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The Plant

GENERAL INFORMATION

MAGMA COPPER COMPANY

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

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

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

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

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

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

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

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

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

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

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

TIGER MINE IN THE 1940'S

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

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

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

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

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

THE SAN MANUEL MINE

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

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

AERIAL VIEW OF SAN MANUEL MINE

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

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

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

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

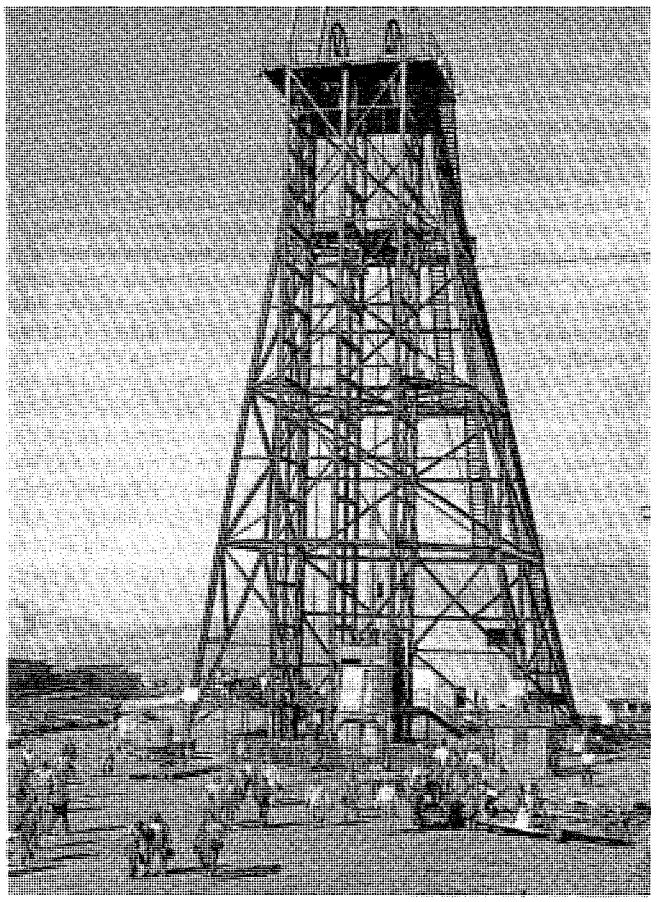
Loading operations from the transfer raises to the ore cars are controlled through steel chutes and air-operated chute gates. The ore cars have a capacity of about 12.5 tons, and each train is made up of 15 cars or 185 tons per train, pulled by a 23-ton, 250-horsepower trolley locomotive. One of these trains is dumped every 4.4 minutes. The electrical power system supplying the trolley is 275 volt DC with rectifier stations so situated as to maintain full voltage throughout the haulage system.

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

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

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

Two ore hoisting shafts, 3-A and 3-B, are equipped with 6,000-hp hoists with 15-foot diameter drums. These hoists can be manually or automatically controlled. The operating hoisting speed is from 2500 to 3000 feet per minute. The 3-C and 3-D hoisting shafts are equipped with 7,000-hp hoists having 15-ft. diameter drums, hoisting at 2,850 feet per minute. The hoisting cables are 2-¼ inches in diameter. The hoisting shafts also serve for ventilation up-cast.



SHIFT CHANGE AT #4 SHAFT

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

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

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

Other facilities at the mine include mechanical and electrical shops, modern timber framing shed, timber treating plant, warehouse, and change rooms. Mine air compressors provide 51,600 cubic feet per minute of compressed air for rock drills and other air-driven tools underground and on the surface.

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

THE CONCENTRATOR

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

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

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

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

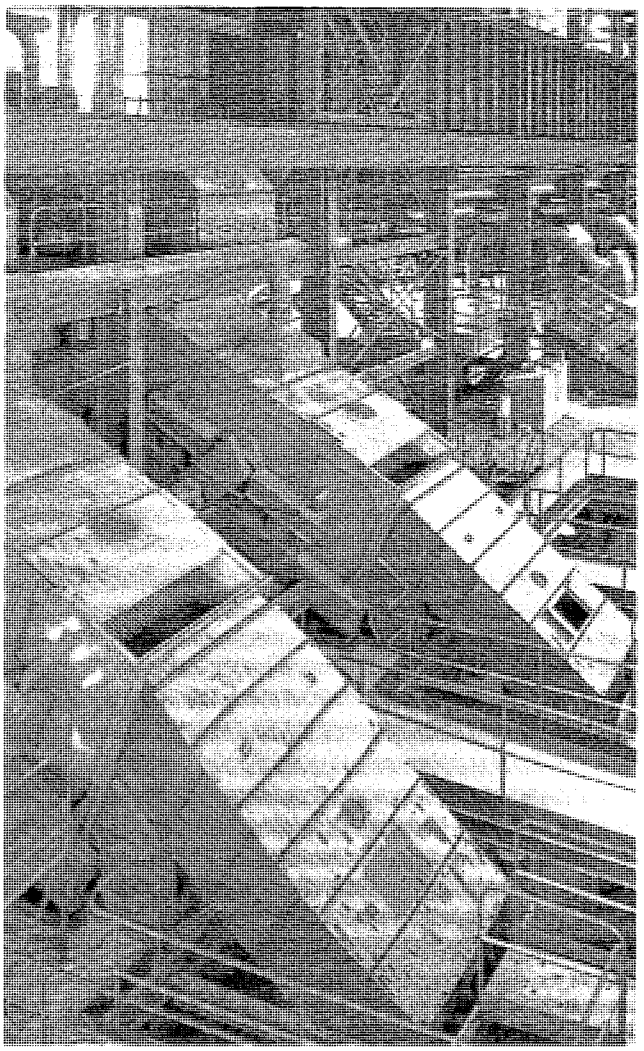
The crushing plant is designed with all crushers on the same level. A panelboard on the operating floor and an intercommunication system provide complete control from one point. A 30-ton overhead crane with a 5-ton auxiliary hook services the crusher floor.

