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PIMA MINING COMPANY - A PROGRESS REPORT

George A. Komadina
Mill Superintendent
Pima Mining Company
Tucson, Arizona

This paper is to be presented at the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc., Chicago, Illinois, February 14 to 18, 1965.

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PIMA MINING COMPANY - A PROGRESS REPORT

By
GEORGE A. KOMADINA
MILL SUPERINTENDENT
PIMA MINING COMPANY

The Pima Mining Company lies 20 miles southwest of Tucson, Arizona, and some 45 miles north of the Mexican border. The mill is situated on a hillside overlooking Tucson and the Santa Cruz Valley, the ground generally sloping northeast at a 2.5 percent grade. The hillside location allows for gravity flow generally through the plant as well as for tailing disposal.

HISTORY

Unlike many mines whose beginnings are shrouded in antiquity, the Pima Mine is in a relatively new district and is a recent discovery.

In 1950, using geophysical methods, discovery of a buried deposit under 200 feet of desert alluvial wash was made by R. E. Thurmond and W. E. Heinrichs while engaged by the United Geophysical Company then headed by Herbert Hoover, Jr. Subsequent diamond drilling, shaft sinking and underground development developed an ore body amenable to open pit mining.

In the fall of 1955, Cyprus Mines Corporation exercised its option on the mine and assumed the management of Pima Mining Company. Union Oil Company retained a 25% interest and a 25% interest was sold to Utah Construction & Mining Company.

After a period of stripping the overburden over the main ore body along with construction work, milling was started in January, 1957. Initial milling rate was 3,000 tons per day.

The Pima Mine occurs in two main ore zones, the Present Pit and the Northeast extension of the Present Pit. These areas are overlain by 200 feet of alluvial wash and thicknesses of cemented conglomerates up to 40 feet. Mineralized areas presently known cover an area 4,000 feet x 2,000 feet comprised of contact metamorphic as well as porphyry type mineralization. The former hornfels rocks contain the high-grade ore as masses and disseminations of chalcopyrite in impure limestones. The latter type of disseminated mineralization occurs in the low-grade hanging wall arkosite rocks.

MINING

Alluvium is removed by a fleet of Caterpillar scrapers and bulldozers.

Primary drilling is done by two rotary drills. Nine-inch diameter holes are drilled. Bench heights are 40 feet.

FROM FLUOR UTAH'S EXPERIENCE IN ENGINEERING AND CONSTRUCTION FOR THE MINERALS INDUSTRY.

P5K

COPPER

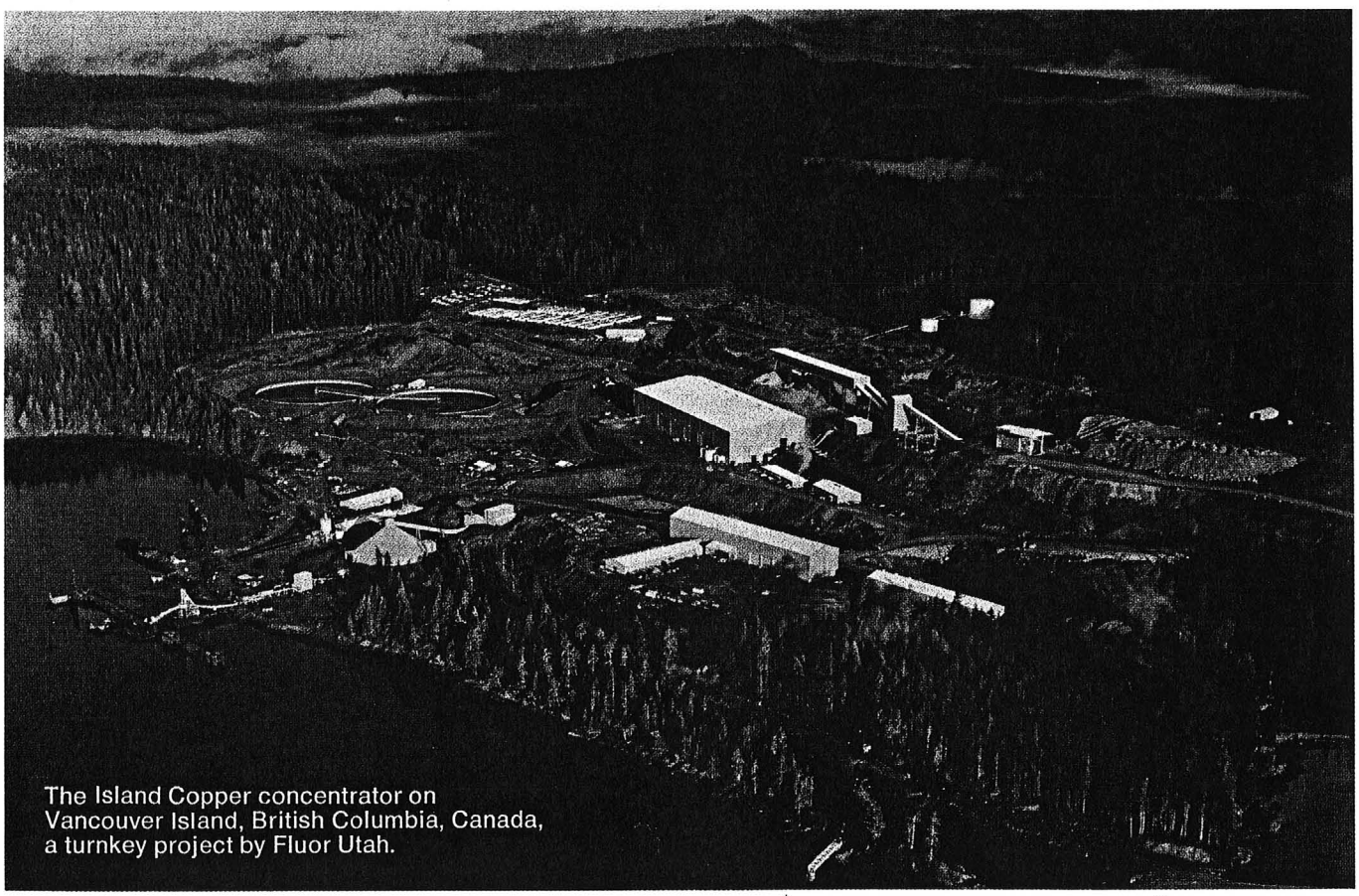
Two noteworthy
North American projects

ISLAND COPPER

33,000 TPD turnkey concentrator

PIMA MINING CO.

Expansion IV to 53,500 TPD



The Island Copper concentrator on Vancouver Island, British Columbia, Canada, a turnkey project by Fluor Utah.

FLUOR UTAH, INC.

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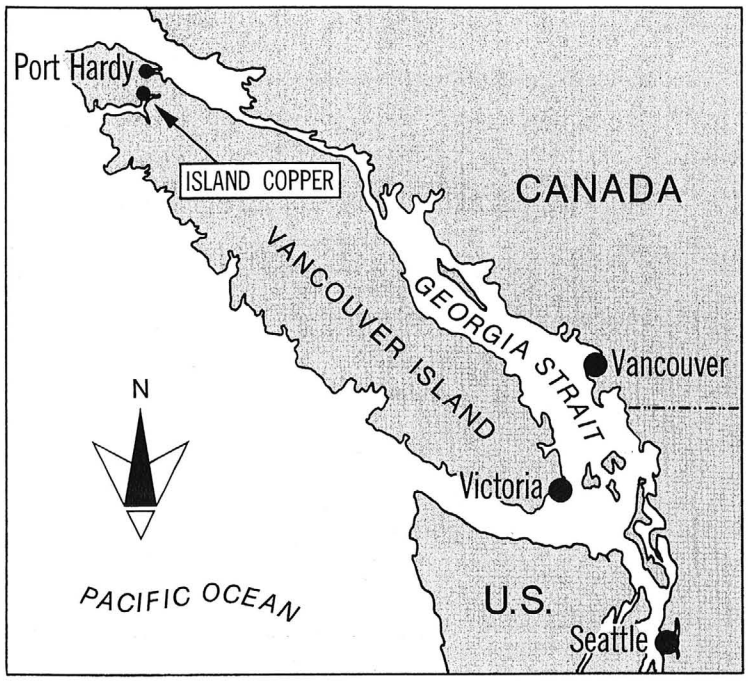


Island

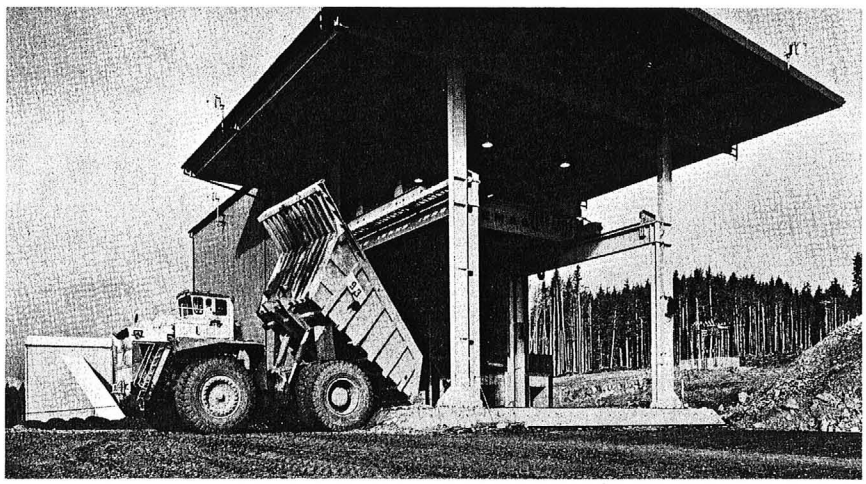
Near Port Hardy on Vancouver Island, the Island Copper 33,000 TPD concentrator—Canada's second largest—is now on stream. Designed, engineered and constructed by Fluor Utah at a total cost for concentrator and all ancillary facilities (excluding the pit) of approximately $50 million.

Completed on schedule, in a remote location, Island Copper represents a new milestone in modern copper concentrators. The grinding section is semi-autogenous and is the largest such installation in the history of the copper industry.

Fluor Utah's responsibilities included the definitive estimate . . . flowsheet preparation in collaboration with owner . . . preliminary design engineering . . . design engineering management . . . construction and construction management.

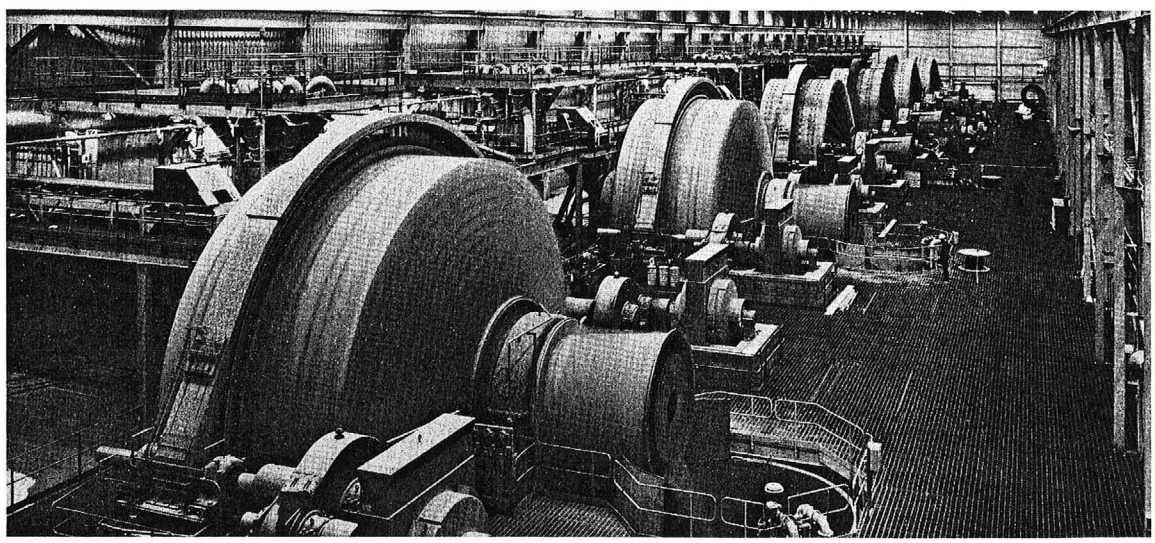
The total cost of approximately $50 million included, in addition to the copper processing facilities, a 600-man construction camp, maintenance shop and grease building, fresh and reclaim water systems, electrical power transmission and distribution systems, and various ancillary civil and structural works.

Copper



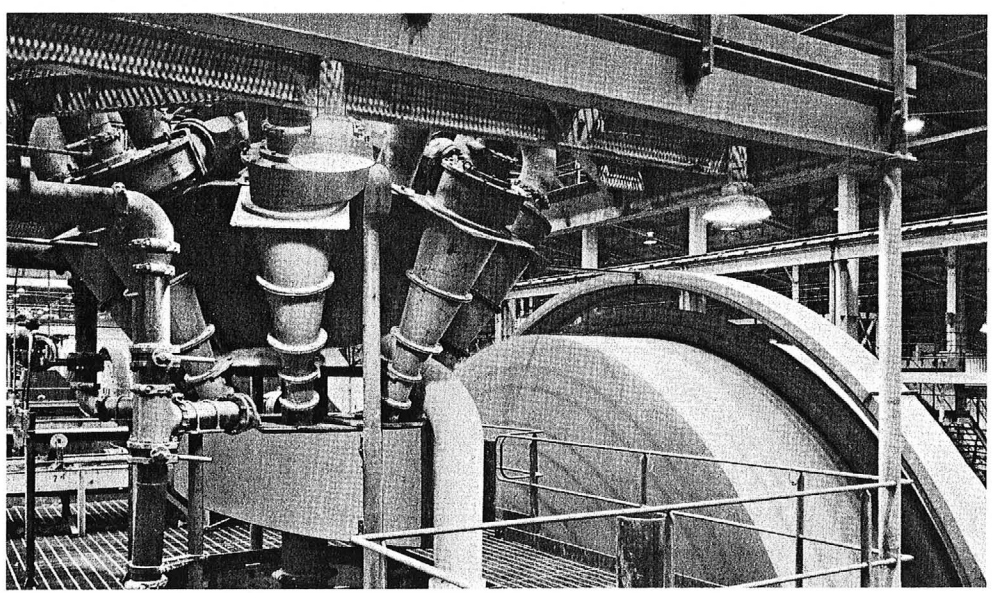
GYRATORY CRUSHER

This 54-inch gyratory crusher, processing 3,000 TPH, reduces ore to minus 12-inch size. From crusher, ore moves on a 60-inch belt to the screening tower, where it is sorted into plus 4-inch and minus 4-inch sizes by two 6-foot x 20-foot vibrating grizzlies.



WORLD'S LARGEST SEMI-AUTOGENOUS COPPER GRINDING CIRCUIT

Each of the six grinding mills is 32 feet in diameter and 14 feet shell length; and each is driven by two 3,000 HP, 900 RPM, 13,200 V wound rotor motors through two pinions to a girth gear, nearly 40 feet in diameter. The ground product for flotation averages 90% minus 100 mesh and 70% minus 200 mesh.



