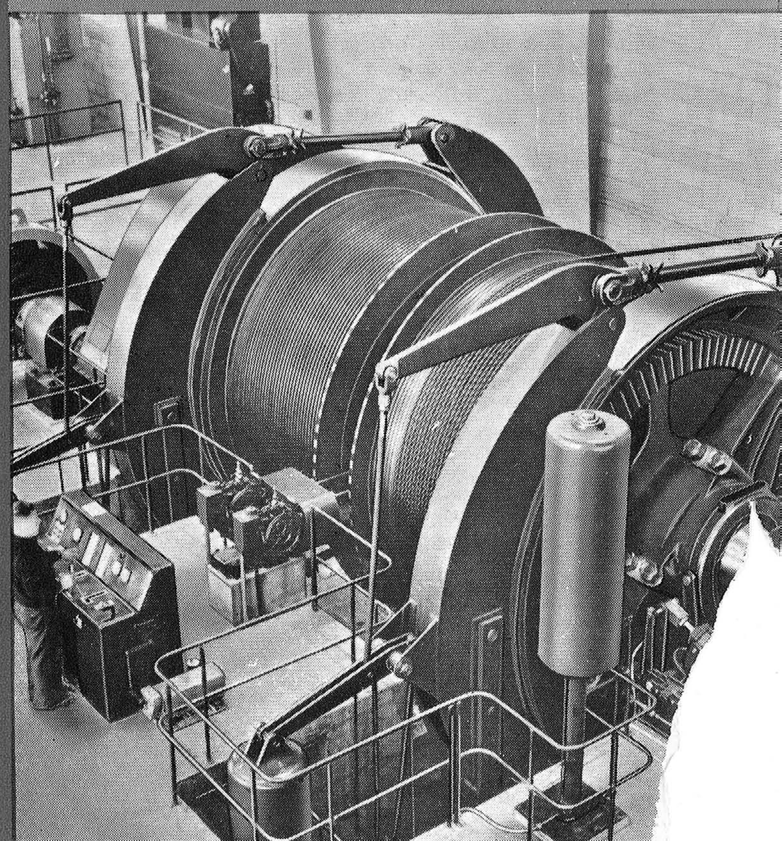

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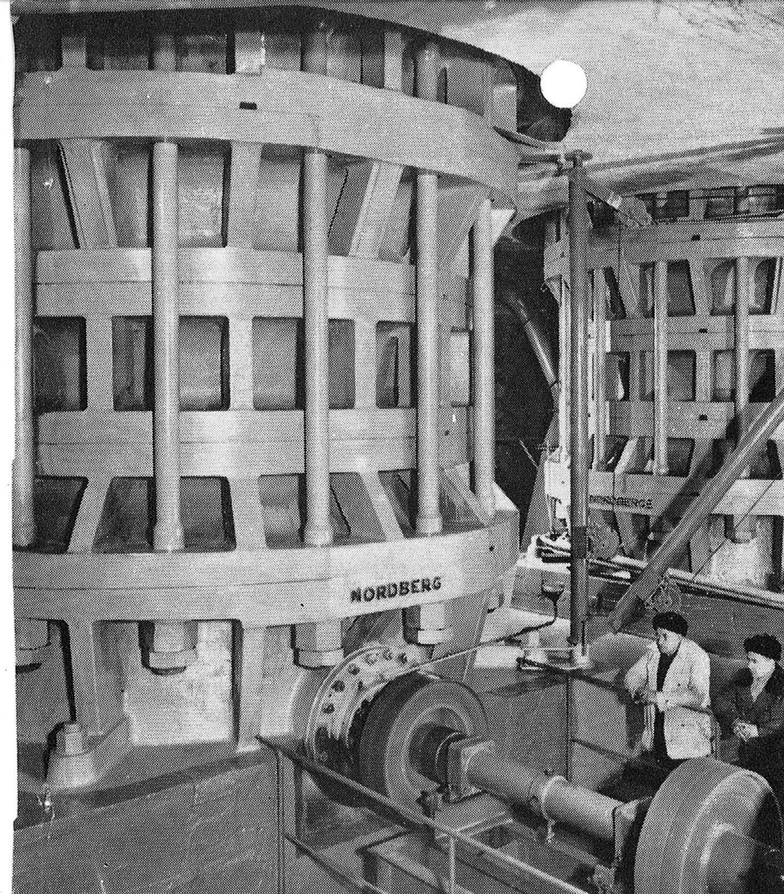
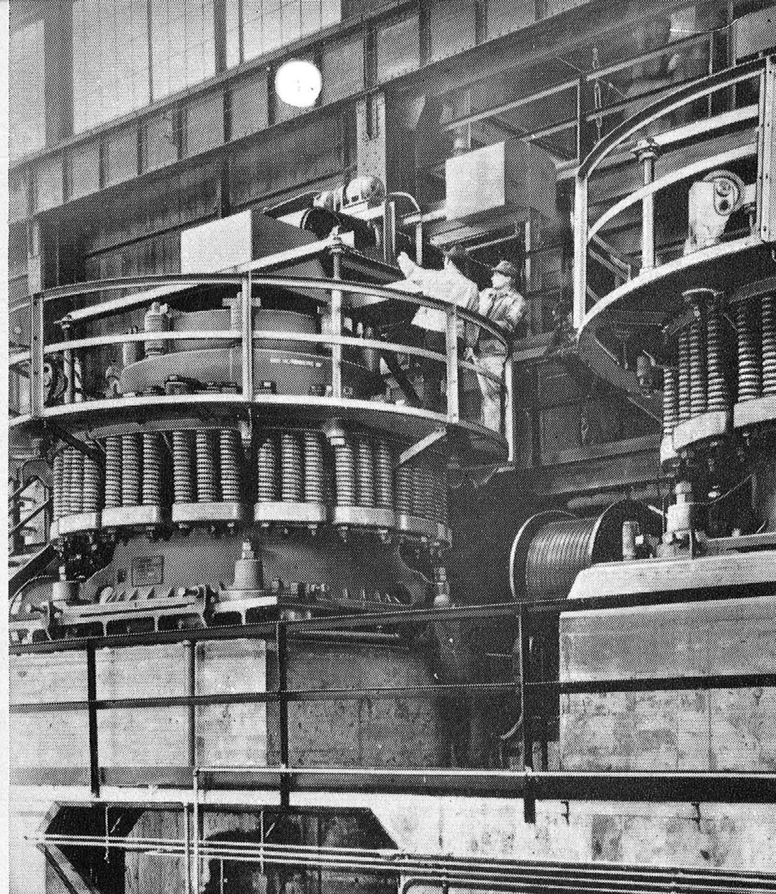
M160-R2





IN PRIMARY CRUSHING

Symons® Primary Gyratory Crushers are built for big tonnage, heavy duty primary breaking in 30″, 42″, 48″, 54″, 60″ and 72″ feed