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

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

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

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

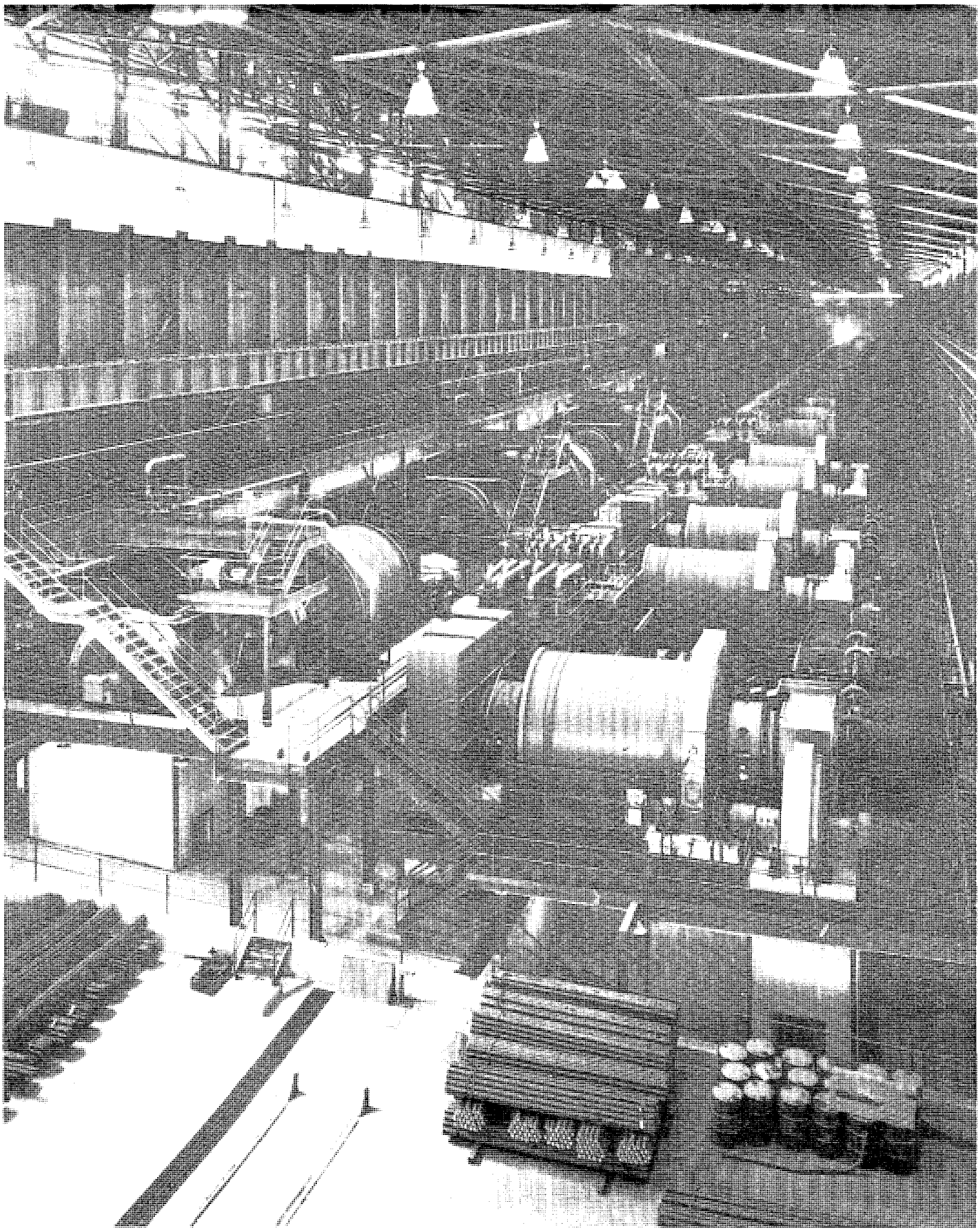


SECONDARY CRUSHING PLANT AT SAN MANUEL

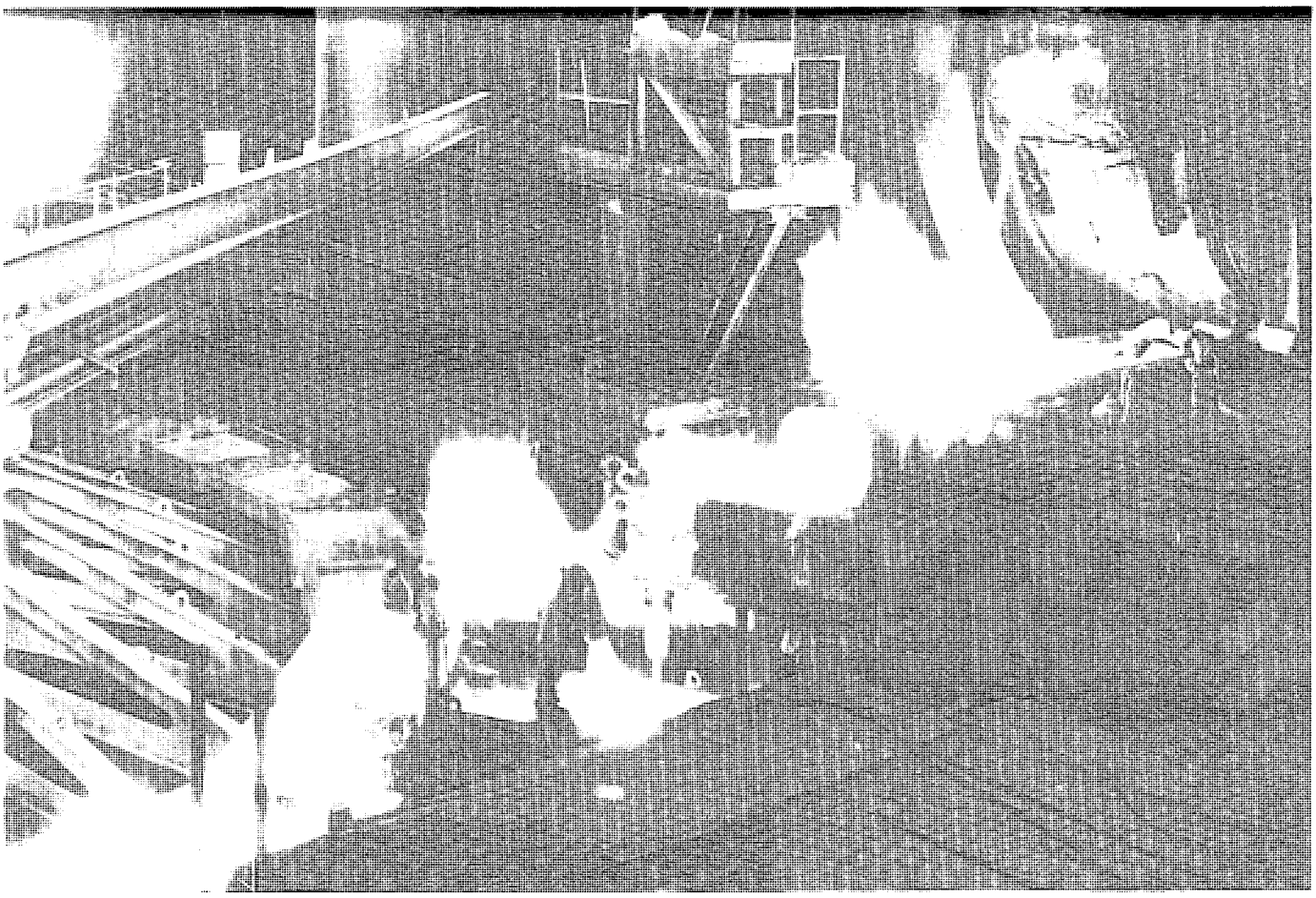
The classifier overflow goes to distribution boxes where, with reagents added, it is distributed to 40 cubic foot rougher flotation cells, and to 300 cubic foot rougher flotation cells, with a retention time of nine minutes. The copper-molybdenum minerals float to the surface of the pulp in each cell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