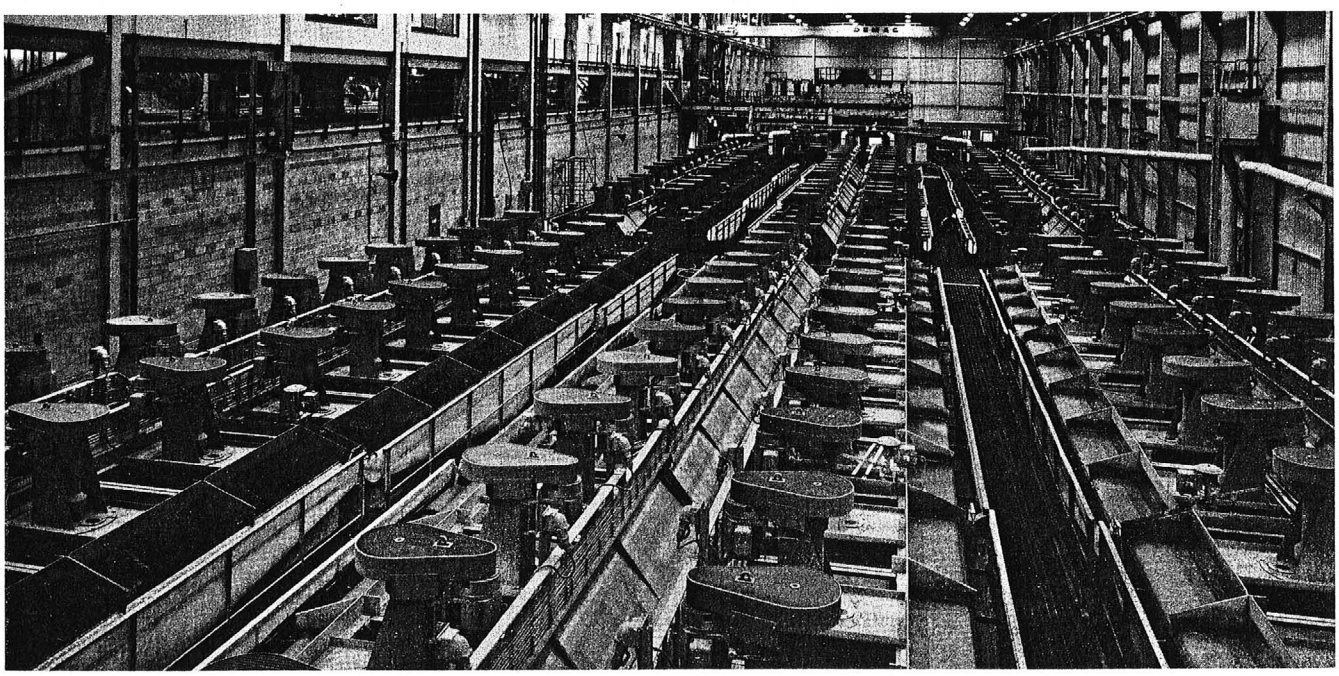
CYCLONE BANKS

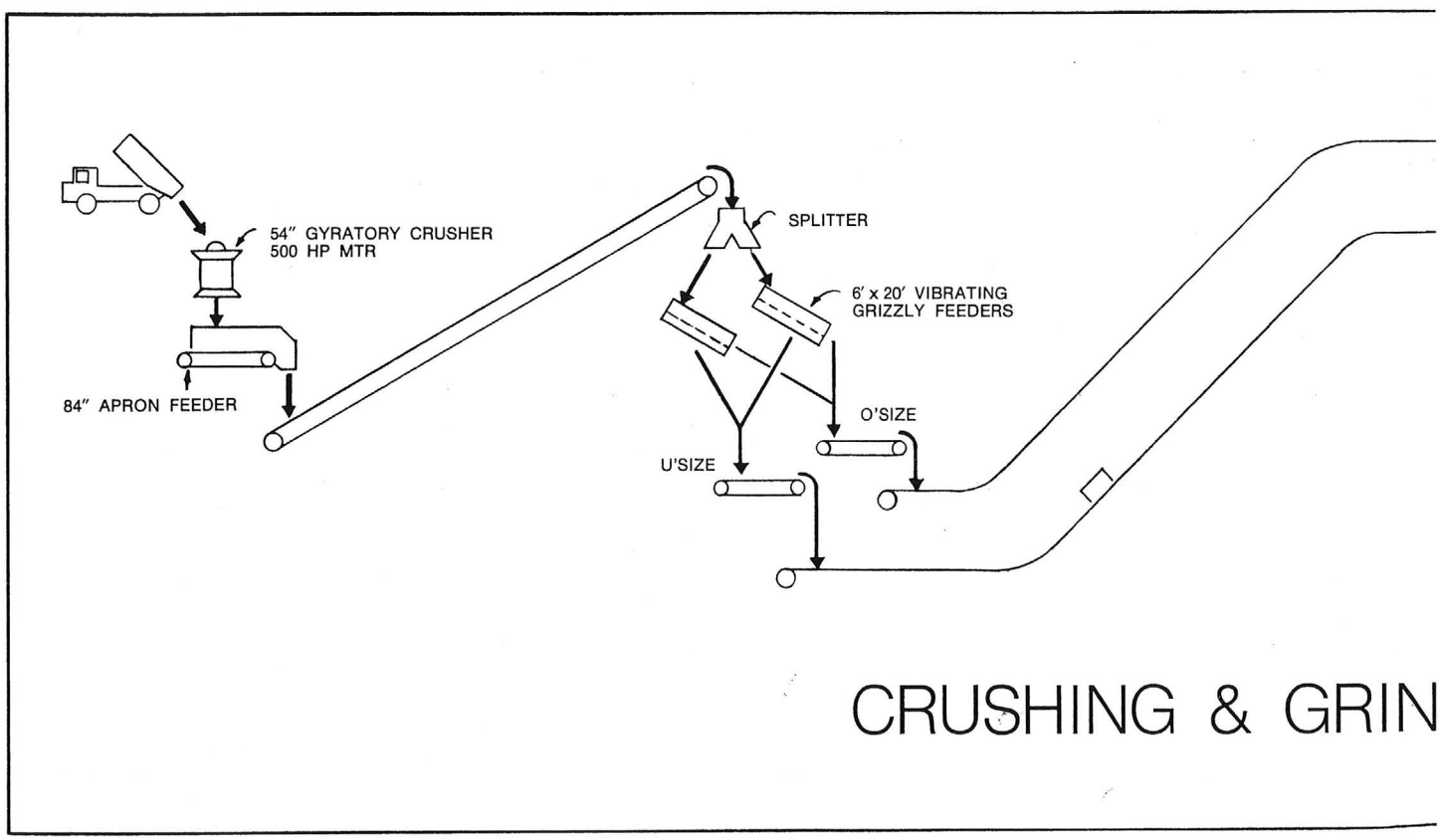
In closed circuit with the mills are six primary cyclone banks of eight cyclones each. Cyclone wear is minimized by recycling gross oversizes back into the mill with scalping trommels.

Island

FLOTATION

The copper flotation circuit consists of ten banks of rougher flotation, five banks of cleaner flotation, two recleaner banks and two scavenger banks. There is a separate molybdenum flotation section.



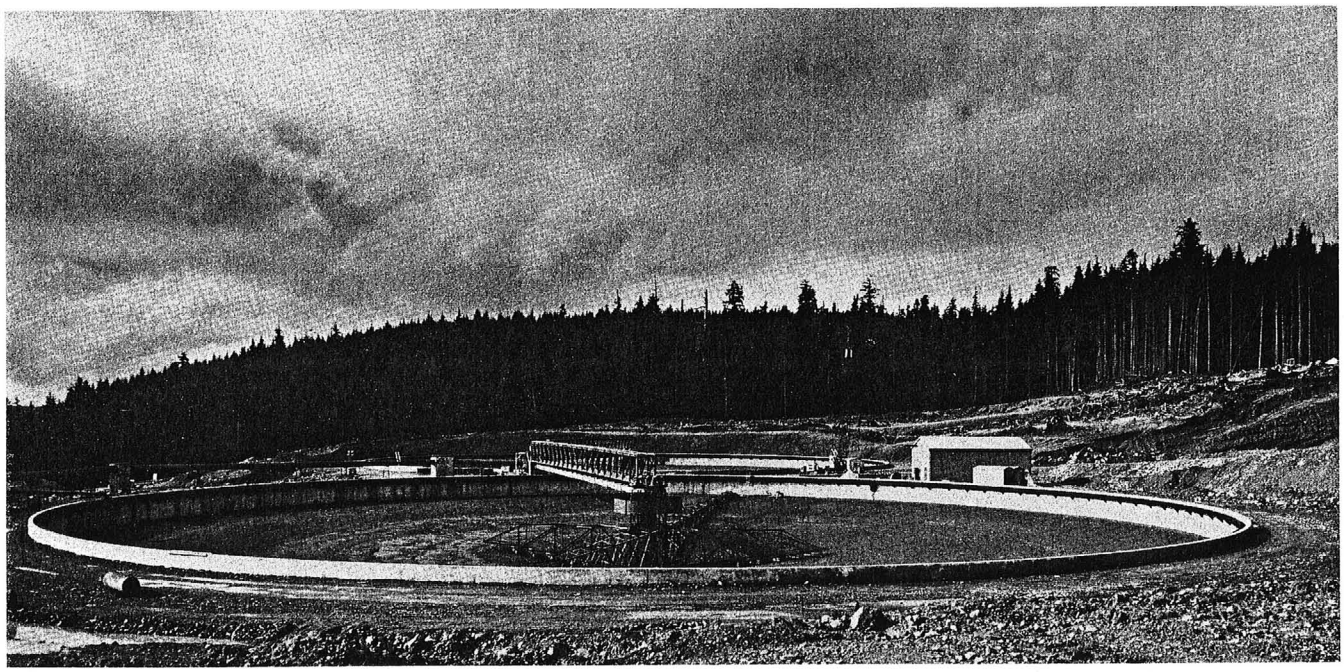


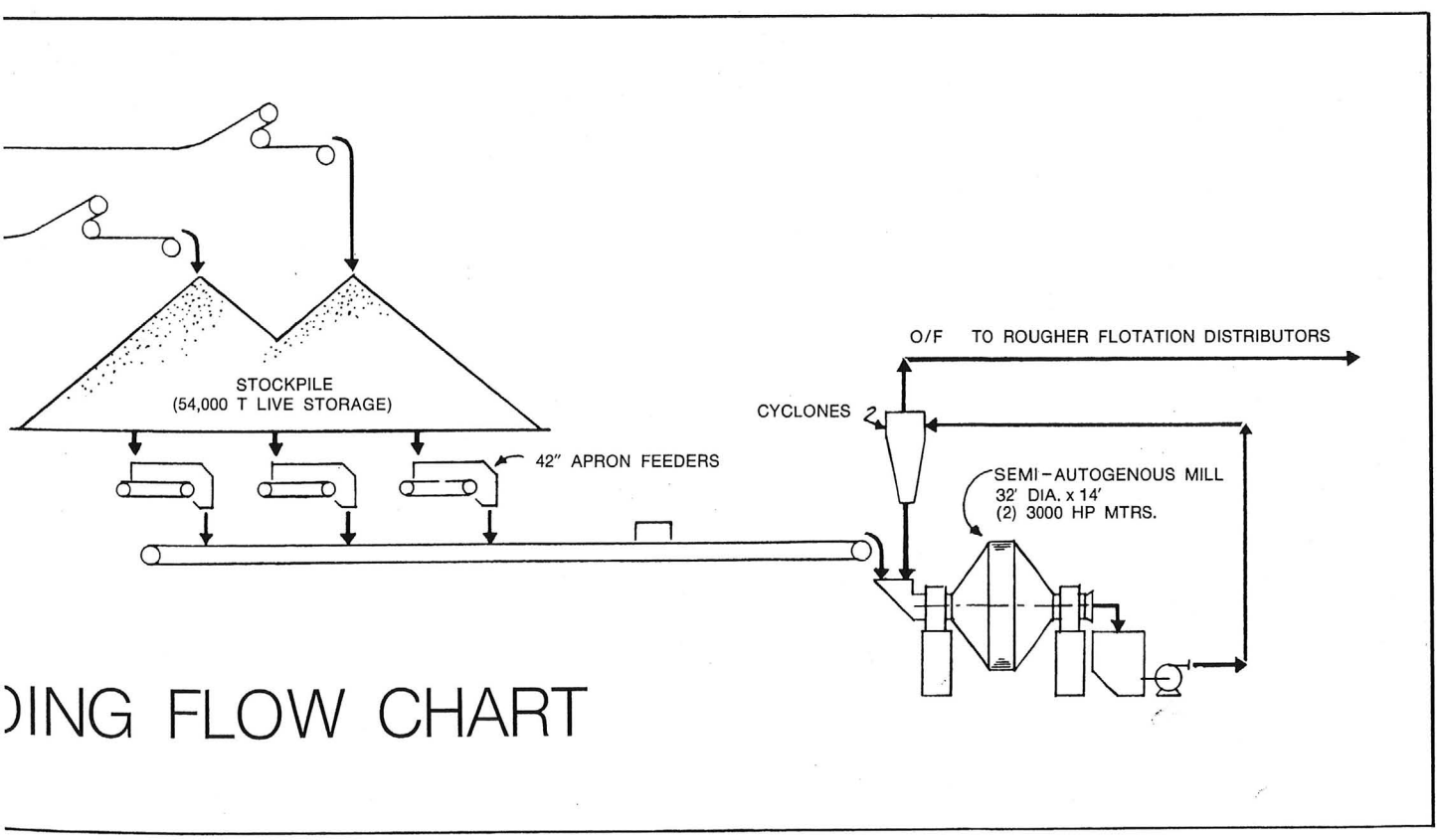
CRUSHING & GRIN

Copper

TAILINGS DISPOSAL

Tailings are gravity-fed to two 375-foot diameter, earth-bottom thickeners. Thickener underflow is maintained at 48-50% solids by modulation of rubber-sleeved valves, actuated by gamma gauge density controllers.





)ING FLOW CHART

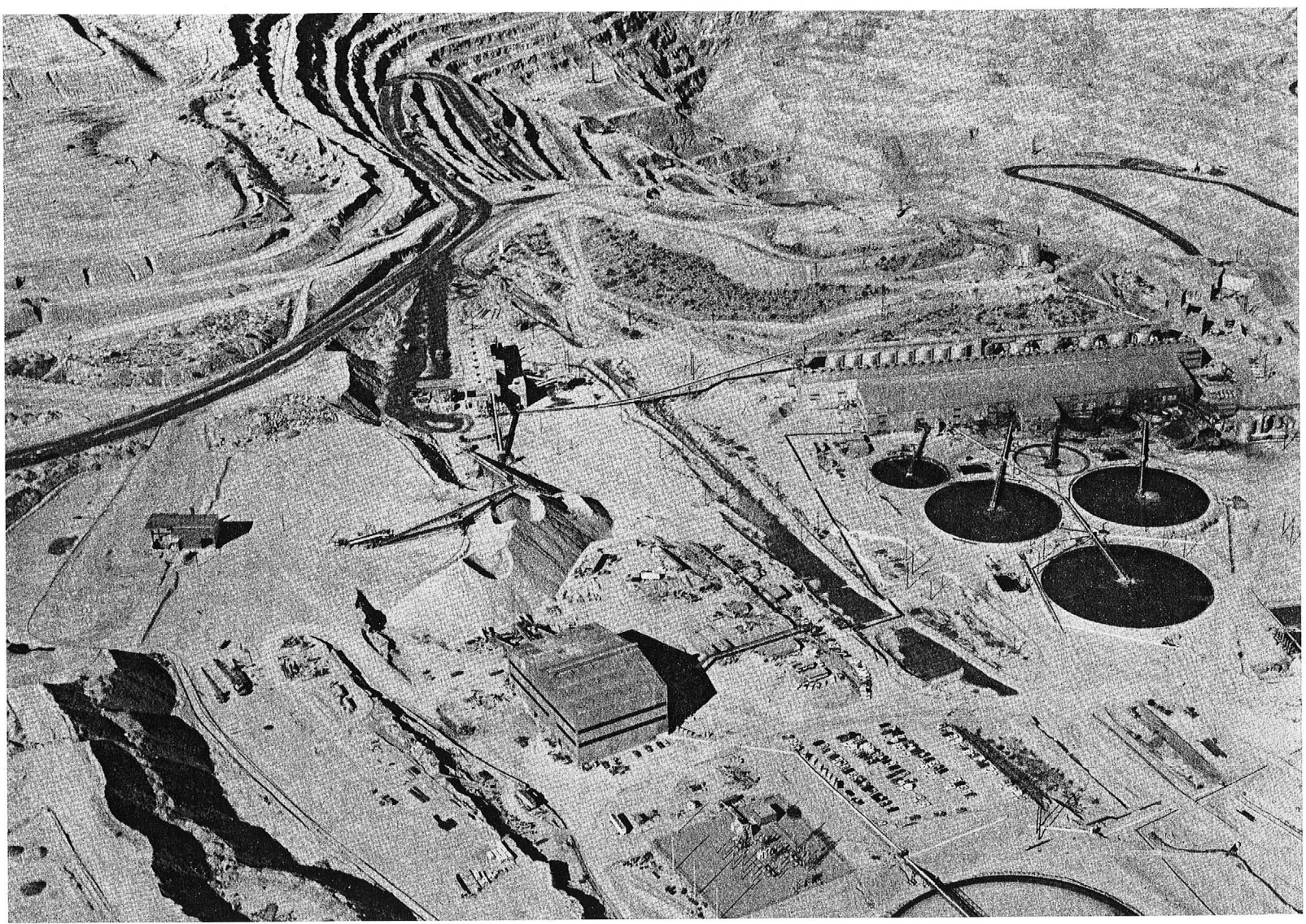
Pima Mining Comp

EXPANSION IV

Pima Mining Company began operations at its open-pit mine and concentrator, south of Tucson, Arizona, in 1955. The Fluor Utah organization constructed the original mill and also did pre-production mine stripping. Initially the mill's copper/molybdenum processing capacity was 3,000 TPD. Today it is 53,500 TPD.

This almost eighteenfold increase has been accomplished through four separate expansions. The Fluor Utah organization performed the engineering and construction for all of them. Expansion IV, which was recently completed and alone increased capacity by 35%, brought the annual output up to approximately 80,000 tons of contained copper in concentrates.

Fluor Utah's role consisted of engineering and construction of additional facilities for crushing, stockpiling, grinding and concentrating. The contract amount on IV was $15 million.