opening sizes. Capacities to 3500 or more tons per hour.

IN FINE REDUCTION CRUSHING

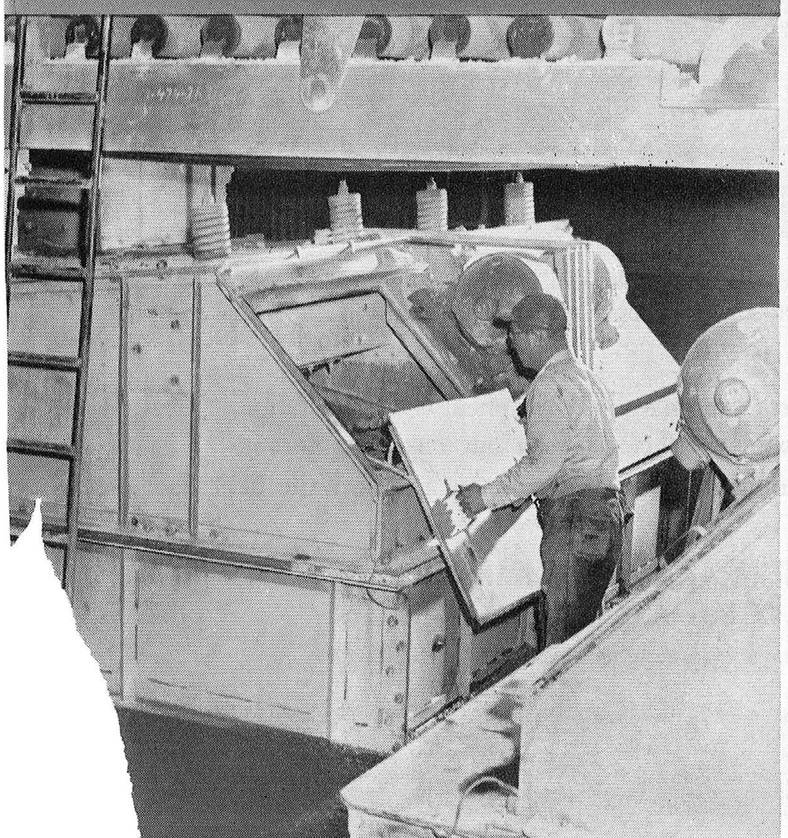
Symons Cone Crushers, the machines that revolutionized crushing practice, are built in both Standard and Short Head types, in sizes from 22″ to 10′ in diameter. Capacities range to 1500 or more tons per hour.