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

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



GRINDING MILLS AT SAN MANUEL CONCENTRATOR



PRECISION ANODE CASTING AT SAN MANUEL SMELTER

THE SMELTER

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

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

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

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

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

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

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

Single anodes are poured on the smaller wheel and removed by an operator controlled mechanism to a quench tank for cooling. On the larger wheel two anodes are automatically poured and removed to a conveyor for cooling by water sprays.

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

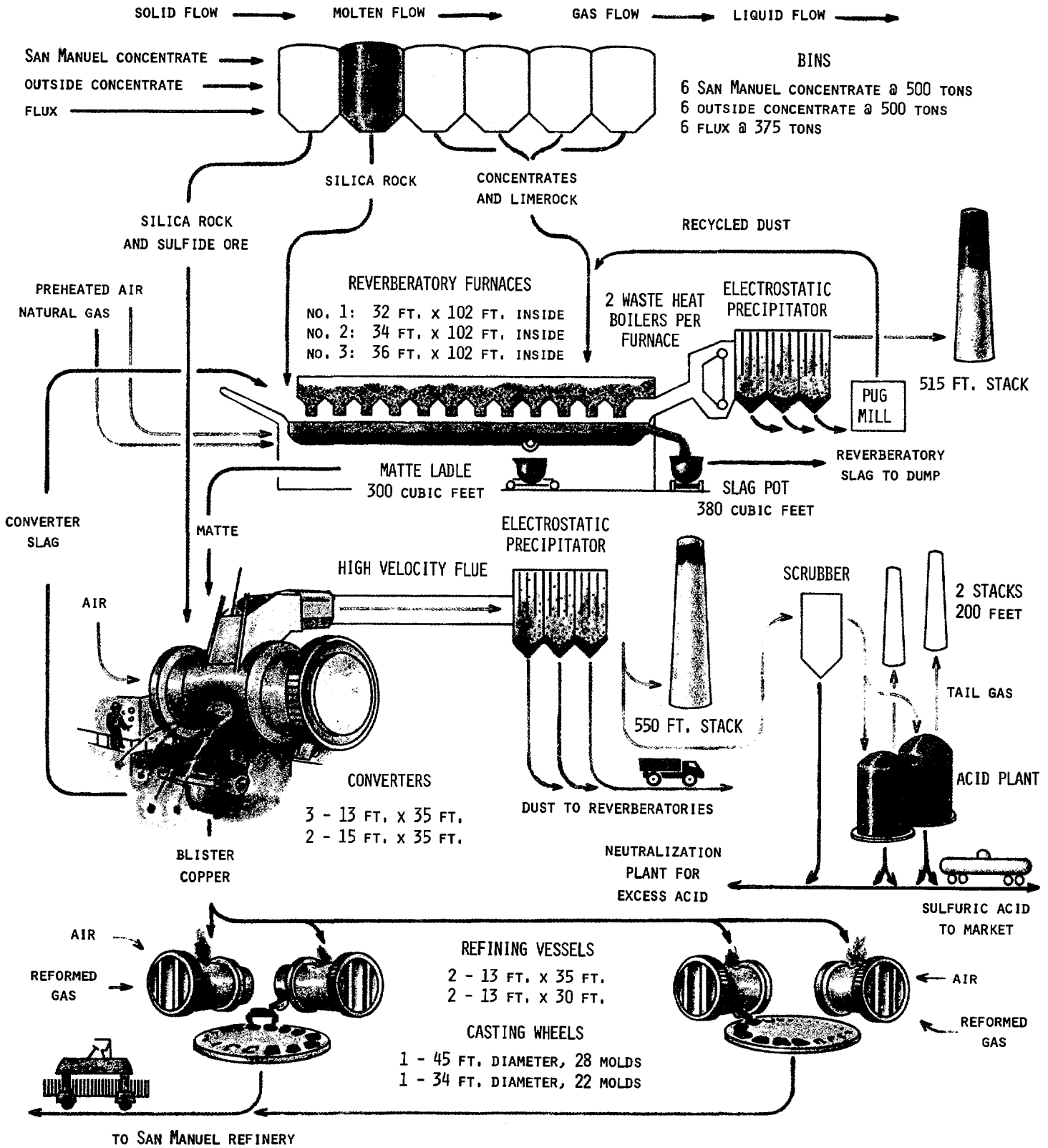
THE SMELTER POWER PLANT

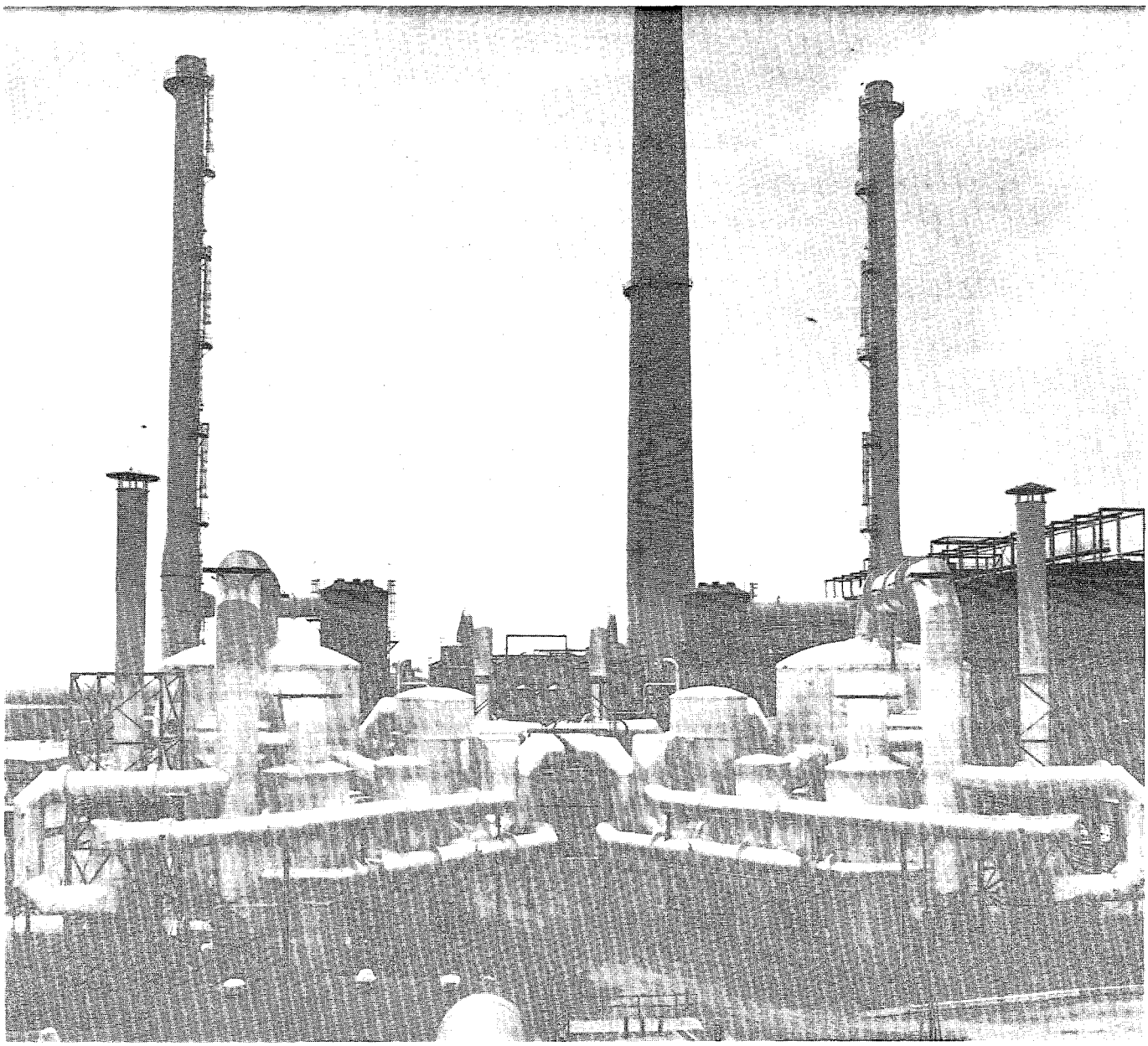
Approximately 20% of the Division electrical power requirements are generated at the smelter power plant which has a capacity of 23,600 KW.