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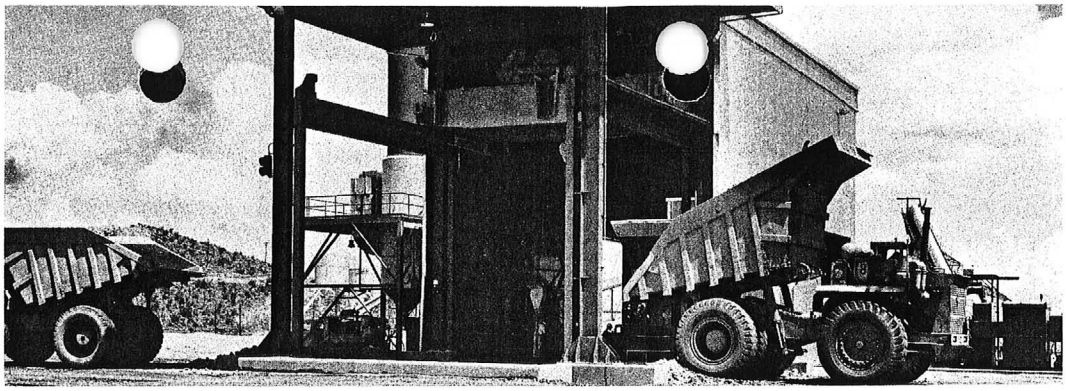
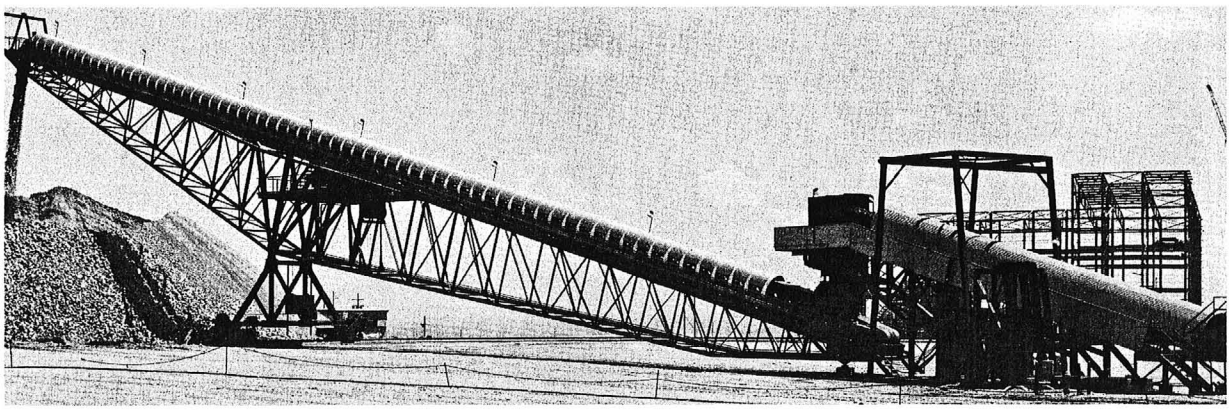
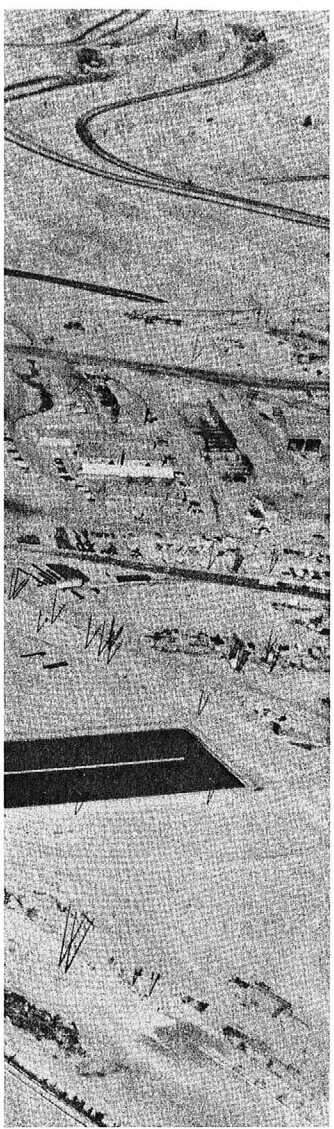


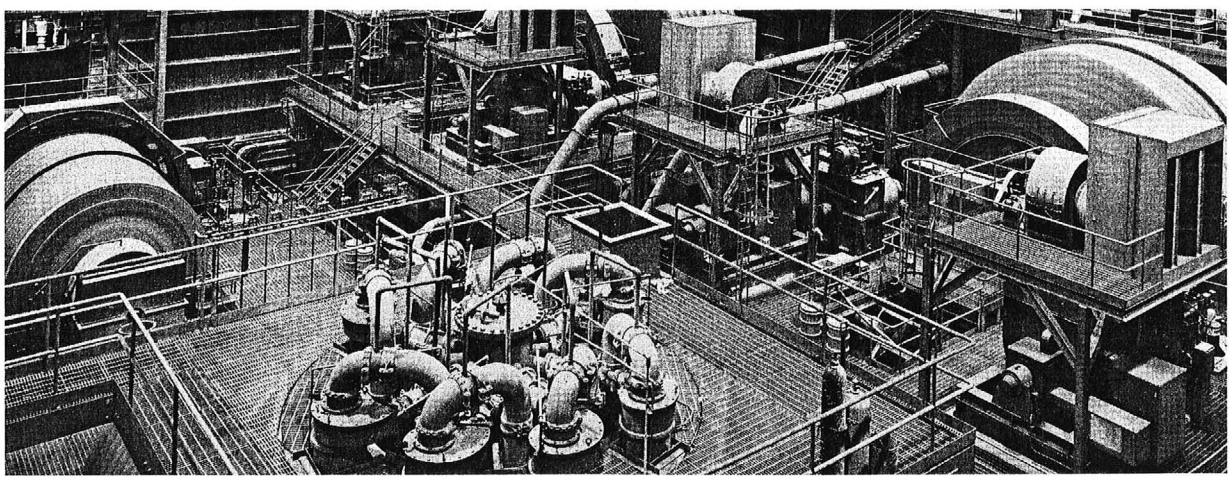
CRUSHING The new single-stage crushing plant, pictured above, contains a 54-inch primary crusher which reduces run-of-mine ore to minus 8-inch.

Pima Mining Company's open-pit copper/molybdenum mine and processing facilities, after completion of Expansion IV by Fluor Utah. The long structure in upper right center is the original mill after three expansions. Facilities added in Expansion IV include the new auxiliary mill ("stubby" building at lower left), primary crusher and radial stacker at left center, and the 400-ft. thickener at bottom right.

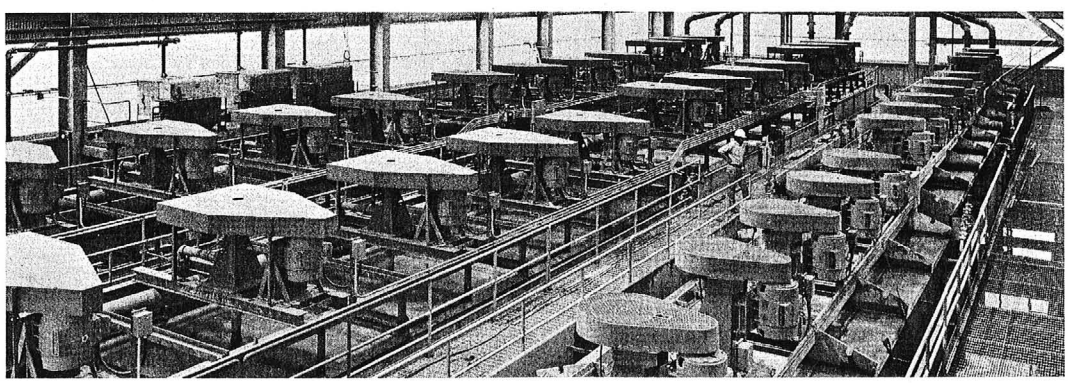


STOCKPILING Crushed ore is conveyed at the rate of 3,200 TPH to stockpile by a radial stacker. The stacker, 256 feet long, traverses on an arc of 106°.





GRINDING From stockpile, ore is fed to two semi-autogenous mills. These grinders were selected for their ability to reduce the ore size without additional crushing. Conventional rod or ball mill circuits require two or three crushing stages to reduce the ore to approximately half-inch size; Pima IV needs but one crusher. After going through the semi-autogenous mills, ore is further reduced in two ball mills.



CONCENTRATING Following grinding, the copper/moly is separated from waste in 300- and 400-cubic foot flotation cells. The concentrate is pumped to the main mill building for additional processing, and the tailings are sent to a 400-foot thickener to reclaim process water. The thickener underflow is pumped to tailings ponds.

Task Force Concept

Fluor Utah's Project Manager and General Superintendent on Pima's Expansion IV are shown here checking a construction detail. This picture typifies the Task Force concept of project organization which Fluor Utah has evolved from its own volume of experience and that of its parent company (Fluor Corporation). This method establishes the Project Manager as the center of project responsibility and liaison with both the client and Fluor Utah management.

What you can expect from Fluor Utah, Inc.

Mine feasibility studies, preliminary engineering, complete design, procurement, engineering and construction of mine and mill facilities. For turnkey operations or for expansions of existing facilities—anywhere in the world—Fluor Utah invites your inquiry. If you would like to know more about the company, please write Business Development Department.

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THE STORY OF THE PIMA MINE *

One of the more outstanding events in the history of the mining industry - the discovery of a major copper deposit by geophysics - occurred at the Pima Mining Company's property 17 miles southwest of Tucson, Arizona. Here in a typical setting of sagebrush and cactus, entirely devoid of surface mineral indications, this company has located and developed a promising copper orebody buried under 200 feet of alluvial wash.

History

The Pima ore body was the first base metal deposit of any magnitude in the western U. S. to be located by geophysical methods. Under the guidance of Herbert Hoover, Jr., who was then President of United Geophysical Corporation, Robert Thurmond and Walter Heinrichs -- exploration engineers for UGC -- made their first discovery in this area in 1950, using equipment primarily designed for use in exploration for buried mineral deposits. Subsequent preliminary drilling indicated a deposit of medium size and grade which could be worked by underground methods.

In January 1952 an underground development program was initiated and carried on until approximately the middle of 1954. During the latter phase of this program, it became apparent that the medium size high grade ore body could be more economically exploited if the halo zone of low grade material were incorporated as a part of the entire ore body. After extensive study, it was decided that the deposit could be more profitably worked as an open pit mine.

In the Fall of 1955, Cyprus Mines Corporation exercised its option and assumed management of Pima Mining Company. Union Oil Company retained a 25 percent interest and a 25 percent interest was sold to Utah Construction Company.

In November 1955, Utah Construction Company started removal of the overburden

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* Source: "Mining World" and W. J. Rundle of the Pima Mining Co.

over the main ore body. In April 1956, Pima started its own stripping operation alongside the Contractor. Utah completed its stripping contract on 1 October 1956 after having stripped 6 million yards of alluvium and waste rock. (Pima had stripped an additional 3 million yards of waste material during the time Utah was working in the pit).

Pima moved its offices to the mine site on June 1, 1956. All efforts were concentrated on completion of the mill, auxiliary buildings and the water supply system in order to get the mine into production. Plans were underway for a County Road due east of the mine which would shorten the haul of concentrates to our railroad spur on the Nogales Highway. Ore was being stockpiled for processing in the mill.

At 8:40 AM on December 15, 1956, the first load of rock was dumped into the crusher for a preliminary tryout. The mill turned over for the first time on December 21st -- and on December 28th, the first concentrates were made.

Pima started its shipments of concentrates to the El Paso smelter on 4 January 1957. There are still problems to be ironed out and some construction to be completed; but after almost seven years of hard work, the Pima Mine is adding its potential to the copper resources of the Country.

Geology

The Pima deposit includes two distinct types of ores:

(1) A highly altered limestone, strongly mineralized and relatively high grade, and

(2) Low grade disseminated ore mineralization in volcano-sediments.

The high grade ore occurs in what was originally a dolomitic limestone which has been thoroughly altered by igneous action to a calcium silicate rock called "hornfels"; the latter was subsequently impregnated with the ore minerals.

The ore formation dips about 45 degrees to the south and trends east-west, curving from a northwesterly bearing on the west to a slightly northeasterly direction on the east. It is quite variable in thickness but probably averages

about 200 feet. In the main part of the mine it has been developed over a lateral extent of 1,600 feet, extending into neighboring property on the west and being cut off by a fault to the east. Its lower limits have not been determined, but it has been intersected by drill holes at vertical depths of around 800 feet.

Enclosing the "hornfels" band is a thick series of detrital rocks, essentially a mixture of sediments and volcanic material, known as "pyroclastics". These have likewise been altered and mineralized, but the ore values are more sparsely distributed, yielding a low grade disseminated ore minable only by low-cost (i.e. open pit) methods. This type of ore is found in most extensive development to the east and northeast of the main high grade ore body. It shows no well-defined structural form, but occurs in irregular masses.

The principal ore mineral at Pima is chalcopyrite. There are also small amounts of sphalerite and molybdenite, neither of which is recovered at present. Pyrite and magnetite (magnetitic iron ore) are accessory minerals. For a short distance below the bedrock surface, the copper sulfides have been oxidized to form the green copper silicate, chrysocolla, and the black copper oxide, tenorite.

Various types of igneous rocks have been recognized in the Pima Mine, but none shows any direct connection with the ore values. It is generally believed that the entire region is underlain at fairly shallow depths by a granite mass which may be the source of the ore solution. Granite has been penetrated by drill holes a short distance west of the Pima property but has not been found to date in any of the Pima holes.

General Mine Description

The mining operation is planned for production of 3,500 tons per day.

The pit development is laid out for a final over-all slope of 1.45/1 in the alluvium and 1/1 in the rock.

Present daily production is as follows:

Ore mining	3,500 tons
Rock stripping and oxidized ore . .	8,500 tons
Alluvial stripping	12,000 tons
TOTAL	24,000 tons

The mine is operated on a 2-shift basis and equipment maintenance and repair on a 3-shift basis. At this time the total mine force consists of 73 men and the maintenance force consists of 29 men. These figures include supervision.

Mining equipment selected to accomplish scheduled production is as follows:

	PRODUCTION CAPACITY
Alluvial Stripping:	
6 - DW-21 Caterpillar Carryalls (rubber-tired)	122 tons/hr/unit
2 - D-8 Caterpillar Tractors (pushcats)	
1 - D-8 Caterpillar Tractor (ripper-dozer)	
Rock Stripping and Ore Mining:	
3 - 54-B Bucyrus-Erie Diesel Shovels $2\frac{1}{2}$ c.y. capacity	343.7 tons/hr/unit
7 - 802 Kenworth Rear Dump Trucks 23-ton capacity	77.5 tons/hr/unit
4 - 802-B Kenworth Tractor-Trailer Rear Dump Trucks	122.6 tons/hr/unit
1 - D-8 Caterpillar Tractor (dozer)	
1 - 40-R Bucyrus-Erie Rotary Blast Hole Drill	47 feet/hr/unit
General:	
1 - No. 12 Caterpillar Motor Grader	
1 - GMC Water Truck - 3,500 gallon capacity	
1 - GMC Flatbed Truck - $1\frac{1}{2}$ ton capacity	
2 - GMC Pickups - 3/4 ton capacity	

In addition to this equipment, a rockover skip system is being installed and will be in operation in the near future. The double drum hoist for this system is powered by four 500 HP wound rotor AC motors. These motors are semi-automatically controlled with grid resistors. Two 22-ton skips will be hoisted in balance and will transport ore and waste rock from the loading pocket (now on the 3070 bench) to the surface. The incline railway for the skip hoist has been placed on

the north side of the pit on what is considered to be a final pit slope. The capacity of this system will be 14,000 tons per day. When this system is in operation, the 802 Kenworths will be used only in the pit hauling to the loading pocket, and the 802-B Kenworths will be used to haul on the surface from the skipway bin to the crusher and to the waste dumps.

At this time, mining has progressed to the 3070 level. This level is roughly the top of the sulfide ore zone. A drop cut has recently been started below this level to the 3030 level.

Milling Operation

The purpose of the milling operation is to separate the wanted copper minerals from the unwanted "gangue" or waste rock. The first step in this separation is to reduce the ore to a size where the individual mineral and rock grains are substantially free of attachment to each other. This action is first accomplished by crushing equipment which reduces the ore to almost all minus 1-inch in maximum size.

Next, water is added and the ore is treated in rod and ball mills where the tumbling action of steel rods and steel balls grind the ore to a size where a large portion of the individual grains of rock and minerals are as fine as face powder.

The resulting suspension of ground rock and water is known as "pulp". The pulp is then agitated and aerated in a series of flotation machines. Certain chemicals are added which have an affinity for the copper minerals and create a water repellent coating on the mineral surfaces. The tiny coated mineral particles attach themselves to air bubbles created in the flotation machines and rise to the top of the machine in the formof a froth. The froth overflows the lip of the flotation machine.

The rejected material, consisting of unwanted rock, is not affected by the chemicals and flows out of the lower portion of the flotation machines. This material is pumped to the tailings disposal area where it is allowed to settle into storage basins covering several acres. The clear water resulting from this settling operation is decanted and returned to the mill water circuit.

The froth overflowing from the flotation machines is twice subjected to re-flotation in order to increase the concentration of copper minerals. The final froth is called "concentrate".

The concentrate is a thin suspension of copper minerals in water and is partially dewatered by thickening in a large circular tank. The partially de-watered concentrate is then treated in vacuum type filters where the water content is reduced to about 12% by weight. The filter cake or dewatered concentrate, containing 20 to 25 percent copper, is now ready for shipment to the smelter.

Conclusion

It took seven years of hard work to convert an area of sagebrush,cactus and alluvial wash to a potential source of valuable copper metal. If it had not been for the application of the latest geophysical know-how, the existence of such a copper orebody would never have been discovered. The Pima Mining Company is engaged in adding to Arizona's wealth instead of depleting it.

May, 1957

DEPARTMENT MINERAL RESOURCES
MINERAL BUILDING
FAIR GROUNDS
PHOENIX 7, ARIZONA

PIMA MINING COMPANY CONCENTRATOR

TUCSON, ARIZONA

by

George A. Komadina, Mill Superintendent

The open pit mine and concentrator of the Pima Mining Company is located approximately twenty miles south of Tucson, Arizona in the Mineral Hill area. The Pima ore body was discovered in 1950 and after an extensive underground development program it was decided that the deposit could be more profitably worked as an open pit mine. The concentrator was completed late in 1956, regularly scheduled operation was started on January 1, 1957. Through October, 1958 the concentrator has treated 2,010,548 dry tons of ore.