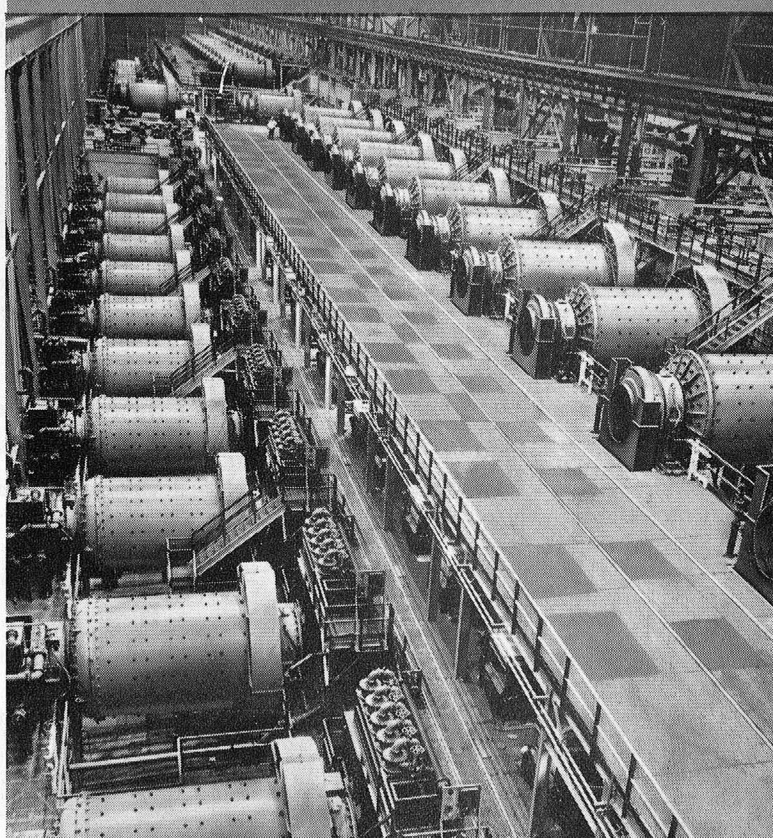
IN SCREENING

From scalping to fine screening, there is a Symons Screen built to do a better job at low cost. Let Nordberg experience help you select the screen best suited to your needs.

IN WET AND DRY GRINDING

Nordberg Grinding Mills include Rod, Ball, Pebble, Tube and Compartment types, in sizes from 6′ to 13′ in diameter and up to 50′ in length.