Gases from each reverberatory furnace pass through two waste heat boilers which furnish steam at 475 psig to the power house. There are three steam turbine generators, one rated at 13,600 KW and two rated at 10,000 KW. In addition there are five turbine compressed air blowers, three rated 30,000 cfm and two 45,000 cfm. The electricity feeds into the nearby utility substation and can be routed to the mine or plant facilities for emergency power.

MAGMA

San Manuel Division Smelter Flow Sheet





SAN MANUEL SULFURIC ACID PLANT

SMELTER EMISSION CONTROL SYSTEMS

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

REVERB EMISSIONS

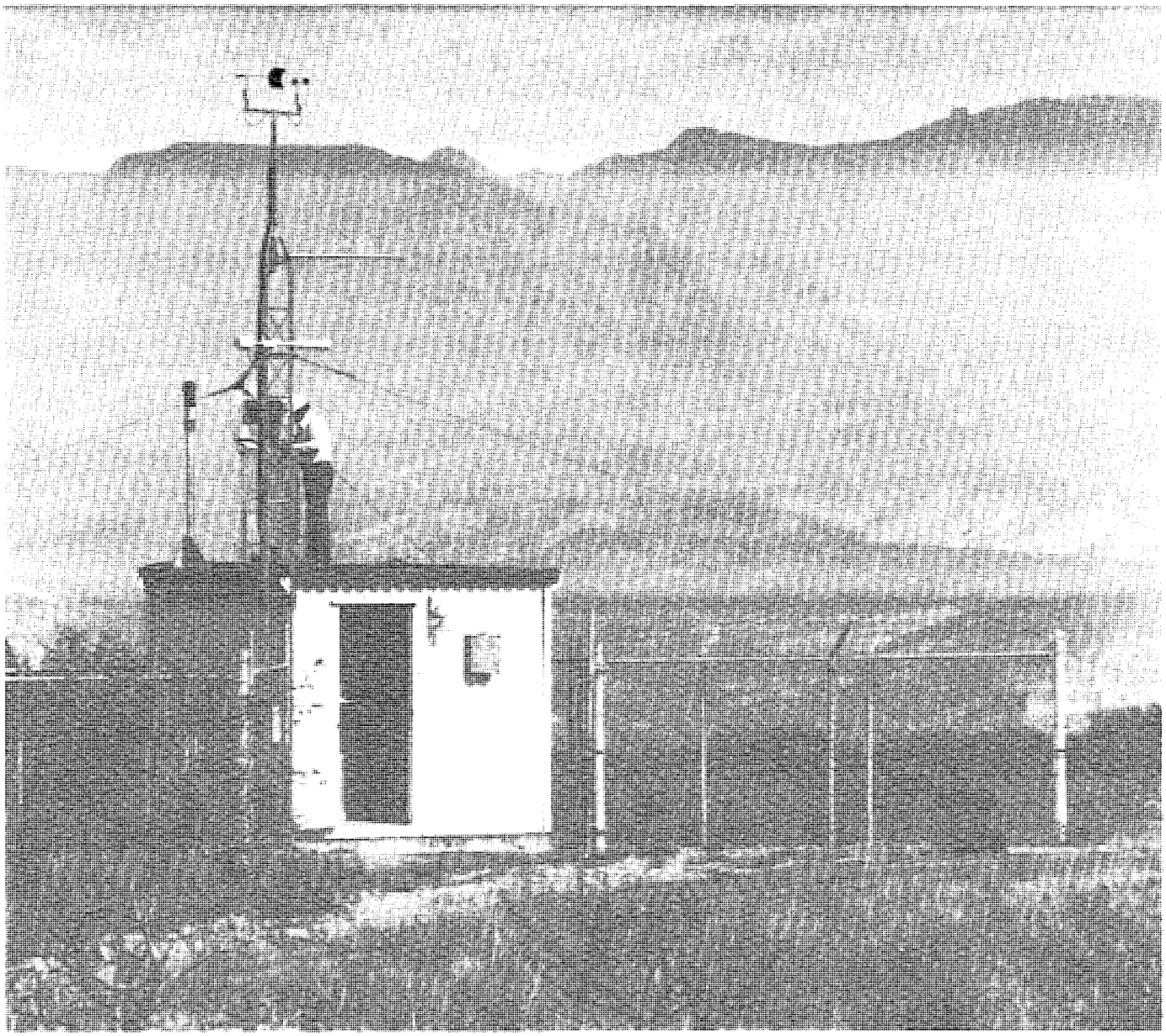
The emission gasses from the reverberatory furnaces contain large amounts of dust, particulates, and water vapor and small amounts of sulfur dioxide (less than 2% SO_2 by volume). For control of the particulates the gases pass through a three-module electrostatic precipitator. At least 98% of the particulate matter is removed and returned to the furnaces. The normal plume from the 515' western smelter stack is composed of approximately 2% sulfur dioxide, 15% water vapor, and 83% inert natural air components.