CRUSHING: Run-of-mine ore is fed by truck from the pit or dozer from a stockpile to the primary crusher chute. A Ross chain feeder draws ore over a 7-in. grizzly to feed a 66 x 84-in. Birdsboro jaw crusher set to produce -7-in. material. The crushed ore is transported to the secondary crushing and screening building by a 54-in. conveyor. The ore is screened over two double-deck Tyler F-900 Tyrock screens dressed with 1½ x 18-in. rod grizzlies on the top deck and 3/4 x 2-in. slotted woven wire on the lower deck. Oversize from the top decks passes to a 7-ft. standard Symons crusher and oversize from lower decks to a 7-ft. shorthead Symons crusher. The screens and crushers are so located that cross conveyors are not necessary -- the screens feed their respective

853

products by gravity into the crushers or onto the fine ore conveyor.

A Link-Belt automatic tripper distributes the -3/4-in. ore to two fine ore bins. These bins were designed to hold 6000 live tons, but experience has proved that the unexpectedly high angle of repose (up to 70°) reduces capacity to 4000 live tons. This relatively small bin capacity for the plant, which grinds up to 3600 tons per 24 hr. has required operation of the crushing and screening plant seven days a week rather than the expected six days. It is planned to increase bin capacity enough to permit operating the mill seven days a week with the crushing and screening plant running six days.

GRINDING: Ore is removed from each bin by means of a pair of tapered slots onto gathering feeder belts. Mill feed at rates up to 3600 tpd is drawn from any combination of two of the four belt feeders. The feeders, integrated with a weightometer provide uniform flow rates, discharge onto a conveyor that flows into the spout feeder of a 10 x 13 ft. Allis-Chalmers rod mill operating in open circuit. The rod mill discharge is split between two primary cyclone feed sumps. One side utilizes a 10-in. type T Ansco dredge pump, while the parallel unit is a type CT Barrett-Haentjens solids handling pump. Each unit delivers rod mill discharge at 50-57 percent solids to two 20-in. model D-20-B Krebs cyclones operated with a feed inlet pressure of 8-10 lb. At the present time 6-3/4-in. vortex finders and 3-1/2-in. ceramic apex pieces are used.

CYCLONE SEPARATION: The cyclones are able to take a fairly wide range of feed rates and still maintain overflows of 27 to 31 percent solids. The

underflow, at 80 to 85 percent solids, is delivered by a spout to a 10-1/2 x 13-ft. Allis-Chalmers overflow ball mill. The ball mill discharge, at 76 to 82 percent solids, returns to the cyclone feed sumps. A portion of the cyclone overflow is bled off to maintain constant levels in the sump boxes. The remainder is reduced to 27 to 28 percent solids prior to flotation.

The regrind circuit consists of a 7 x 12-ft. Allis-Chalmers overflow ball mill operating in closed circuit with six 10-in. model D-10-B Krebs cyclones. The cyclone overflow is used as dilution water in the primary grinding circuit. The use of the regrind circuit has been deferred until a change in character of ore requires finer grinding of either the middling fraction or the rougher concentrates. During the first 10 months of 1958, 88 percent by weight of the middling product was -200 mesh and contained 89 percent of the total copper in this product.

The rod mill, operating at 15.55 rpm, was charged with 3-1/2-in. and 4-in. rods at a rate of 0.572 lb. per ton for the first ten months of 1958, the October rate was 0.712. It now appears that 4-in. rods will be the standard makeup. Single wave chrome-moly steel liners are used. The initial set of shell liners treated 1,719,002 dry tons of ore.

One of the ball mills is now operating at 16.85 rpm or 70% of critical while the other one is scheduled to go to 18.6 rpm or 77.5% of critical at an early date. Considerable increase in ore hardness has necessitated the speedup of the mills. Ball consumption for the first ten months of this year was 1.079 lb. per ton, in October the rate was 1.215. Starting late in October ball rationing was resumed using one-third

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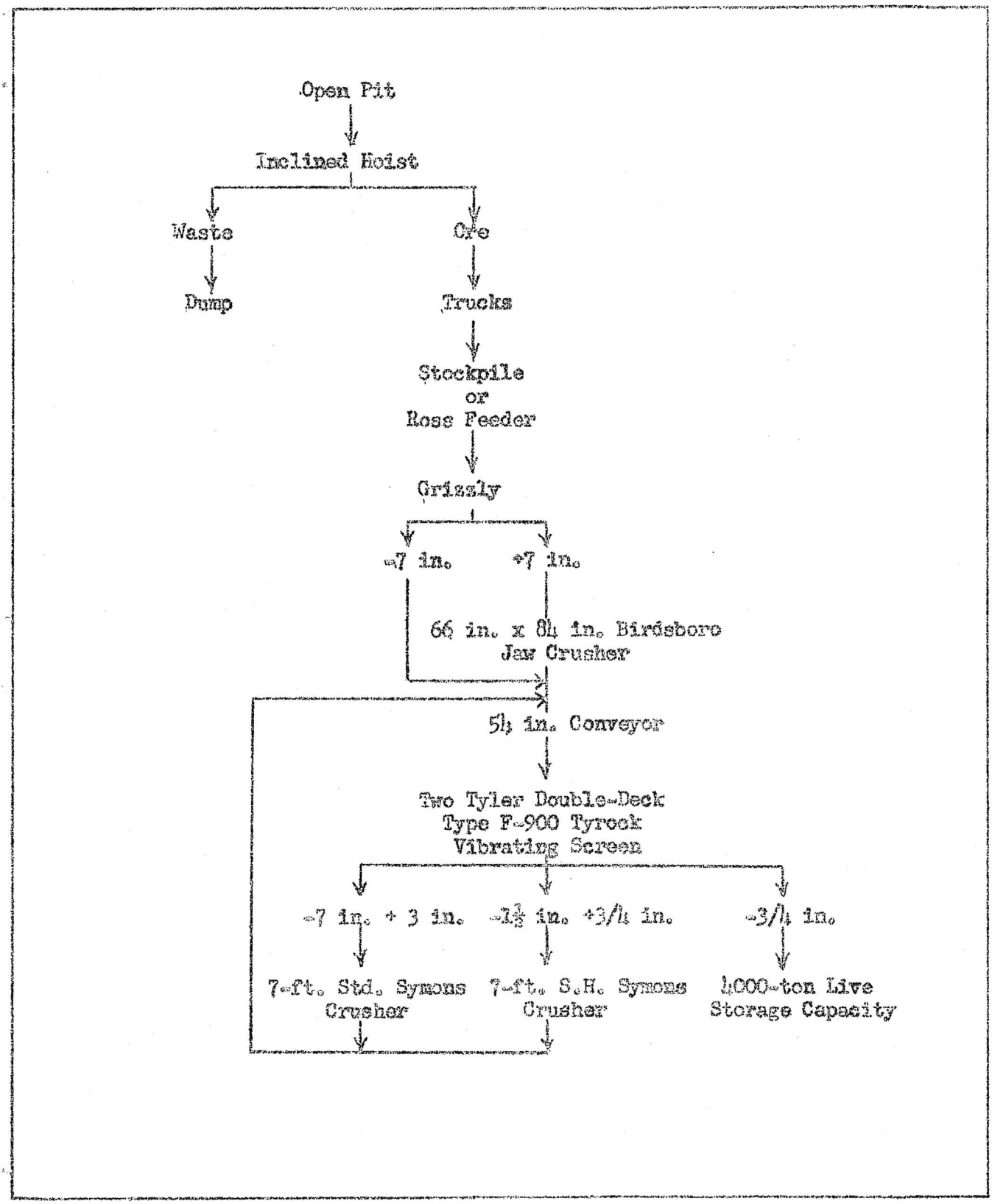
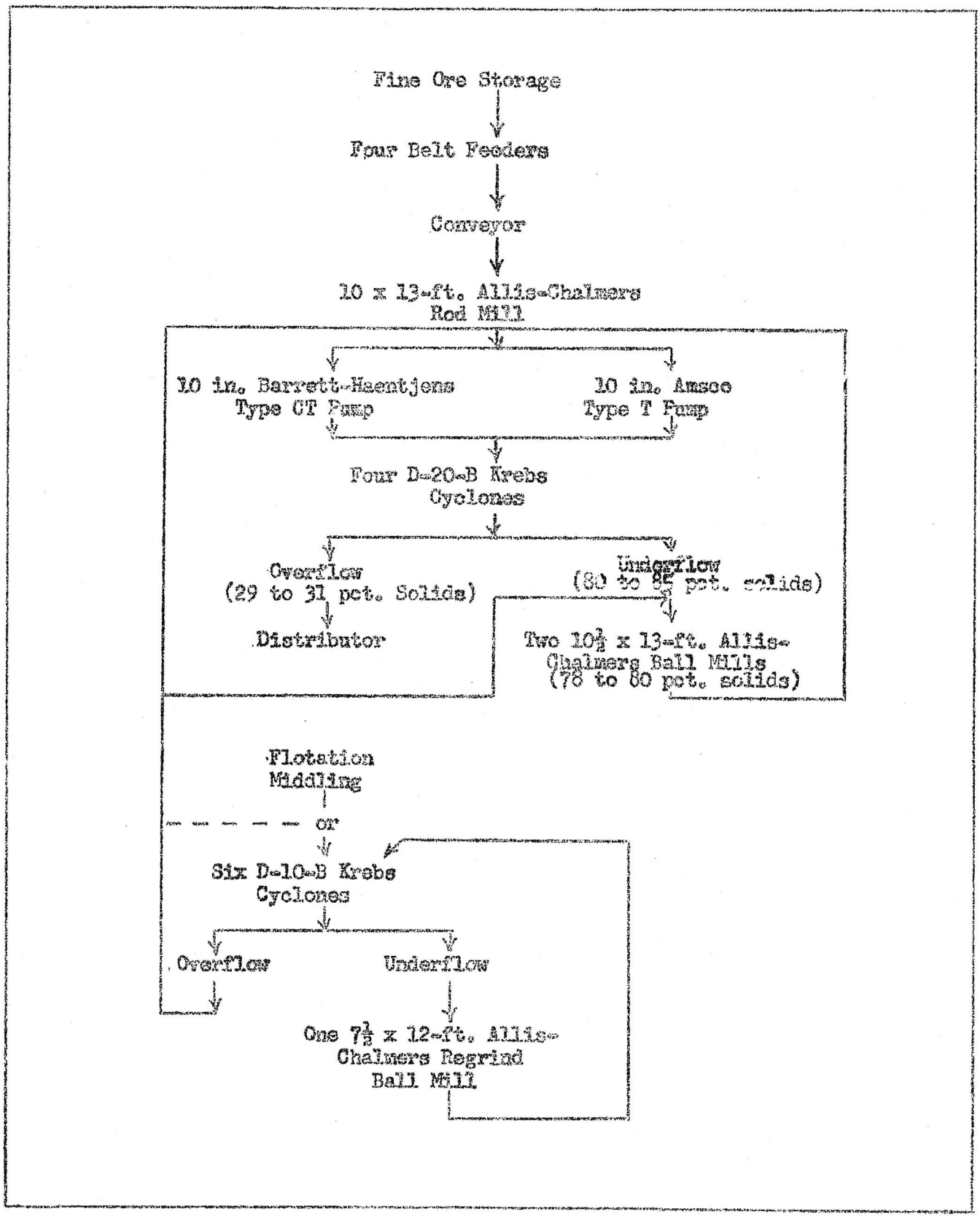
CRUSHING FLOWSHEET



B52

GRINDING FLOWSHEET



B49

three inch, balance two inch. Double wave chrome-moly steel liners are used in the ball mills. All of the original liners are still in the ball mills, in the very near future the feed end liners will have to be replaced.

As yet there is no information to show the effect of feed rates, pressures, and other variables on classification performance of the cyclones.

THE FLOTATION SECTION: The flotation feed passes through a distributor that divides the pulp to six parallel banks of 66-in. single overflow Fagergren flotation machines. The rougher concentrate from the first four cells goes to the 10-cell No. 24 Denver cleaner and recleaner machine. The cleaner tailings are combined with the scavenger concentrate produced on the last six cells of the rougher bank. At present this middling pulp is being pumped to the head of the primary grinding circuit for use as dilution water. The alternate flow is to send the middlings to the regrind circuit.

Recleaner concentrate flows to a 50-ft. Dorr thickener, the underflow is moved by centrifugal pump to a 6-ft. diameter 7-disc Eimco filter, and overflow is returned to the middling sump for use as dilution water in the grinding circuit. Experience has shown that the pump can be directly connected to the underflow discharge spigot. Currently the thickener is also used for storage to permit filtering for 2 hours and then an idle storage period for 10 hours. This cycle is repeated twice every 24 hours. The filtered concentrate (containing 10 to 11 percent water) is conveyed to storage and then scraped by a Joy slusher into 25-

B48

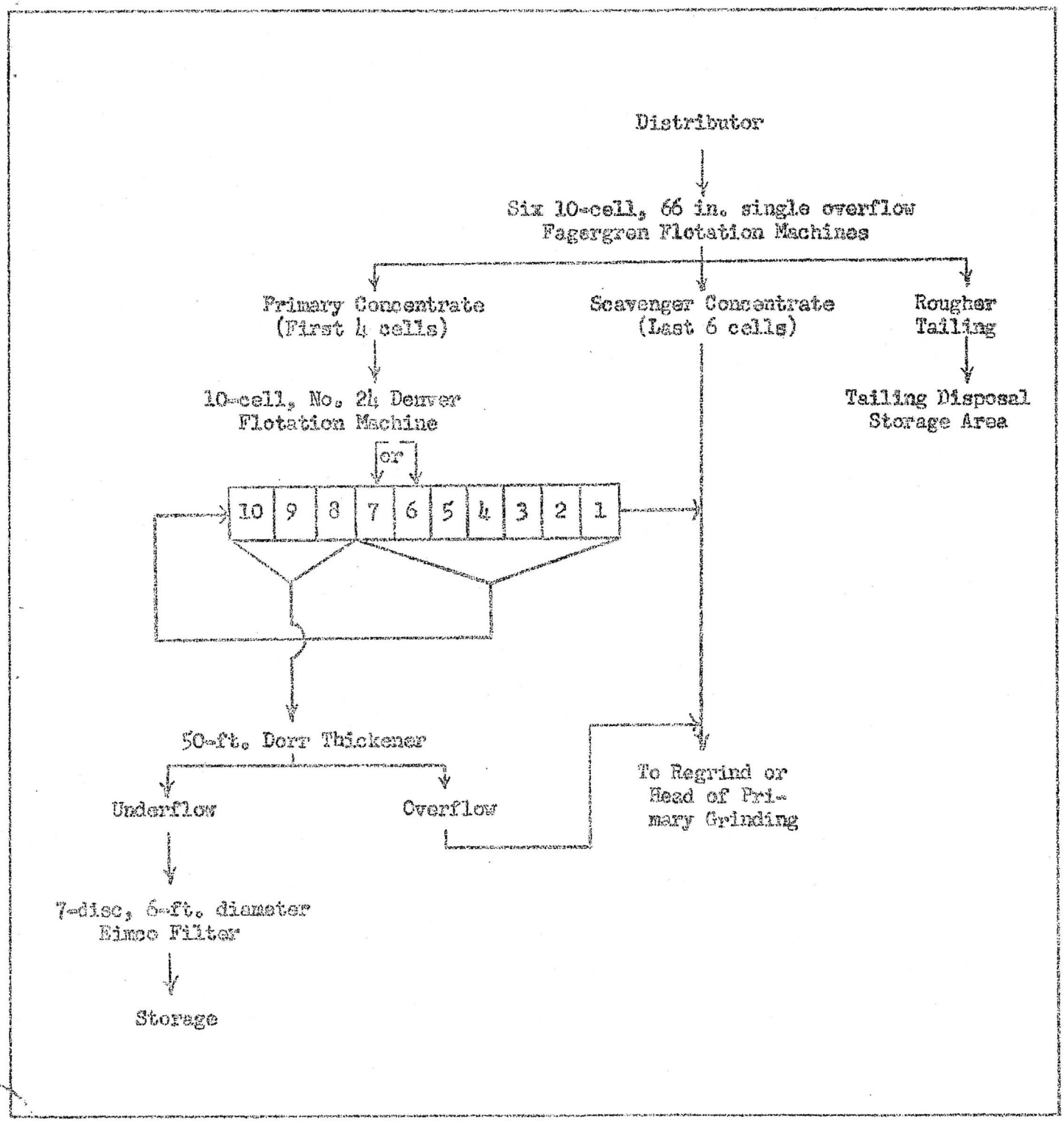
ton Kenworth dump trucks. The concentrate is weighed and sampled for moisture at the mill and then hauled seven miles to the railroad. After the car is loaded and leveled, it is pipe-sampled in a grid pattern for copper analysis. Concentrate is shipped to the copper smelter at Hayden.

Tailing from the concentrator flows by gravity unthickened to slime disposal ponds 5000 ft. from the mill. This pulp is cycloned to remove the sand fraction for berm building while the slimes flow to the central portion of the storage pond. Reclaimed water passes through six inch drain holes in a decant line placed at each six inch rise in elevation. At a later date a decant tower will be constructed at the end of the present decant line. Water passes through the decant line to a gathering sump from which it is pumped to a 250,000 gallon water storage tank above the mill. The mill water is treated with phosphate to minimize lime scaling in the various mill water lines.

Fresh water is pumped six miles from wells along the Santa Cruz river to a 50,000 gallon storage tank. This is the potable water supply as well as make-up for the mill. The mill requires 240 gallons of make-up water per ton of ore treated.