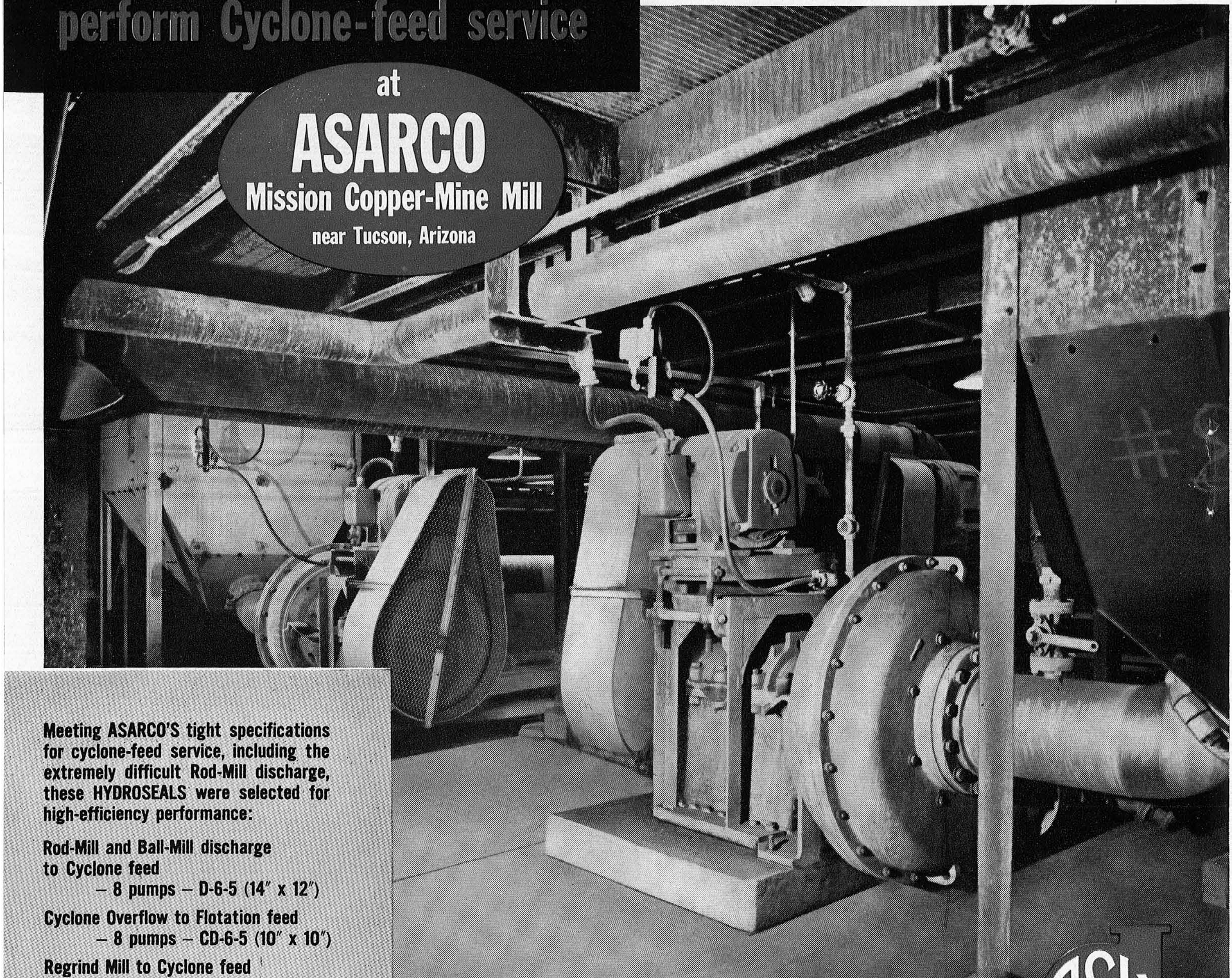




HYDROSEAL
Rubber-lined Pumps
perform Cyclone-feed service

at
ASARCO
Mission Copper-Mine Mill
near Tucson, Arizona

Tough Rod-Mill — Ball-Mill Discharge



Meeting ASARCO'S tight specifications for cyclone-feed service, including the extremely difficult Rod-Mill discharge, these HYDROSEALS were selected for high-efficiency performance:

Rod-Mill and Ball-Mill discharge to Cyclone feed
— 8 pumps — D-6-5 (14″ x 12″)

Cyclone Overflow to Flotation feed
— 8 pumps — CD-6-5 (10″ x 10″)

Regrind Mill to Cyclone feed
— 4 pumps — B-6-5 (6″ x 6″)

Filter Plant, Cyclone feed
— 1 pump — B-6-5 (6″ x 6″)

Final Concentrate Transfer
— 2 pumps — B-6-5 (6″ x 6″)

Concentrate Thickener feed
— 2 pumps — BC-6-5 (6″ x 6″)

Hydroseparator Underflow
— 8 pumps — A-6-5 (3″ x 3″)

Hydroseal pump installation in the Mill of American Smelting & Refining Company's Mission open-pit copper mine.

For the sake of economy in capital investment and in operation, together with maximum efficiency, ask our engineers to suggest the proper equipment for *your* pumping needs. Write us.