CONVERTER EMISSIONS

Emission gases from the six converters contain greater amounts of sulfur dioxide (3% to 7% by volume) and lesser amounts of moisture and dust. All converter emissions are passed to the sulfuric acid plant which is capable of recovering approximately 96% of this sulfur.

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

An electrostatic precipitator removes dust before the gas is passed through cooling and humidifying towers and then through a bank of 8 mist precipitators to remove all remaining solids and acid mist.



REMOTE AIR MONITORING STATION NEAR SAN MANUEL

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

The sulfur trioxide passes to towers where it is absorbed into circulating sulfuric acid. The resulting saturated acid is then concentrated to 93%-94% commercial grade for storage and transport to market.

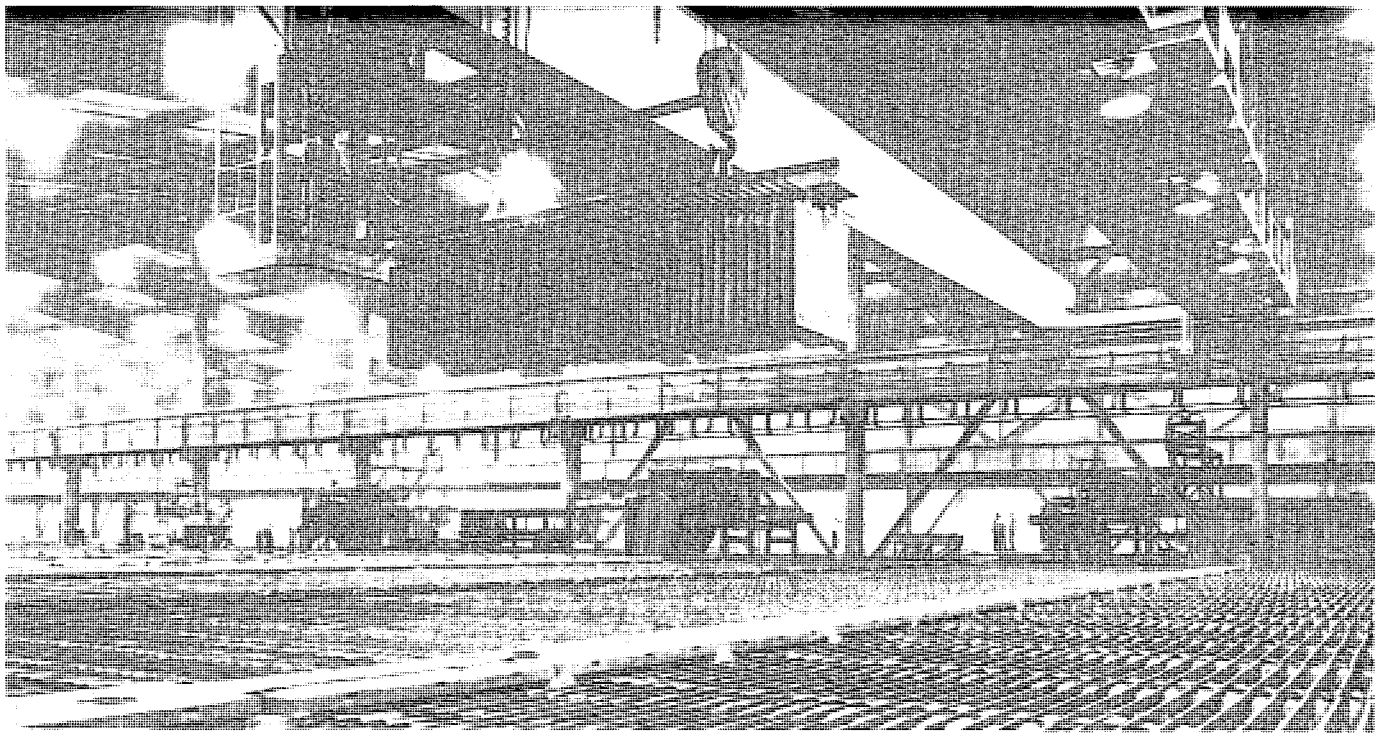
The plant has a production capacity of approximately 2,000 tons per day of sulfuric acid. Storage is provided at the loading docks for 20,000 tons. Neutralizing facilities are provided for any amounts of acid, including, if necessary, the entire production. A limestone slurry is mixed with the acid and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

When the sulfuric acid plant is in full operation the eastern 550-foot high smelter stack is dead. Minor tail gases from the two stainless steel acid plant stacks are invisible.