REAGENTS: Mill reagents are mixed on day shift and pumped to day storage tanks. Pebble lime is purchased and slaked in a Dorr lime slaker. The lime slurry is pumped throughout the mill and is withdrawn as needed. Nearly all the lime being added is used in the grinding circuit. A pH of 11.3 to 11.5 has been found optimum for current ores when using the following reagent combination which was standard for the first six months of this year. Lime, Z-6 and/or Z-11 xanthate and methyl isobutyl carbinol

FLOTATION FLOWSHEET



B46

(MIBC) are added to the rod mill. Z-6, Z-11 and MIBC are added to the distributor, the second, fourth, sixth and eighth cells. Sodium sulfide, when needed, is added to the fourth, sixth and eighth cells.

After laboratory investigation showed promise a mill test employing Z-200 as one of the reagents was tried during July and a portion of August. The results were encouraging so during September a repeat test was scheduled. More operating details were clarified so that an optimum condition could be determined. During October the plant used this anticipated optimum condition and came up with results that compared with the better to date. The change from the standard previously described was that Z-200 was substituted for the Z-11 in all points of addition, Z-6 was reduced in quantity, a pH of 10.2 maintained on the grinding circuit. Dowfroth 250 or MIBC was found to be approximately equal in the laboratory -- mill testing of this condition is currently being carried on.

The average reagent consumption in pounds per ton of ore milled for the various periods follows.

	First Six Months, 1958	October, 1958
Lime	6.849	3.104
Z-6, Xanthate	0.086	0.039
Z-11, Xanthate	0.043	----
MIBC	0.094	0.012
Dowfroth 250	----	0.045
Sodium cyanide	0.019	0.004
Sodium sulfide	0.429	0.032
Phosphate	0.014	0.010
Z-200	----	0.040

The concentrator is laid out to utilize the natural slope for gravity flows through the plant. The entire plant is designed to use minimum labor. The crushing crew, working on single shift under a foreman, consists of one primary and one secondary operator and one or two laborers

B45

who clean up spills and remove wood and steel from the ore. Steel is removed by hand -- a tramp steel detector will not work because of the magnetite content of the ore.

The plant operates on a seven-day basis, relief operators are employed to maintain a five-day work week for all hourly employees. The concentrator is handled by a shift foreman, a grinding operator, flotation operator and a tailing laborer. On day shift a concentrate loader and a reagent man are also available. Maintenance of the mill and crusher is handled by nine repairmen, one oiler, and three laborers under the direction of the repair foreman. The total mill manpower of 50 includes supervision, operation, maintenance, metallurgy, sampling, assaying and clerical employees.

Electrical power purchased from the Tucson Gas, Electric Light & Power Company is delivered to the Pima substation at 44,000 v. Power is stepped down to 4160 v for distribution to the mine and mill. Power consumption for the first 10 months per tone is as follows:

Crushing	1.087
Concentrator	16.312
Fresh water	2.288
Reclaim water	0.593
Total mill	20.280 KWH per ton milled

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APPENDIX

ROD MILL SCREEN ANALYSIS, JANUARY-OCTOBER, 1958

FEED

Size	Percent Retained	Cum. Pct. Retained
+ 1 inch	0.04	
-1 +½ inch	19.10	19.14
-½ in. +4 mesh	37.76	56.90
-4 mesh	43.10	100.00
Total	100.00	

DISCHARGE

Size	Retained	Retained
+ 8	3.02	
+ 10	3.97	6.99
+ 28	26.22	33.21
+ 48	15.09	48.30
+ 65	5.23	53.53
+ 100	6.03	59.56
+ 150	5.18	64.74
+ 200	4.10	68.84
+ 325	7.15	75.99
- 325	24.01	100.00
Total	100.00	

FLOTATION CONCENTRATE ASSAYED SCREEN ANALYSIS JANUARY THROUGH SEPTEMBER, 1958

Size	Percent Retained	Cum. Pct. Retained	Assay Pct. Total Cu	Distribution Percent	Distribution Cum. Pct.
+ 100	0.82		16.77	0.60	
+ 150	3.54	4.36	20.09	2.74	3.34
+ 200	7.70	12.06	23.56	6.91	10.25
+ 270	13.82	25.88	25.34	13.21	23.46
+ 325	8.73	34.61	25.65	8.46	31.92
- 325	65.39	100.00	27.57	68.08	100.00
Total	100.00		26.56	100.00	

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APPENDIX

FLOTATION TAILING ASSAYED SCREEN ANALYSIS
JANUARY THROUGH SEPTEMBER, 1958

Size	Percent Retained	Cum. Pct. Retained	Assay Pct. Total Cu	Distribution Percent	Distribution Cum. Pct.
+ 65	1.91		0.49	3.36	
+ 100	6.74	8.65	0.34	8.63	11.99
+ 150	10.23	18.88	0.28	12.26	24.25
+ 200	9.72	28.60	0.24	9.91	34.16
+ 270	11.38	39.98	0.21	10.16	44.32
+ 325	6.39	46.37	0.19	5.24	49.56
- 325	53.63	100.00	0.22	50.44	100.00
Total	100.00		0.236*	100.00	

* Of this 0.089 percent is oxide and 0.147 percent is non-oxide copper.

SUMMARY OF OPERATING DATA
JANUARY THROUGH OCTOBER, 1958

Flotation feed pH	11.3
Rod consumption	0.572 lb. per ton
Ball consumption	1.079 lb. per ton
Crusher operated (single shift basis)	86.17 percent
Mill operated (3 shift, 7-day basis)	96.23 percent
Ore, Specific Gravity	2.937

PERCENT SOLIDS IN MILL PULPS

Rod mill discharge		70.57	
Cyclone feed	No. 1 - 54.05		No. 2 - 54.85
Cyclone Underflow	No. 1 - 82.94		No. 2 - 81.61
Cyclone overflow	No. 1 - 29.13		No. 2 - 30.10
Ball mill discharge	No. 1 - 79.78		No. 2 - 79.10
Rougher flotation feed		27.01	
Cleaner flotation feed		17.30	
Recleaner flotation feed		16.00	
Concentrate Thickener Underflow		53.80	

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APPENDIX

METALLURGICAL SUMMARY
JANUARY THROUGH OCTOBER, 1958

Product	Dry Tons	Assay, Pct. Copper			Distribution, Pct.		
		Total	Oxide	Sulfide	Total	Oxide	Sulfide
Mill Feed	915,989	1.84	0.09	1.75	100.00	100.00	100.00
Concentrate	56,979	26.39	0.28	26.11	88.98	18.27	92.83
Tailings	859,010	0.21	0.08	0.13	11.02	81.73	7.17

OCTOBER, 1958 RESULTS
EMPLOYING Z-200 AND Z-6 AS COLLECTOR

Product	Dry Tons	Assay, Pct. Copper			Distribution, Pct.		
		Total	Oxide	Sulfide	Total	Oxide	Sulfide
Mill Feed	90,536	1.78	0.03	1.75	100.00	100.00	100.00
Concentrate	5,338	27.85	0.18	27.67	92.08	36.06	93.02
Tailings	85,198	0.15	0.02	0.13	7.92	63.94	6.98

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RESUME OF MINING OPERATION

PIMA MINING COMPANY

Open Pit Division, A.I.M.E.

April 25, 1950

B4D

HISTORY

The Pima ore body was the first base metal deposit of any magnitude in the western United States to be located by geophysical methods. Exploration engineers for United Geophysical Company made their first discovery in this area in 1950, using equipment primarily designed for use in exploration for buried mineral deposits. Subsequent preliminary drilling indicated a deposit of medium size and grade which could be worked by underground methods.

In January 1952 an underground development program was initiated and carried on until approximately the middle of 1954. During the latter phase of this program, it became apparent that the medium size high grade ore body could be more economically exploited if the halo zone of low grade material were incorporated as a part of the entire ore body. After extensive study, it was decided that the deposit could be more profitably worked as an open pit mine.

In the Fall of 1955, Cyprus Mines Corporation exercised its option and assumed management of Pima Mining Company. Union Oil Company retained a 25 percent interest and a 25 percent interest was obtained by Utah Construction Company.

In November 1955, Utah Construction Company started removal of the overburden over the main ore body. In April 1956, Pima started its own stripping operation along side the contractor. Utah completed its stripping contract on 1 October 1956 after having stripped 6 million yards of alluvium and waste rock. (Pima had stripped an additional 3 million yards of waste material during the time Utah was working in the pit.)

On December 15, 1956, the first load of rock was dumped into the crusher for a preliminary tryout. The mill turned over for the first time on December 21st - and on December 28th, the first concentrates were made.

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GEOLOGY

The Pima deposit includes two distinct types of ore:

1. A highly altered limestone, strongly mineralized and relatively high grade, and

2. low grade disseminated ore mineralization in volcano-sediments.

The high grade ore occurs in what was originally a dolomitic limestone which has been thoroughly altered by igneous action to a calcium silicate rock called "hornfels"; the latter was subsequently impregnated with the ore minerals.

The ore formation dips about 45 degrees to the south and trends east-west, curving from a northwesterly bearing on the west to a slightly northeasterly direction on the east. It is quite variable in thickness but probably averages about 200 feet. In the main part of the mine it has been developed over a lateral extent of 1,600 feet, extending into neighboring property on the west and being cut off by a fault to the east. Its lower limits have not been determined, but it has been intersected by drill holes at vertical depths of around 600 feet.

Enclosing the "hornfels" band is a thick series of detrital rocks, essentially a mixture of sediments and volcanic material, known as "pyroclastics". These have likewise been altered and mineralized, but the ore values are more sparsely distributed, yielding a low grade disseminated ore minable only by low-cost (i.e. open pit) methods. This type of ore is found in most extensive development to the east and northeast of the main high grade ore body. It shows no well-defined structural form, but occurs in irregular masses.

The principal ore mineral at Pima is chalcopyrite. There are also small amounts of sphalerite and molybdenite, neither of which is recovered at present. Pyrite and magnetite (magnetitic iron ore) are accessory minerals. For a short distance below the bedrock surface, the copper sulfides have been oxidized to form the green copper silicate, chrysocolla, and the black copper oxide, tenorite.

Various types of igneous rocks have been recognized in the Pima Mine, but none shows any direct connection with the ore values. It is generally believed that the entire region is underlain at fairly shallow depths by a granite mass which may be the source of the ore solution. Granite has been penetrated by drill holes a short distance west of the Pima property but has not been found to date in any of the Pima holes.

GENERAL MINE DESCRIPTION

The mining operation is planned for production of 3,500 tons per day of 1.93% copper ore at 0.60% cut off, and sufficient stripping of alluvium and waste rock to maintain developed ore.

The pit development is laid out for a final over-all slope of 1.2 to 1 in the alluvium, 50' bank heights, 0.6 to 1 bank slopes, 30' benches except at the base of the alluvium where an 85' bench is left as a measure of protection from excessive sloughing. Final slopes in rock are laid out at 1 to 1 with 40' bank heights, 0.375 to 1 bank slopes, and alternate 10' and 40' benches.

Present daily production is approximately as follows:

Ore mining - - - - - - - - - - - - - - - -	1,600 cubic yards
Rock stripping and oxidized ore - - - - - -	4,400 cubic yards
Alluvial stripping - - - - - - - - - - - -	6,000 cubic yards
TOTAL - - - - - - - - - - - - - -	12,000 cubic yards

The mine is operated on a 3-shift basis and equipment maintenance and repair is also on a 3-shift basis. At this time the total mine force consists of 115 men and the maintenance force consists of 43 men. These figures include supervision.

The present stripping ratio is a little over 3 cubic yards per ton of ore. The stripping ratio for the remaining life of the mine is 2.6 cubic yards/ton of ore.

Mining equipment selected to accomplish scheduled production is as follows:

	PRODUCTION CAPACITY
Alluvial Stripping:	
6 - DW-21 Caterpillar Carryalls - - - - (rubber-tired)	75.3 cubic yards/hour/unit
2 - D-8 Caterpillar Tractors - - - - - - (pushcats)	
1 - D-8 Caterpillar Tractor - - - - - - (ripper-dozer)	

PRODUCTION CAPACITY

Rock Stripping and Ore Mining:

3 - 54-B Bucyrus-Erie Diesel Shovels - 2½ cubic yard capacity	123.5 cubic yards/hour/unit
7 - 802 Kenworth Rear Dump Trucks - - -	45.8 cubic yards/hour/unit
4 - 802-B Kenworth Tractor-Trailer Rear Dump Trucks - - - - - - - - - -	59.0 cubic yards/hour/unit
1 - D-8 Caterpillar Tractor (dozer) - -	
1 - Westfall Rubber Tired Dozer - - - -	
1 - 40-R Bucyrus-Erie Rotary Blast Hole Drill - - - - - - - - - -	45.0 feet/hour/unit

General:

1 - No. 12 Caterpillar Motor Grader
1 - GMC Water Truck - 3,500 gallon capacity
1 - GMC Flatbed Truck - 1½ ton capacity
3 - GMC Pickups - 3/4 ton capacity

In addition to the above listed equipment, a rockover skip system is used to hoist ore and waste from the 3070 bench to the surface (3315'). The double drum hoist for the system is powered by four 500 H.P. (1750 RPM) wound rotor AC motors. The hoist is somewhat unique in that high speed AC motors are used. The two 20 ton skips are normally hoisted in balance but may be operated separately (when not loaded) by unclutching the drums. The hoist rope speed is 1650'/min.

The inclined railway for the system has been placed on the north side of the pit on what is considered to be a final slope. The maximum capacity of the system is 2800 cubic yards per shift.

The 802 Kenworth trucks are used mainly in the pit hauling from the shovels to the skip loading structure and the Kenworth 802-B trucks are used mainly on the surface hauling from the headframe to the crusher or the waste dump.

At this time mining has progressed to the 2950 bench. This bench is roughly 400 feet below the surface.

The ore being mined varies considerably in grade and blending is a problem. Usually one shovel is worked in high grade ore running from 3% to 7% copper and one shovel is worked in low grade running from 0.6% to 1.0% copper. These classes of ore are being blended to about 1.85% copper mill head.

To date 1,372,092 tons of ore averaging 1.74% copper have been mined and milled.

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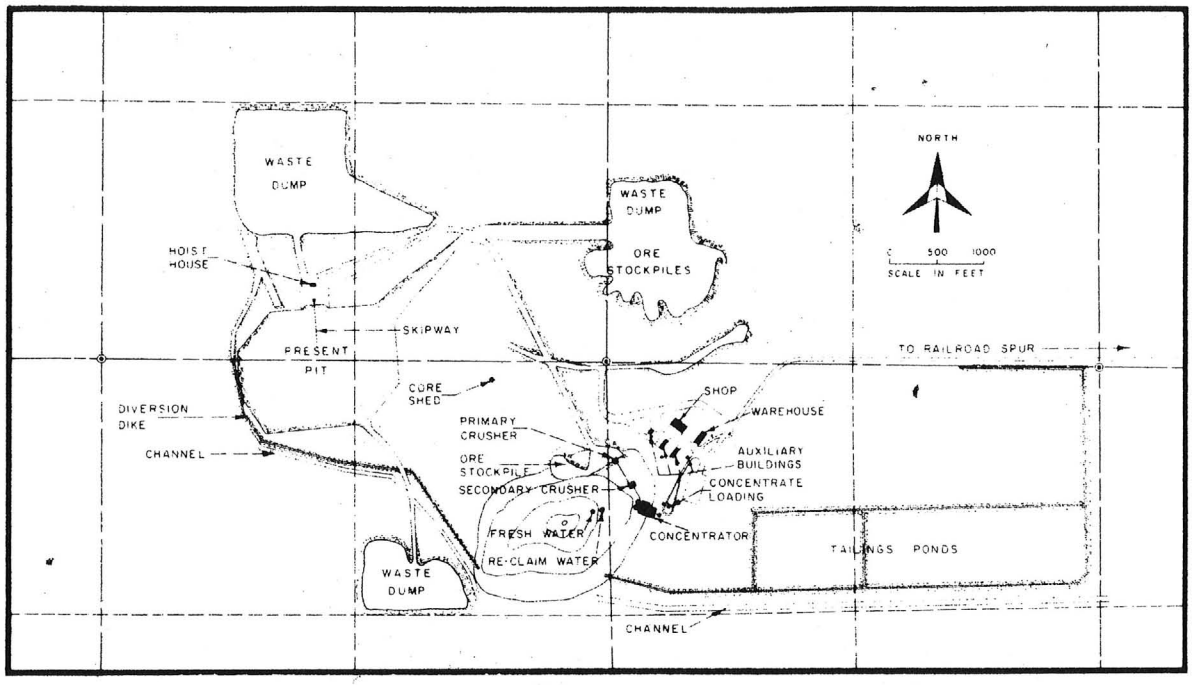
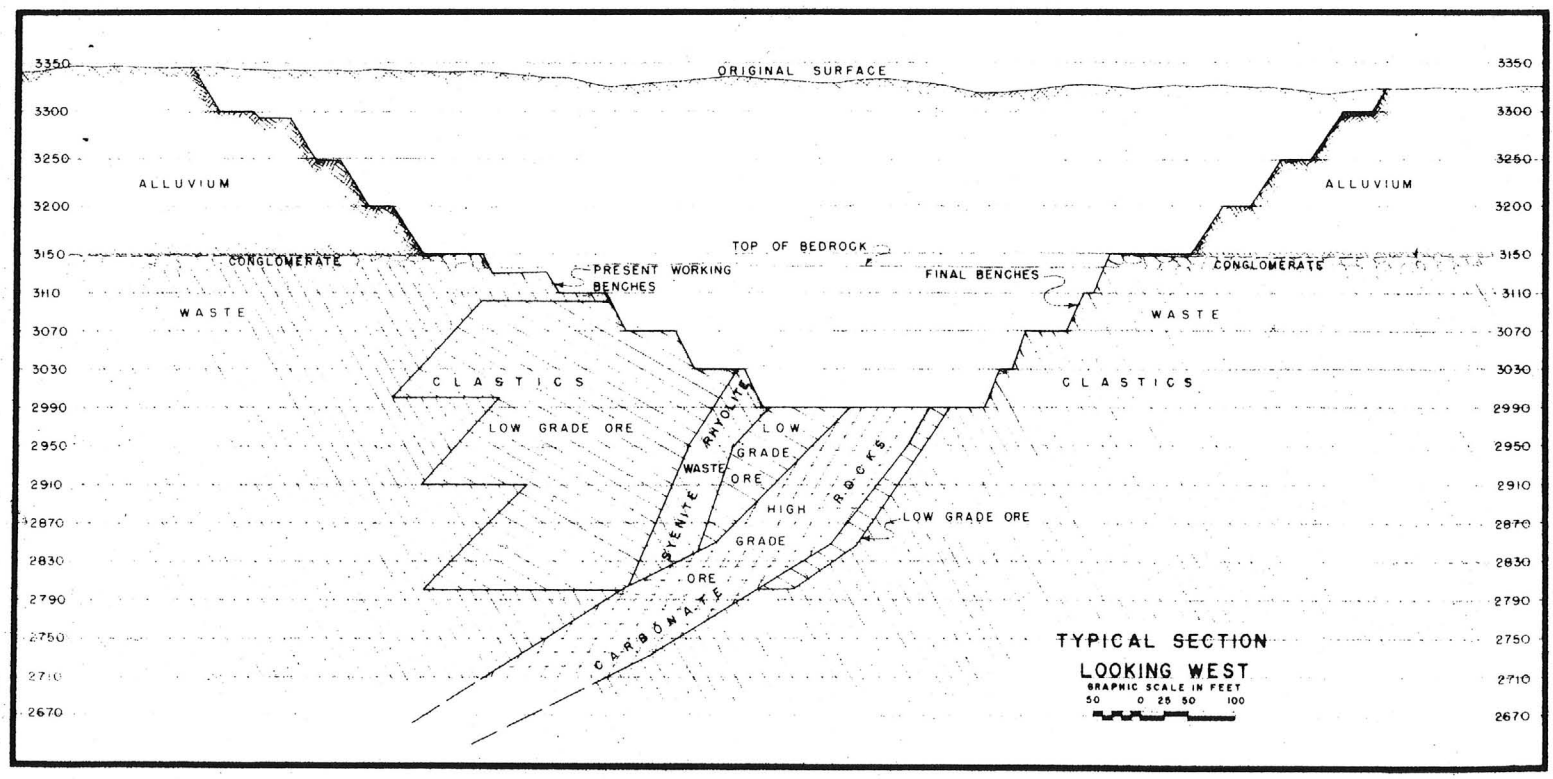
PIMA MINING COMPANY