THE ALLEN-SHERMAN-HOFF PUMP CO.
Dept. J—P.O. Box 635, Paoli, Pa.
Representatives throughout the World

HYDROSEAL *and CENTRISEA*
SAND, SLURRY & DREDGE PUMP

CAPITOL concentrates

GOVERNMENT ACTION AND REACTION AFFECTING MINING

Silver Policy Is Not An Unmixed Blessing . . . A Start Toward Printing Press Money? . . .

The decision of the Administration to stop the sale of "free" silver, demonetize the metal excepting for use in coins, and to seek repeal of the Silver Transactions Tax so that bullion can be traded in on the Commodity Exchange may not be an unmixed blessing to silver producers. The new policy also carries with it a determined attempt to repeal the Silver Purchase Act. This would remove the 90.5-cent floor price which would be a life-saver were unexpected amounts of silver to be dumped on the market or the price depressed for other reasons.

An attempt to repeal the Silver Purchase Act will meet strong opposition in the United States Senate. Many bills seeking repeal have been introduced by Senators from the silver-using states, but never have reached the Senate floor.

Although the withdrawal of silver as backing for paper money naturally has to be a slow process, no longer will silver advocates be able to say that the silver certificate is the only paper money which is 100 percent backed by precious metal. The managed currency clique has won a great victory.

An increase in price is inevitable, at least for a time, and it will be interesting to note at what level the price settles. It may be noted (speculators take heed) that the Treasury will have a vast hoard of silver available for release by calling in currency, and can resume sales at any time the market appears to be getting out of hand. Around 2,000,000,000 ounces might be available and the total Treasury holdings are said to be about 3,500,000,000 ounces.

As the silver certificates are called in they are to be replaced by Federal Reserve notes which have a 25 percent gold reserve in back of them under the law. This will spread the gold stock still thinner. Some economists feel that the 25 percent gold backing for present Federal Reserve notes is not actually available, and there are strong influences at work to have the reserve requirement abolished entirely. If this happened, together with the presently announced new silver policy, we would have a totally managed or "fiat" currency. What this would do to the dollar on world money exchange is hard to predict.

While other countries are building up gold reserves and trying to make their currencies "hard," our trend seems to be toward "printing press" money. The economists who believe that money should be printed in sufficient quantities to accelerate the economy during "tight" times and withdrawn in the right amounts to retard "booms" seem to be on the winning side.

Undoubtedly, money management can be a political as well as an economic weapon and currency without adequate metallic backing often has been so used. Without accusing the Administration of looking forward to a totally managed currency, we must note that the formula which is supposed to alleviate depressions by making money plentiful and to halt excessive booms by making money scarce might be used to great advantage before a Presidential election.

Meanwhile, we look forward to the new "shin-plasters" with interest—and a good deal of trepidation!

Preferential Purchase Rights Are Suggested For Located Claim Holders . . .

The Interior Department is taking a new look at mining claims which have been located for other purposes than mineral extraction, especially if the possessory titles have been sold to "innocent" third or fourth parties.

Secretary Udall has stated that in northern California there are several thousand persons living on such claims and he intends to ask the Congress for legislation which would give the occupants preferential purchase rights to the land instead of revoking the titles to the claims and evicting the "squatters" or "trespassers," to use the Secretary's language.

The Secretary thinks that "occupants" should be encouraged "to enter into purchase contracts to regularize the occupancy; the contracts generally would be limited . . . under established principles . . . to five acre tracts or smaller."

This appears to be a completely new idea of handling questionable mining claims which have been located for homesites, gas stations, etc. In the view of Secretary Udall, "The innocent victims of circumstances deserve a Congressional review," not "hasty, ill-advised or vindictive action."

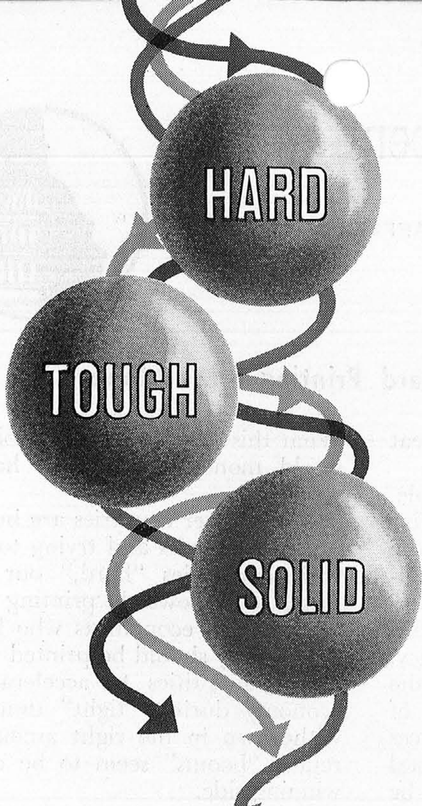
Be sure your quit-claim deeds are registered, boys, and don't worry about valuable and marketable minerals in place!