An average of the controls over the two emission sources at the smelter results in an overall 70% positive control of sulfuric dioxide and 98% positive control of particulates, well within the air quality control standards imposed by state and federal governments.

AIR MONITORING

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



OVERHEAD CRANE WITH CATHODES IN TANK HOUSE

THE ELECTROLYTIC COPPER REFINERY

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

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

Process and Facilities

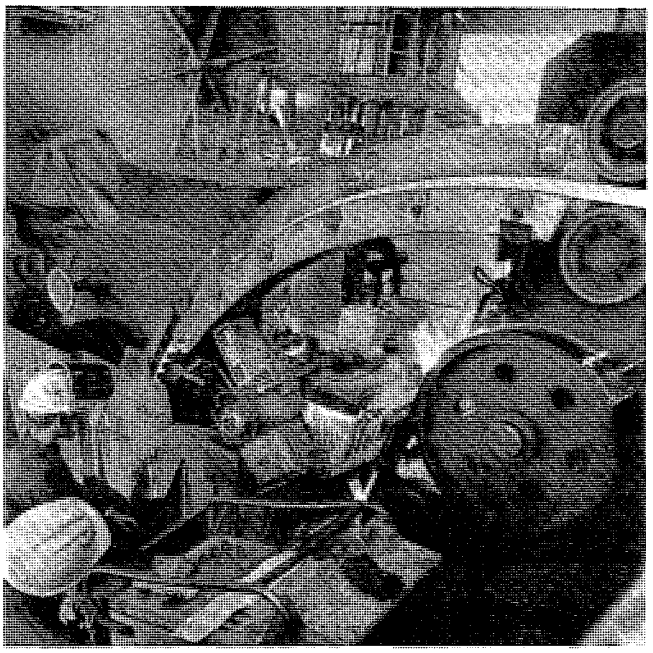
Refining takes place in the tankhouse. Smelter anodes are loaded in refining cells with 4" spacing with copper starting sheets suspended between the anodes. Electrolyte containing 48 grams per liter copper and 185 grams per liter sulfuric acid, with solution temperature controlled at 150°F, is circulated through each cell at the rate of 4 to 5 gpm.

Electric current is applied in a series-paralleled system to provide 21,000 amperes per cell. The DC voltage per cell is nominally 0.23. This provides a current density of slightly over 22 amperes per square foot of cathode surface. In the electro-refining process, copper ions go into solution at the surface of the anode. At the same time, copper ions are deposited from the eletrolyte on the surface of the cathode. As the anode is depleted, the cathode grows in thickness and weight. Anodes are replaced after 28 days in circuit. Each anode charge produces two pulls of cathodes. Under normal operating conditions, an anode weighing 795 pounds produces two cathodes weighing 330 lbs. each. The remaining 137 lbs. of anode after 28 days exposure is washed and returned to the smelter converters for recycling. Cathodes are washed and transferred to the rod casting plant, shear building or shipping docks.

Soluble impurities and copper which tend to concentrate in the electrolyte are controlled within strict concentration limits in the electrolyte purification (Liberator) section. The process of purifying the electrolyte is a modification of the commercial electrolytic refining process. Insoluable lead anodes are used with copper starting sheets as the cathode. Copper ions in the electrolytic deposit on the cathode, thereby depleting copper in the electrolyte. Impurities settle to the bottom as sludge or partially plate out in the low quality Liberator Cathode. Impure cathodes and the sludge are recycled to the smelter.