PIMA MINE

TUCSON, ARIZONA



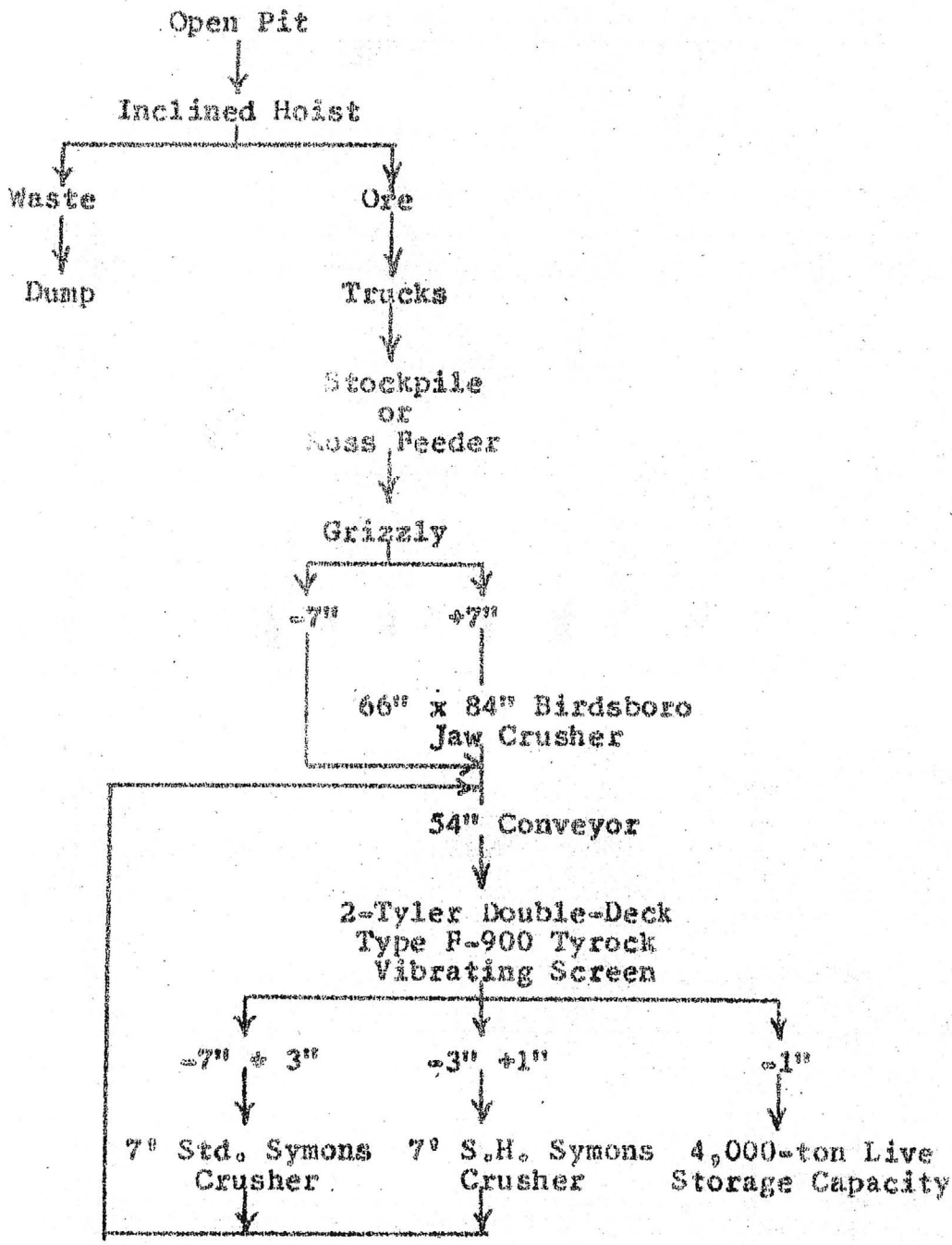
GENERAL AREA MAP



AIME OPEN PIT SECTION
ANNUAL SPRING MEETING
APRIL 25, 1958

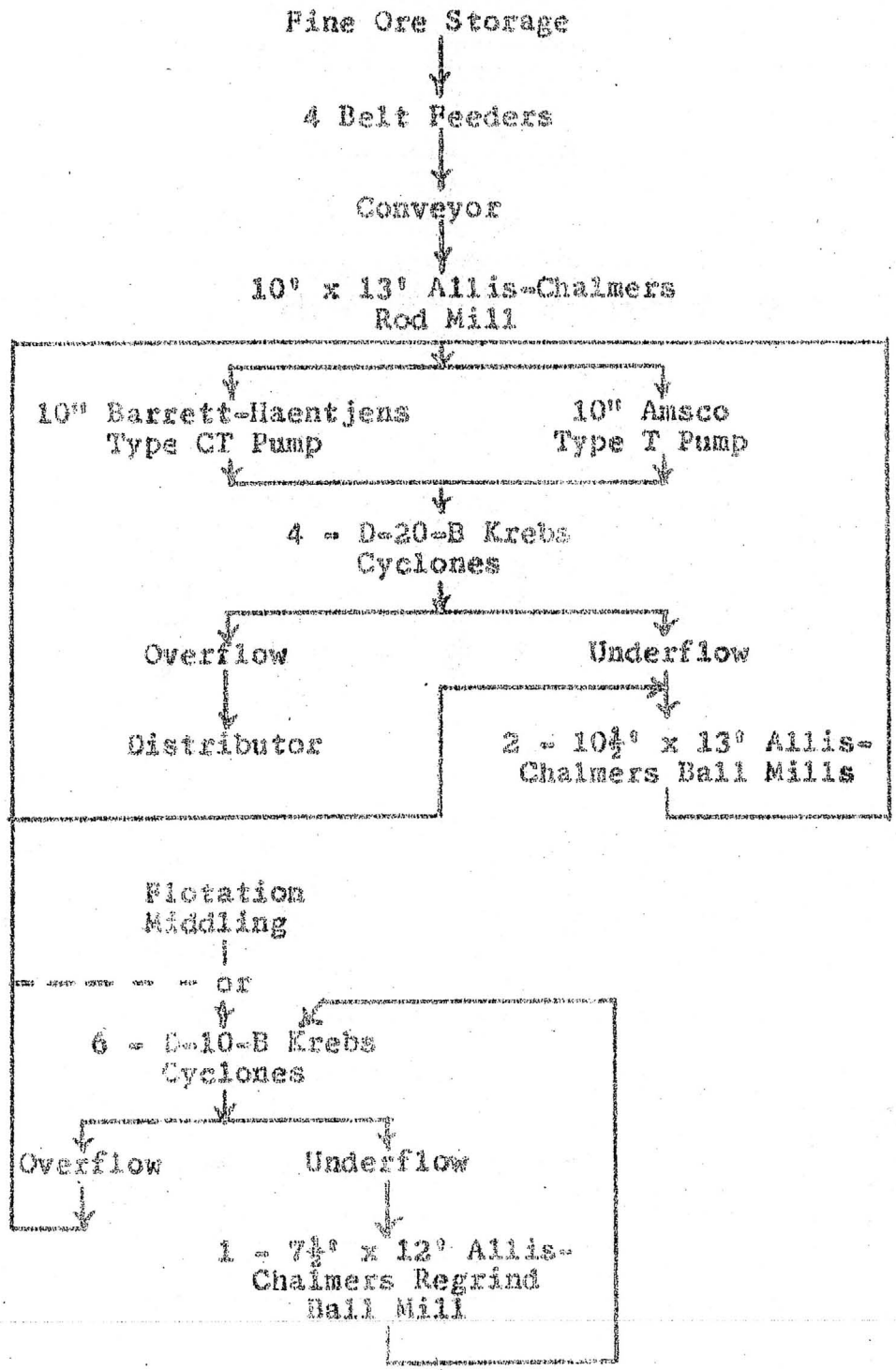
B35

CRUSHING



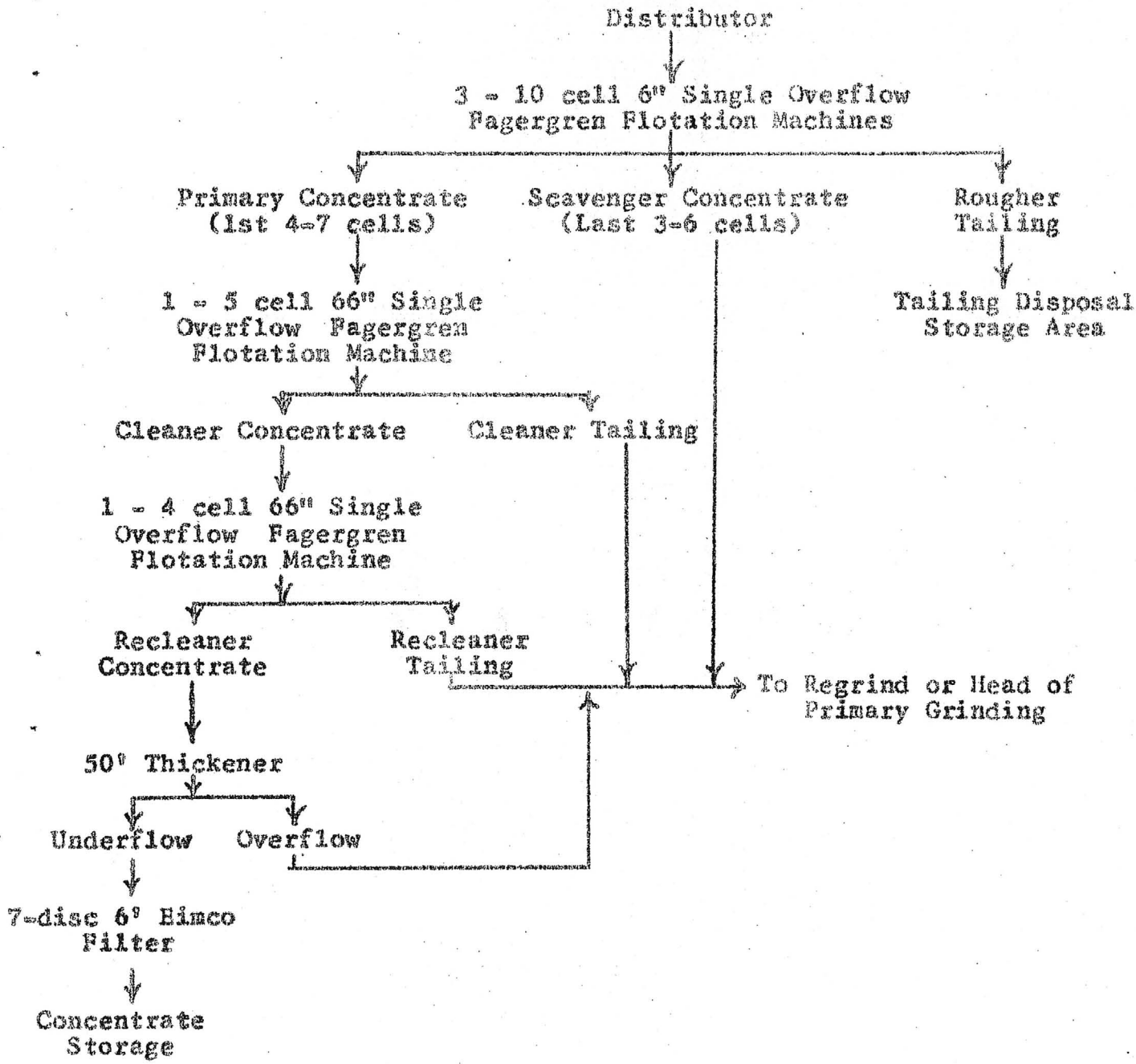
B34

GRINDING



B33

CONCENTRATION



B32

PRIMARY BLASTING WITH PRILLED AMMONIUM NITRATE

Isbell Construction Company

Lynn Christian

B31

During the last few years, Isbell Construction Company, at their different operations has broken approximately 25,000,000 tons of ground with Ammonium Nitrates. Two-thirds of this being with fertilizer grade Ammonium Nitrate prills and fuel oil, and the remainder with commercially prepared nitro-carbon nitrates; Carbamite, LDX, and NP167.

The change to fertilizer grade prills and fuel oil, came in the latter part of 1956, during the stripping of AS&R's Silver Bell unit. This method proved satisfactory and was passed on to our other jobs. Practice is to distribute the bagged prills at the collar of the hole, a gallon of fuel oil is then poured into each 80# bag, and when allowed to set for 45 minutes so the excess oil will drain, the right ratio of fuel oil to prills is obtained. In the beginning the priming charge used was 60% gelatin dynamite, 8 x 22 Amogel, which was split on the sides and dropped into the hole after the primacord had been lowered; the prills now sensitized by the fuel oil are poured into the hole with additional priming charges added at intervals until the priming was 20 to 30% by weight of the total charge. In the event of decking the charge, a new primacord line and primer was put into the hole, prills added until the charge was completed. Using Amogel as a primer, the net results were equal to using a 40% straight dynamite. This has held

true for blast holes ranging in size from 2 3/4" up through 9", in all types of ground, Andesites, Porphyries, Shales, Sandstones and Quartzites. We have maintained our hole spacing and burden consistent with what it would have been with conventional explosives, varied of course to suit the ground being shot.

Before going further, it must be stated, that in extremely hard ground, where bit cost would be prohibitive to close up on spacing and burden, it is our custom to use a column of Amogel together with prills and fuel oil to get a denser charge where needed. Also, in wet holes, Amogel is used to raise above the water, and then the charge is completed with prills and fuel oil.

At the present time we are using 400 grain primacord in one foot prepared lengths, tied with rubber bands to the standard reinforced 50 grain primacord at intervals throughout the charge as a primer. This use of 400 grain series together with delayed shooting has given excellent results in the pioneer work we are now doing at Duval Sulfur and Potash. We have pulled as high as 35 foot toe on 20 foot hole spacings, in what we would classify as medium hard ground. Better fragmentation is quiet apparent as reflected in reduced shovel wear and maintenance. As to what the ultimate results will be regarding comparison to straight

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dynamites when working on conventional benches, it is hard to say, but indications are to a better than 50% straight dynamite.

Regarding powder factor, we are conscience of a good powder factor but are not unduly influenced by it, at the expense of wear and tear on equipment. A few extra pounds of powder to make better digging is well worth the price.

In comparing costs between 60% Amogel, prills-fuel oil with 25% by weight Amogel, and prills-fuel oil using 400 series primacord, in a typical 9" blast hole. The results are about as follows: Prill-fuel oil with 25% by weight Amogel is 65% less in cost than using all Amogel; Prill-fuel oil with 400 series is 42% less in cost than prills-fuel oil & Amogel, and is 80% less in cost than using all Amogel.