Small-Mine Lead-Zinc Subsidy Bill In Line With Aiding Ruined Industries . . .

The Interior Department, according to reports, hopes to have the regulations for operating the new small-mine lead-zinc subsidy (P. L. 87-347) ready by the middle of December.

Prior to publication the department arranged a series of four "informal" meetings with mine operators.

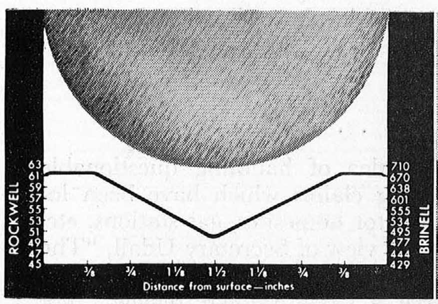
Besides the subsidy situation, and evidently in anticipation of the government's decision to ask the Congress for authority to make deep tariff slashes over the next several years, representatives of the Area Redevelopment Administration attended. The idea evidently was to find out just how much distress there now is in mining areas and to estimate how much further damage will be caused by additional tariff slashes or removal of quotas. This determination is in line with the new idea of aiding industries ruined by low or no tariffs or quotas, and relocating or retraining the jobless. The reports of these meetings, if any are formally published, will make interesting reading.



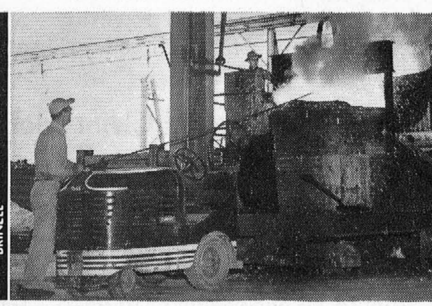
Naco Heat-Treated Cast Alloy Steel Grinding Balls

Through precise laboratory controls of the elements in steelmaking — right from spectrographic analysis through final heat treating — Naco Grinding Balls possess the precise structure and hardness for maximum impact absorption and wearing qualities. That's why Naco Grinding Balls are solid favorites with hard-to-please mill operators doing tough grinding jobs.

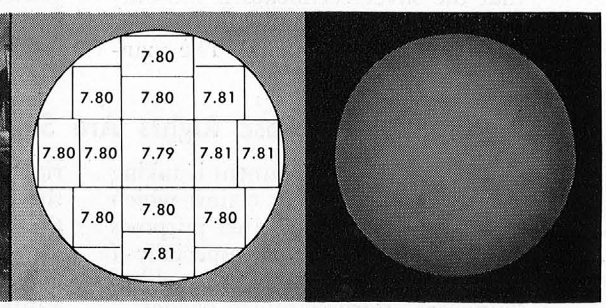
A-5227A



HARD. Curve shows controlled hardness between surface and inner core. Figures are average hardness of samples taken from representative production runs.



TOUGH. Naco Balls resist breakage longer because of close metallurgical control in electric furnaces . . . quality controlled pouring into special molds . . . careful heat treatment.



UNIFORM SOLIDITY. Grid, at left of X-ray photograph of Naco Ball, shows average specific gravity of various sections. Figures are from 169 three-quarter inch sections from 13 production balls.

NATIONAL CASTINGS COMPANY
Cleveland 6, Ohio

STEEL CASTINGS — DESIGN WITH STEEL CASTINGS — STRENGTH IN SHAPE

CAPITOL FOUNDRY DIVISION
POST OFFICE BOX 750
PHOENIX, ARIZONA

NACO CAST STEEL HEAT TREATED GRINDING BALLS • SHOVEL TEETH • MILL LINERS • DISCHARGE GRATES • CRUSHER JAWS • MANGANESE STEEL CASTINGS • CARBON AND ALLOY STEEL CASTINGS