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

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



FIVE SQUARE INCH BAR CASTING

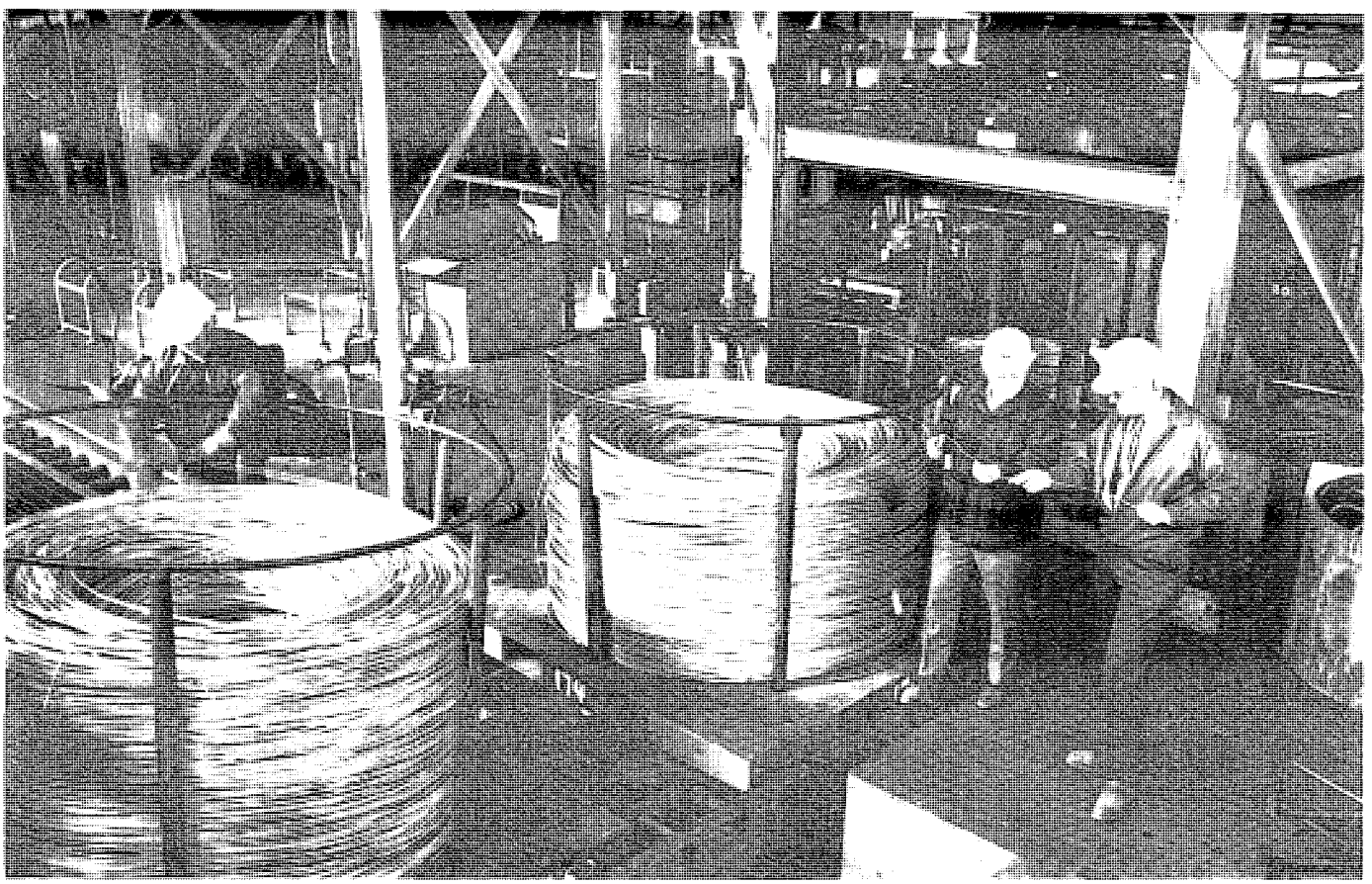
Continuous Rod Casting

Refined copper, in the form of cathodes, with dimensions approximately 38" x 38" and weighing approximately 330 pounds are transferred to the casting house. Approximately 125,000 tons per year are melted and cast into 5/16" and 13/32" diameter rod.

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

Molten copper is fed to the rod casting machine at a controlled rate of near 30 tons per hour by rotating the holding furnace. The molten copper flows into a casting ladle which directs the flow into the cavity of the casting wheel. The copper casting wheel is 96" in diameter with a rim cavity specifically designed and machined to produce a casting with 5 square inches cross-sectional area. The entire casting assembly is water cooled and lubricated to produce a smooth casting.

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



FINISHED 8-TON LAID COILS AT 5/16" CONTINUOUS CAST MAGMA ROD

QUALITY CONTROL IS ESSENTIAL IN PRODUCTION OF MAGMA COPPER

METALLURGY

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

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

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

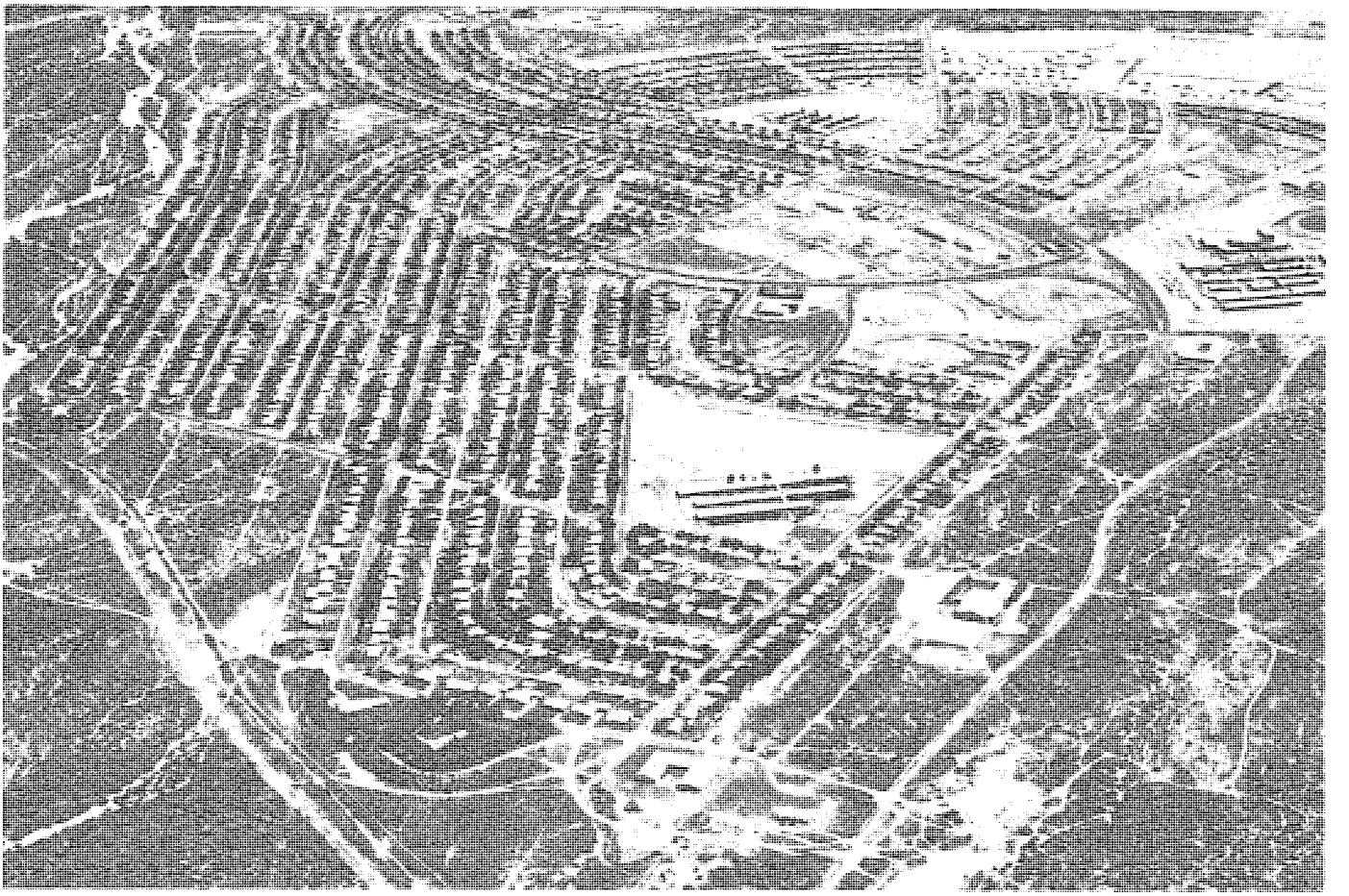
Extensive use of electronic data processing is utilized for metallurgical determinations and a teletype network gives prompt information at operational control points throughout the Division.

OTHER PLANT FACILITIES

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

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

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



SAN MANUEL, ARIZONA

THE TOWNSITE

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

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

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

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

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

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

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

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

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

San Manuel elementary schools, Mammoth elementary school and San Manuel High School and Junior High School serve the Mammoth School District, which includes students from San Manuel, Mammoth and vicinity.