Other properties that fertilizer grade Ammonium Nitrate prills have, is safe handling and easy storage. Our storage facilities consist of five well ventilated van type semi-trailers, each with a capacity of 25 tons of prills, and parked near the pit. Handling is safe if prills are accorded the same respect as any other potential explosive.

MAINTENANCE PROCEDURES AND THE NEED FOR ADEQUATE PERSONNEL

(A Survey in Southern Arizona Section)

By

M. H. Nicholson
Mechanical Superintendent
Pima Mining Company
Tucson, Arizona

B57

The inception of the wheel has often been referred to as the greatest invention of all time, for every present day machine employs the principle of the wheel in one form or another. Just when the wheel came into existence is shrouded in the dim shadows of civilization's past. It is safe to assume that it was first used for the transport of material from one place to another and it is conceivable that this material may have been for dwelling construction. It is doubtful that the first load was of material from which metal was to be extracted but by the measure of man's existence on earth, this process was soon to follow.

Visualize the first wheel made from a flat circular stone with a hole in the center into which the axle was affixed. In all probability, the axle was made of wood or possibly stone. But regardless of the materials used, as the wheel turned on the axle, friction and wear occurred eventually destroying the device. Thus the demand for maintenance was created and man's efforts since this early time has been toward the maintenance of the machines which he has created.

Webster defines maintenance as "a maintaining or being maintained; upkeep, support, defense, etc.".

In a literal sense, maintenance is the everyday attention of lubricating, cooling, cleaning and the compensating for wear or breakage which guards against the eventual replacement of units involved. Wherever a wheel turns, maintenance is required. The replacement cycle of component parts is dependent entirely upon the effectiveness of

the daily service allotted toward its continued usage. Since the existence of man is dependent upon his mobility, so is his mobility dependent upon his maintenance program. This may be demonstrated today in your own operations. Imagine if you will, how long the plant would operate if the maintenance program were to cease. In a few short days the plant would fail to function. This, of course, is a drastic example of the importance of maintenance. A more practical example of this importance may be observed in the shops where a member of operations might be seen frantically looking over a mechanic's shoulder while inquiring when the machine will be returned to service. This too is a time-honored practice dating back to the first repair job. History does not record the true date of the first wheel nor does it mention this "over-the-shoulder" practice. Yet there is no question of their existences - and you can be sure that the first mechanic was not alone.

Present maintenance is a many faceted program divided into three main categories: service, scheduled maintenance and unscheduled procedures. In the mining industry maintenance requirements are further divided into mine, mill and electrical maintenance groups which may be supervised by one man or split into various responsibilities. Since I am involved primarily in the maintenance of mine equipment, my comments are intended basically in support of this type of equipment.

When a maintenance organization is established it is normally headed by one individual who is responsible to management for the entire program. He is supported directly by his foreman, his craftsman and his warehouse organization. Indirectly, he is supported by manufacturers' parts supplies, service personnel and by vendor shops. Due to great diversification of demand and application, there is no universal organization upon which he may pattern his own organization. Further, procedures must be varied when he considers the type, quantity, and scheduling of equipment. Available shop facilities will vary the planned program as applied to his particular operation.

Service procedures are basic and involve the fueling, lubricating and cleaning of machines. Equipment manufacturers supply adequate service literature with machines from which an excellent service program may be drawn.

Some manufacturers offer a preventative maintenance program which may serve as a base, while others make no recommendations. A procedure based on past operation or experience may be formed, but only through machine operation over a given period of time can a true preventative maintenance program be scheduled. The time period involved may be subdivided as follows:

From 0 - 2500 hours - A period of acquaintenance and observation during which time performance is only indicated.

From 2500 - 5000 hours - A period during which performance is recorded and some component life expectancies may be established.

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From 5000 - 10,000 hours - A period during which total performance can be critically appraised and true preventative maintenance can be scheduled to apply to future operations.

But regardless of how rigidly the service and preventative maintenance programs are stressed, these two procedures are continually interrupted by the element of unscheduled maintenance or breakdown of equipment which may necessitate sacrificing one program to accomplish major repair. Depending upon the severity of the breakdown and equipment type involved, it may be necessary to reschedule equipment to maintain production at normal levels. In maintenance shops there is an axiom which goes "when things get rough for us, the rest of you people are in deep trouble". This is certainly true, for when maintenance organizations fail to provide equipment on schedule, the whole plant suffers with them.

In contemplating a maintenance program, adequate shop facilities, warehousing and personnel must be considered. Shop facilities depend upon area location and the percentage of repair to be done on the property as compared to the amount sent out for repair at other shops. Parts warehousing is established by plant inventory allotment levels and the ability of vendors to supply adequately upon demand.

Basic personnel requirements are estimated on mechanical man-hours available for equipment shifts scheduled. Since there are so many extenuating circumstances involved in this evaluation, no industry-wide figure can be derived which might apply to all operations. An area check of five properties in this vicinity shows an average of 4.63 mechanical man-hours available for each equipment shift scheduled.

B23

This figure varied from a high of 6.0 to a low of 3.68. The mechanical man-hours used in arriving at these ratios were those hours expended by service personnel, mechanics and welders only. It does not include support from indirect sources such as machinists, carpenters, supervisory personnel, clerks or laborers.

Regardless of how well the maintenance program is written and enforced or how plentifully the organization is staffed, the end product of equipment availability at a reasonable cost depends entirely upon the knowledge and skill of the personnel within the organization and the application of that knowledge and skill toward a given task.

Who are these men who accomplish maintenance? Where do they come from and how did they learn their craft? What future source of supply is available and will they have adequate training?

Once again reference is made to the direct support of service personnel, welders and mechanics and I refer to them in that order.

Service Personnel:

These are the people who attend the fueling, lubricating and cleaning requirement of equipment each day. The supply of personnel in this classification is adequate, and normally some prior instruction in service of automotive type equipment has been taught either in high schools or through post-high school employment at service stations or garages. This training is directly applicable to mine equipment and in a relatively short period of time the individual becomes competent. Future supply appears adequate to meet the requirements.

B22

Welders:

The personnel in this craft are involved in the fabrication of new components and build up or repair of existing components. The supply of personnel in this classification is adequate and the percentage of first-class craftsmen among new hires is relatively high. In almost all instances, instruction has been obtained through high schools or at trade schools. Further basic training is seldom required after shop procedures have been outlined. Through continued instruction at high schools and trade schools and through self-teaching, future supply appears adequate.

Mechanics:

These are the men in whose hands is placed the continued operation and eventual life of equipment. Recent trade and technical journals have had many articles written about the lack of qualified personnel in the mechanic and repairman classification. The mining industry, as well as the construction industry and highway trucking firms, shares this alarm. One recent article was entitled "The Disappearing Mechanic". I disagree with this article only to the extent that he has already vanished.

The fact of their absence is borne out not only by virtual "open arms welcome" by personnel departments to anyone who hints that he has had experience in this line, but also by the volume of repair sent out to vendors' shops where it will be repaired on a single shift basis - under the watchful eye of a service manager who is concerned with only one manufacturer or one special repair.

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It is estimated that the supply of qualified mechanics is from five to seven years behind demand.

Present shop crews are somewhat lacking in training. Statistics from one mine in the area indicate that the average age is 42 years - 18% are 55 or older; 29% are 50 or older; yet only 22% are under 35. The average education level is 10th grade; 7-1/2% have had one or more years of college training; 54% have had no special training; 18% have had trade school or correspondence school training of short duration; and 28% have had training in military services.

These figures indicate an urgent need for immediate upgrading of present crews - this can be achieved only by further training. Since the total crew cannot be taken off the job for training and there are no replacement crews, this training must take place on the job. This can best be accomplished a step at a time through instructional procedures outlined on filmed frames to be shown simultaneously with audio instructions. Normally, 12 to 18 frames will instruct the correct repair procedure of a unit.

As an example, a rear wheel brake relinement is cited. Eighteen frames will show tire, planet assembly, axle shaft, hub and shoe removal; also instruct the inspection, repair and reinstallation of parts in proper sequence and specifications. A shovel hoist drum shaft repair is equally simplified by this method. Thus, individual instruction is made available without loss of supervisory time and little loss of productivity from the craftsman. Instruction may be and should be repeated again and again as required.

B20

Presently, there are no such training aids available to us but equipment manufacturers, who invest thousands of dollars yearly in training aids in printed maintenance and repair manuals and who are currently using pictures in these publications from their own filming processes, would be receptive to this practical training method if a strong demand was made.

Considering again the local survey of mining properties in the immediate area, let us assume that today 184 mechanics are required to staff maintenance organizations.

In the next ten years, 33 will have reached the retirement age of 65. Forty will have been lost to other fields and other jobs. Therefore, 73 mechanics will be required for replacement only. It is calculated that a 20% increase in production will demand an additional 36 men and new properties will demand another 45. Thus a minimum of 154 mechanics will be required by mines alone in our own small area. Where will they come from? How well qualified will they be? The answer rests entirely with me and with you.

It is evident that no training is available to meet the demands of the present mine maintenance shop. High schools offering advanced training in automotive mechanics stress engine repair and only touch upon the principals of power train, braking, steering and suspension systems. Lacking entirely at this time are hydraulics and air systems instructions.

Correspondence courses and trade schools available to prospective mechanics in this field place heavy emphasis on the diesel engine and its care, which, ironically, is an area in which we ourselves are most adept in training - and which we can watch more closely due to the nature of the repair. Also, the present trend to engine repair in dealer shops reduces the demand for high technical skill in this area.

Therefore, the training of future shop crews to meet our requirements is entirely our responsibility. Not only the mines, but also the contractors and highway trucking industries, must recognize this requirement and start training programs immediately. This must necessarily be a joint venture between government, union and management toward apprenticeship training. Regardless of our present views on apprenticeship training, we must recognize it as a salvation rather than a burden. It is not a case of "shall I start training" but "how soon can I start?"

Webster defines an apprentice as "one bound by legal agreement to serve another for a certain time with a view of learning an art or trade in consideration of instruction". As it applies to us, the apprentice would enter a legal agreement with his employer and the state. This agreement would include:

1. An age limitation.
2. Organized instruction in the classroom and on the job.
3. A schedule of work processes and a number of hours determined for each process.
4. Provisions for an approximate number of hours of classroom instruction per year.

.B13

5. Wages and hours of work.

6. The number of training hours required for the apprentice to become a qualified journeyman in the trade.

7. A grading system for both classroom studies and on-the-job training which would serve as a guide toward advancement and/or additional requirements. Of course, grades would also be used in determining whether the apprentice should stay in the program.

Classroom instruction appears to be the greatest drawback at this time. Lack of both classroom facilities and qualified instructors are contributing factors. However, I feel this is a problem that can be worked out through cooperative effort between the public school systems and our own instructional potential.

Currently, the traditional ratio of one apprentice to ten journeymen applies and the number in training is far below this level. I suggest a more practical ratio of three to ten in this classification since the finished product will not be realized until 1967 or 1968. Group training in the classroom and early stages of on the job training is as easily accomplished as individual instruction. Employers should consider seriously an increase in personnel authorized for maintenance departments to allow for these trainees who appear to be our only source to fill present and future demands for skilled craftsmen.

In summation, I appeal to all of you to consider strongly a joint demand for supplementary training aids more suited to our requirements that we may stock individual instructional libraries for the upgrading of present crews and the reeducating of future crews. Further, let us cooperate in a concentrated study toward immediate participation in apprentice training, which will be to our mutual benefit.

A. I. M. E.

SPRING OPEN PIT MEETING

TUCSON, ARIZONA

April 25, 1958

PROGRAM:

9:00 A.M. - Registration at Pima Mine. General tour of open pit. Return to starting point at approximately 11:30 A.M.

12:00 N - Luncheon, Karichimaka Tavern. 2 miles south of Ajo Way on Mission Road

2:00 P.M. - Technical session - El Conquistador Hotel, 3300 block, east Broadway

PAPERS:

1. "Turbochargers at Inspiration Consolidated Copper Company" -- by R. V. Banerie

2. "Primary Blasting with Prilled Ammonia Nitrate" -- by Lynn Christian

3. "Recent Mining Development in East Africa" -- by A. A. Friedman

6:00 P.M. - Cocktails - El Conquistador Hotel.

7:00 P.M. - Dinner - El Conquistador Hotel.

Robert E. Thurmond

R. E. Thurmond, Chairman
PIMA MINING COMPANY, Host

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Location.

This mine is in the Pima Mining District, 20 miles south of Tucson and mostly is Section 1, T. 17S. R12 E. Elevation is 3300 ft. Good roads connect it with Tucson and with a shipping point near Sahuarita, 12 miles eastward. It adjoins the copper property of the Banner Mining Company to the west and the San Xaxier mine of Eagle Picher to the southwest. The property embraces 46 claims.

History.

The mine is owned by the Pima Mining Company, a wholly owned subsidiary of United Geophysical Company, which is wholly owned by the Union Oil Company.

Strong geophysical anomalies were found by United Geophysical and after proving ore by diamond drilling, Pima Mining Co. was formed. Union Oil purchased United Geophysical from Herbert Hoover, Jr., and Union advanced $450,000 for equipping and developing the ore body.

Geology.

The ore occurs in an altered and brecciated fault zone in sediments, largely limestones, that appear to dip about 35° to the south. The ore dip conforms only generally to the dip of the host rock, average dip is about 45° south, but becomes vertical between the north ends of the 5th. and 6th. levels.

The ore body is overlain with about 200 feet of loosely consolidated gravels. Ore minerals are chiefly chalcopyrite and chalcocite, with scant native copper in the upper levels. Gangue contains abundant magnetite and some pyrite.

Equipment.

Present surface plant buildings consist of a small combination office and change room, hoist and compressor houses, blacksmith-welding shop, carpenter shop and shelter over the Diesel generators, a 50' steel headframe with steel ore bin.

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Power is purchased, and there are two standby G.M. diesel generators. Hoist is a 112 H.P. double drum Wellman Seaver Morgan unit suitable only for moderate duty.

The timbered shaft is 620' deep, has two compartments, each 5' x 5' with levels at 100 ft. intervals commencing with the 300'. Hoisting is done with a cage, using a counterbalance in one compartment.

Ventilation air is returned to surface thru a 42" drilled hole which connects with a series of manway raises extending down to the 600' level.

Production.

Production to date has been from development work with some tonnage from 6 small stopes that are being carried across the ore body on three levels to determine physical stoping characteristics and to check mining grade. To date 35,000 tons have been shipped that averaged 5.79% Copper. Gross value is over $900,000 and net value about $550,000.

Ore Reserves.

There are about 5000 feet of drifts and crosscuts on the four levels, and limits and grade of ore are further defined by numerous drill holes from underground workings. From this work, a reasonably accurate estimate of ore reserves can be made. Some question exists as to the milling characteristics and recovery of the vein below the gravel capping, and I have used only 50' of available ore above the third level. Drill holes north and south from the west end of the 600' level show ore apparently separated from the main body, and ore has been discovered in a surface diamond drill hole at a depth of 711', some 500' southeast of the shaft. This indicates that the apparent bottoming as interpreted from the level maps may be only a feature caused by a local change of dip.

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Levels

Above	Length Ore	Av. Width.	Area	Assay.
300	550	55'	28000	3.80 Cu.
400	760	60	45600	5.38%
500	630	57	35200	4.92
600	200	40	8000	5.27

Tonnage & Grade

				H.	Vol.	Assay	Tons
Above 300	550 L	55'W.	28000	50	1400000	3.8%	127 272
300-400	655	57½	37662	100	3766000	5.0	342 363
400-500	695	58½	40657	"	4065700	5.18	369 608
500-600	415	48	19920	"	1992000	4.98	181 091
				350	11223700	4.91	1 020 334
Dilution 10%					1122300	-	102 033
					1 2346000	4.42	1 123 367
Less previously mined						5.79	35 000
Minable Ore Total						4.37	1 087 367

Dilution will contain some copper so assume a 4.40 grade.

Milling.

A number of tests run at Iron King on a head sample that assayed 3.5 Cu. and 0.5 oz. silver indicate that a 90% recovery of copper and 65% of the silver will report in a concentrate assaying 25% copper and 26% iron. Reagent cost is moderate and grind not difficult. The net value of ore on these results is the same as with 95% recovery in a 20 - 21% grade of concentrate.

The calculation for value ore based on shipping to El Paso, about 400 miles. Superior and Ajo are about 150 miles, and Inspiration is 250 miles.

Mining & Milling Costs.

The ore is structurally weak, as are the walls and the following is based on mining with timber and careful filling of stopes.

Stoping labor	1.40 per ton				
timber	1.00				
explosives	.10				
		2.50			
filling stopes		.50			
development & exploration		.50			
haulage & hoisting		.80			
mechanical mnt. & repair		.50			
drill steel & drills		.20			
power		.30			
miscellaneous		.20			
Total direct mining			$5.50		
Milling			3.00		
Office expense etc.			.50		
local taxes			.30		
Depreciation , replacements			.50		
Total Operating cost			9.80	is	11.13¢ lb. contained Cu.
76.8# payable copper per ton					12.76¢ " payable Cu.

Marketing

Heads 4.4% Cu. 1.0 oz. Silver 90% recovery oc copper 65% of silver
Recovered by mill 80# copper and .65 oz. silver. Ratio 6.25 to 1.

Concentrates		29½¢ Copper		24¢ Copper.	
Copper 500#		29.556¢		23.875	
Less 20		3.080		3.080	
Payable 480#		26.476	$127.08	20.795	$99.82
Silver 4.0 - ½ oz		3.5	3.10		3.10
Total Value			130.18		102.92
Treatment	9.42				
Frt. (5% H_2O)	4.55				
Trucking	1.00		14.97		14.97
Net Smelter			115.21		87.95
Per ton of mine ore			$ 18.43		$14.07
Per pound payable copper			.24		.1832
Per pound copper in ore			.2095		.1599

General Conditions affecting Plant Investment.

The present facilities represent over $100,000 in building, machinery and equipment, part of which can be utilized in the future. The two largest items of cost for a 400 ton operation are the mill and a shaft. A new mill of 400 ton capacity can be constructed for $500,000. To dismantle, move and erect,with some new equipment, the Denn mill would cost about $250,000. From this, and because of the used nature of some of the machinery, it may be estimated that the Denn mill has a worth in place at Lowell of $150,000-$200,000 if it is used for the Pima.

The mine makes 350 G.P.M. of good quality water, and this is more than enough for milling and camp purposes. The mill could operate on as little as 150 G.P.M. and it is felt that this amount of water would always be procurable from the mine.

The present shaft is large enough to handle the proposed mill tonnage. This shaft is approximately 200 feet in the hanging wall at ledge and crosses into the footwall just below the 400 level. To properly protect this shaft against any future misalignment due to stoping operations it would be necessary to leave approximately 150,000 tons of ore as support pillars from the 400 level up. While these pillars could be recovered later, I believe it advisable to insure the future with a new shaft, the cost of which is only a small part of the total plant investment. This new shaft will be some 200 feet north of the present shaft, and will be entirely in the footwall below the top of mining operations.

Estimate of Capital Expenditures.

Moving, dismantling & erecting Denn Mill		250,000	
Shaft 650' @ $120.	78 000		
Guides & Signals, ladders	13 000		
Hoist (used)	35 000		
Headframe	15 000	141,000	
Shaft Bins, conveyors etc.		25 000	
Skips and cages		10 000	
Underground equipment			
6 slushers, 3 muckers, 2 motors			
12 cars, machine drills & hoses		39 500	
Surface Plant			
Additional compressor	10 000		
Compressor & hoist housing	10 000		
Machine shop	11 000		
Office & warehouse	12 000	43 000	
Total Improvements			$ 508 500

Preliminary underground work.			
Drifting top of ore	700'		
300 level	500		
400 "	720		
500 "	600		
	2520' @ $30.	75 600	
Crosscuts from new shaft to new drifts	1200' @ 30	36,000	
Shaft pockets 4th and 6th. levels		30 000	
2 Transfer raises		6 000	
Enlarging ventilation to surface		10 000	
Total Underground			157 600
Total			$ 666 100
Add for present value Denn Mill			150 000
Total cost of equipping ore body.			816 100

R72

Value.

Tons	1, 087,000	(At. 11 cu. ft. per ton.)
Grade	4.40 Cu.	1.0 silver.
Mine 400 tons per day	140,000 tons year.	
Life	8 years.	

	29½ ¢ Copper	24.0¢	
Net Smelter Return	$18.43 per ton	$14.07	
Estimate Operating Cost	9.80	9.80	
Operating profit	8.63 (11.24¢ #)	4.27	(5.56¢ Lb.)
Profit per year	$1,208 200	$ 597,800	
Profit after 26% Tax	894 070	443 112	
Total profit 8 years	7 152 000	3 544 896	

Approximate present value 12% return and 4% sinking fund-

Equipped	3 920 000	1 940 000
Less initial cost	816 000	816 000
Value ore body	3 104 000	1 124 000

Plus reasonable allowance for salvage value of plant and some increment for possible additional ore.

Conclusion.

The Pima Mine has a compact continuous ore body containing over one million tons of 4.40% copper, with probabilities of additional minable ore. Accessibility, topography, climate, availability of water and proximity to Tucson and labor markets are all favorable factors for a profitable operation.

Jan 15, 1954.
Humboldt, Arizona.

H.F.Mills

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April 19, 1966

Mr. Clyde Hull
4535 North 18th Ave.
Phoenix, Arizona

Dear Mr. Hull:

The following is a list of assay results from the samples collected from your mine:

Sample No.	Au	Ag	Cu
12301	Tr	Nil	4.20
12302	Tr	Nil	0.68
12303	Tr	Nil	0.36
12304	Tr	Nil	1.00
12305	Tr	Nil	2.70
12306	Tr	Nil	0.14
12307	Tr	Nil	0.88
12308	.03	Nil	1.46
12309	Tr	Nil	0.30
12310	Tr	Nil	4.80
12311	.01	Tr	0.20
12312	.04	Tr	3.28

Those samples with particularly high copper results are due to selected sampling of chalcopyrite veinlets etc.

On reviewing the property again, I think the tonnage potential would be a problem for our consideration. However, as I mentioned on the phone, I shall relay the pertinent data regarding the mine to another who might be interested. I will leave it with him to contact you.

Thank you for the opportunity to examine this property.

Yours truly,
SHATTUCK DENN MINING CORPORATION

J. Olaf Sund
Chief Geologist

JOS/db

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PLANNING, PLANTING, AND PROGRESS FROM ENVIRONMENTAL STUDIES AT PIMA MINING COMPANY

By

Kenneth L. Ludeke

1973

A greater public awareness of the environment, pollution and the increasing scope of industrial activities, has brought mine reclamation to the public's attention. The prime aim of the reclamation of mine wastelands, as viewed by Pima Mining Company, is to bring about the establishment of a permanent, self-sustaining, maintenance-free vegetative cover to the tailing disposal berms. This is to be achieved by utilizing the tailing material as it occurs on the constructed disposal berm, without the expense of capping the tailing with overburden, or mix overburden with the tailing material. Tailing material contains only trace amounts of copper and is principally worthless rock. Tailing material is spherical in shape and does not lend itself to compaction. Soil samples indicate that tailing material has no organic matter and is completely lacking in clay content. Tailing commonly has the texture of fine sand, is deficient in plant nutrients, and lacks normal microbial populations. The disposal berms resulting from the accumulation of tailing, often range from the very acid to the very alkaline pH conditions.

To provide for stabilizing tailing berms and to help meet the aesthetic objectives and overcome possible pollution problems posed by mine wastes, efforts have been made to produce vegetative growth on sterile tailing soil. However, mine wastes are often unfavorable growth media, due to presence of iron sulfides, which when present, will have formed armor-like crusts on portions of the tailing surface. Wind erosion will have carved ridges and large holes; and water erosion from escessive

summer and winter rains creates numerous deep gullies. Therefore, special treatments and techniques are required for plant establishment and continued growth.

At the present time, a large excess of tailing is being produced from mining operations. Ceramic tests have demonstrated the feasibility of using copper mill tailing for making building bricks (1). Some tailing material has been used as railroad and highway ballast and even land fill in some cases (2). The amount of tailing used for the foregoing purposes is very small compared to the ever growing tailing ponds. Thus, the principle answer to this particular problem is stabilization. The successful initiation and preparation of vegetation on fine mill wastes involves improving a number of adverse factors.

Mill wastes are usually deficient in plant nutrients, contain excessive salts and heavy metal phytotoxicants, consist of unconsolidated sands that when wind-blown destroy young plants by sandblasting and/or burial, and lack normal microbial populations (4).

The sloping sides of tailing berms receive varying amounts of solar radiation depending upon the direction of exposure. Gates (3) indicated that, contrary to popular belief, photosynthesis in plants is not a continuous process while the sun is shining. Under high temperature conditions, photosynthesis may almost completely terminate. Furthermore, most tailing materials are light in color and may reflect excessive radiation to plant surfaces, thus intensifying physiological stresses.

For these reasons, vegetation that may be effective on northern and eastern exposures may not be suitable for southern or western exposures (5). Ideally, vegetative stabilization should produce results necessary to provide for the many problems concerned with stabilizing the tailing berms.

Over the past couple of years copper mill tailing has been tested and it is possible to bring about the establishment of vegetation on tailings by satisfying certain conditions, and to add the essential elements. These elements would be humus, nutrients, moisture and bacteria or microorganisms. The conditions are that the climate must permit the vegetation to become established and to persist. This condition can be met by supplementing the moisture requirements at times of distress, as well as following planting dates.

Tests have also been conducted on tailings utilizing hay or barley straw as a mulch. This provides the following results.

1. The straw mulch insulates the surface from both heat and cold. This stabilizes the temperature of the soil, creating a better environment for the fast germination and root growth of the seed.

2. A uniform coverage of straw mulch over the area to be seeded breaks up the fallen raindrops and permits the soil to absorb this moisture. The mulch also creates small dams to slow down the velocity of fallen water which causes erosion.

3. Finally, the use of mulch adds to the growth of bacteria and microorganisms.

Salinity is also a common problem in arid soils thus leaching must occur before vegetation can be properly established. In the initial vegetative process it is desirable to utilize plants that can withstand high concentrations of salt.

The pH rating of the tailing will initially dictate the vegetative procedure and it will be essential to know the representative pH values of the surface and plow layers. Tailing pH values clearly illustrate three definite categories.

1. Tailing of normal or neutral pH (6.5 to 8.5).
2. Tailing of low or acid pH (6.5 to 2.0 or less).
3. Tailing of high or alkaline pH (8.5 to 12 or more).

A large quantity of commercial and organic fertilizers are normally worked into the tailing berm. The amount of N-P-K will be made to vary according to tailing conditions. The organic fertilizers applied provide little complete fertilization but are rich in bacterial populations and are therefore considered soil conditioners rather than fertilizers. One key element that inert soils or sterile tailing lacks is, of course, an adequate bacterial population, numerous and varied to permit the germination and growth process of plants to proceed in aiding the absorption of added nutrients. Therefore, new plantings are carried out throughout the year to properly utilize both of the Arizona growing seasons. In winter, cover crops such as barley and rye, are planted to be utilized as green manure crops. Other types of winter and summer annuals are also

disked back into the ground as a mulch. Ultimately indigenous vegetation will take over. There are very encouraging signs that this is already taking place.

Grasses are essential to the establishment of an initial vegetative cover. Grasses become well rooted rapidly and will provide for the necessary vital protection against erosion. They also act as a nurse crop to the slower growing, more vulnerable leguminous plants. However, the legumes do thrive in the favorable micro-climate provided by the proper selection of indigenous grass species.

The legumes are a basic tool of the reclamation process due to their precise ability to fix nitrogen from the atmosphere with the help of the rhizobium bacteria contained in the nodules and make it available to benefit not only the legumes themselves but the entire vegetative cover. An excellent grass and legume mixture will develop a dense subsurface netting of roots: rhizomes, vertical taproots, sod forming roots, deep rooting fibrous bunches, that are capable of reaching down and considerably consolidate the tailing soil.

Often, the immediate concern of the public is to desire planting of trees when the natural process of reclamation of tailing berms are not fully understood. Numerous trees planted on extensive barren tailing slopes do nothing to prevent erosion either by wind or water, and under ideal circumstances barely succeed in surviving in a stunted condition of

growth. As a rule, most of the trees will die as seedlings, and if transplanted, hardly sustain a chance for survival. However, once the tailing slopes have properly provided a thick cover, the legumes have been fixing nitrogen into the soil and the root systems of various types of plants have firmly stabilized, aerated and otherwise properly preconditioned the tailing soil, a planting of indigenous trees could be considered.

Preparation of a tailing slope for planting includes numerous steps to follow:

1. Heavy or fine grading to smooth up the deep gullies formed on the side of the tailing berm.

2. Dragging a spiked chain over the surface of the slope to break up areas where iron sulfides have created a crust, and to rough up the excessive compacted areas and smooth out irregularities.

3. Grading a two foot lip on the leading edge of the slope to insure against runoff water eroding away the surface.

4. Grading cross dikes adjacent to the slope in order to collect excessive water from rainfall and prolonged irrigation.

5. Application of compost manure at five tons per acre to provide for a better soil condition.

6. Compaction of barley straw at 2.5 tons per acre with a sheep-foot roller to adequately provide mulching.

7. Preirrigation with application of fertilizer injected into irrigation line.

8. Hydroseeding a mixture of desired seeds with various rates of woodfiber as the artificial seedbed.

9. Hydraulic spraying of sewage effluent at 1,000 gal. per acre to act as a soil conditioner.

10. Additional irrigation with a liquid fertilizer added to insure germination and seedling emergence.

Major emphasis has been directed towards developing vegetative, physical and chemical stabilization and combinations thereof. To protect the seeded tailing soil from tremendous heat, and to retain moisture in the uppermost layer of the tailing in order to permit successful initial growth, and to insure against surface erosion, a combined chemical-vegetative stabilization procedure utilizing a resinous adhesive compound in conjunction with selected vegetation appears exceptionally effective for achieving this desired affect.

A large area of tailing slope exposed to the summer heat will quickly lose all the available moisture in its surface layer and will adequately reach temperatures over 100°F. A moderate wind, blowing

against the tailing slope will cause a sand storm condition close to the surface and the sand blasting effect will quickly destroy the established plant material either by sand blasting or burial of the seedlings. These conditions can occur in practically all areas where there is tailing material to be vegetatively stabilized, even if it only occurs once or twice a year. Environmental irregularities in the climate pattern, either high temperatures or freezing snow conditions, are also factors which alter vegetative response on tailing material.

Hydroseeding has been utilized extensively in Arizona in a great variety of landscaping situations, along highways, railroads, canal banks, and for the seeding of tailing disposal berms, where the fastest possible methods of seeding under adverse conditions exist. Hydroseeding permits the conditioning, seeding, fertilizing, and mulching at a high rate of speed, but it does not surpass mechanical seeding for accuracy.

Cattle, rabbits, pocket gophers, javelina, field mice, deer and other animals have invaded the tailing ponds seeded with various succulent grasses and forbs and have been a disruptive influence. However, the tailing ponds appear to be completely stable, and excessive damage is not apparent. In attempting to restore nature's balance, and even improve on it, Pima constructed a small game refuge which is utilized by the animals in the surrounding area. A 750 gallon watering tank has been placed below the tailing pond, and it has been surrounded by desert plants that are natural habitat for the animals.

Tests have been conducted recently utilizing a combination system of hydroseeding and the chemical-vegetative method. This system was applied to a 20 acre test plot on a copper mine tailing disposal berm. The following was applied per acre in this testing program.

TABLE I

COST OF CHEMICAL-VEGETATIVE STABILIZATION

Item	Rate of Usage	Cost
0.5 inch covering of overburden		$ 90.00/Acre
Compost Manure @ 13.00/ton	5 tons/A	65.00/Acre
Barley straw @ 37.00/ton	2.5 tons/A	92.50/Acre
Dairy Sewage Sludge @ 150.00/A	1,000 gal./A	150.00/Acre
Seed source - Pecoff Seed Mix (trees, shrubs, and ground cover)	750 lbs./A	287.00/Acre
Soil Seal	80 gal./A	387.00/Acre
Fertilizer - Ureasol 25-00-35	200 lbs./A	80.00/Acre
Wood Fiber - Aspen Wood Filings	1,500 lbs./A	120.00/Acre
Hydroseeder - Application Cost	seed one acre	200.00
Labor @ 4.00/hr.	3 men	288.00/Acre
Water Truck	Supply water to seeder	100.00/Acre
	Total	$ 1,859.50

TABLE II

COST OF VEGETATIVE STABILIZATION WITH TAILING SLOPE PREPARATIONS

Item	Rate of Usage	Cost
Overburden Capping	.5 inch cover	$ 90/acre
Compost Manure	5 tons/a. @ $13/ton	65/acre
Barley Straw	2.5 tons/a. @ $37/ton	92/acre
Sewage Sludge	1,000 gal./a. @ $150/a.	150/acre
Ureasol Fertilizer 25-00-35	200 lbs./a.	80/acre
Hydroseeding	1,200 lbs./a. 200 lbs. Barley	385/acre

Preparations	$477
Hydroseeding	385
TOTAL	$862/acre

TABLE III

COST OF VEGETATIVE STABILIZATION WITHOUT TAILING SLOPE PREPARATIONS

Item	Rate of Usage	Cost
Sewage Sludge	1,000 gal./a. @ $150/acre	$ 150/acre
Ureasol Fertilizer	200 lbs./acre	80/acre
Hydroseeding	1,200 lbs./acre	360/acre
TOTAL		$ 590/acre

TABLE IV

COST OF VEGETATIVE STABILIZATION WITHOUT TAILING SLOPE PREPARATIONS AND WITH MECHANICAL (HAND) SEEDING

Item	Rate of Usage	Cost
Fertilizer - Ureosol 25-00-35	200 lbs./acre	$ 80.00/acre
Sewage Sludge	1,000 gal./acre @ $150/acre	150.00/acre
Hand Seeding - labor (broadcast seeding)		79.46/acre
TOTAL		$ 309.46/acre

It was revealed from the testing program that the chemical-vegetative stabilization (Table I) did perform adequately, however, the cost factor was high. The vegetative stabilization with tailing slope preparations (Table II) provided the best results with a cost figure far below the method of chemical-vegetative stabilization. Vegetative stabilization without tailing slope preparations (Table III) was equal in results obtained and was also less expensive per acre with adequate vegetative stabilization occurring. Finally, Table IV illustrates that hand seeding on tailing slopes without slope preparations was the cheapest of all the methods tested, but did not result in adequate vegetative stabilization of the tailing berm.

Severe windstorms and excessive rains have passed over the stabilized tailing berms without raising dust clouds or carving unsightly erosion crevices into the slopes. The vegetation has satisfactorily maintained the surface of the tailing berms and appears fully resistant to wind erosion. As tailing berms increase in height, successive benches will be planted with material that has proven successful. The ultimate objective is, of course, to maintain the natural splendor of low desert environment to the disposal area. The success of the vegetative stabilization has illustrated that such an objective is feasible, at a reasonable cost, and is being accomplished.

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