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

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

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

STATISTICAL DATA

ORE DEPOSIT

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

OREBODY

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

OVERBURDEN OR CAPPING

Description	Gila conglomerate and weakly mineralized monzonite
Thickness	Averages 670 feet

MINE OPENINGS

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

MINE PRODUCTION

Capacity	62,500 tons daily
Mining method	Block caving
Underground haulage	Electric trolley locomotives; ore car capacity, 12.5 tons; 15 cars per train, 180 trains per day
Hoisting	Hoisted through four vertical shafts First hoisting level 1475 feet (now completely mined out) Intermediate hoisting level, 1775 ft. Second hoisting level, 2075 feet Hoists: 2 - 6000-hp, double drum 2 - 7000-hp, double-drum Hoisting speed: 2500 to 3000 fpm Capacity of skip: 21 to 28 tons Run-of-mine ore: up to 14 inches

ORE CRUSHING

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

ORE TRANSPORTATION — MINE TO CONCENTRATOR

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

ORE CRUSHING (PLANT)

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

CONCENTRATION OF ORE

Concentrator	62,500 tons per day capacity
Rod mills	Ten 10' x 13' rod mills and three 12'6" x 16' rod mills; primary grind in open circuit
Secondary Grind	In closed circuit with 20-inch cyclone classifiers; twenty 10' x 10' and six 12'6" x 14' ball mills with twenty-six sets (122) 20-inch cyclone classifiers
Flotation	1056-40 C.F. and 63-300 C.F. mechanical cells.
Concentrate regrind	Eight 8' x 12" ball mills
Cleaner concentrate	1300 to 1500 tons of concentrate to molybdenum plant for recovery of molybdenum
Molybdenum plant	Products — 90% MoS2 concentrate ready to market and 28% copper concentrate to smelter storage bins
Gold plant	Products — Precipitate with gold assey of more than 1000 ounces per ton, and silver assay of more than 1500 ounces per ton

SMELTING OF COPPER CONCENTRATE

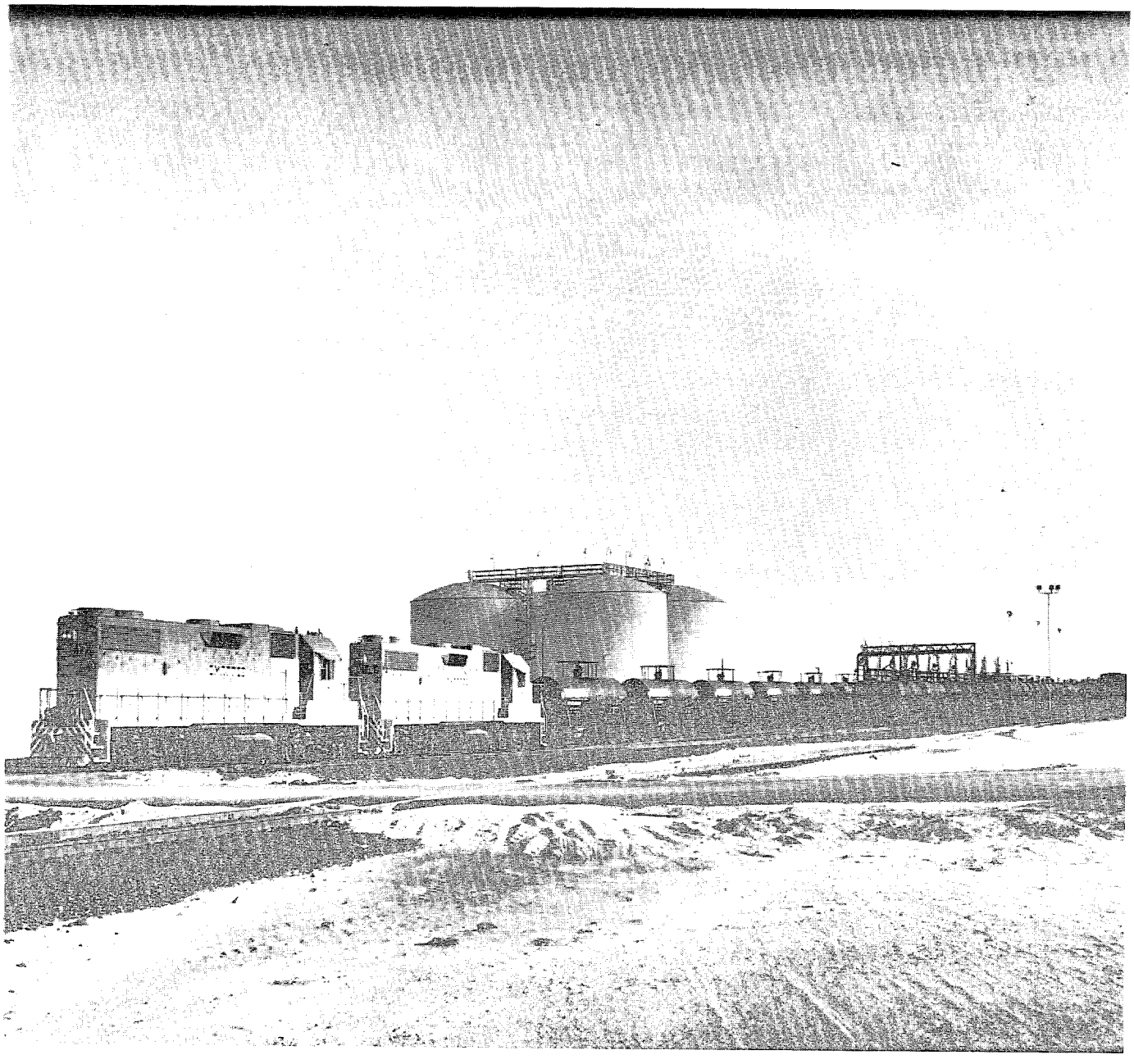
Copper concentrate	28% final copper concentrate to one of three natural-gas fired, side-feed, reverberatory furnaces, 32' x 102', 34' x 102' and 36' x 102'.
Reverberatory products	Matte at 32% to 35% copper Slag, to slag dump. Waste gases — about 50% of contained heat recovered by two waste-heat boilers on each furnace. Flue dust recovered from gases by a three compartment electrostatic precipitator before entering 20' x 515' stack.
Matte to converters	Three 13' x 35' and three 15' x 35' Pierce-Smith type converters.
Converter products	Slag, return to reverberatory furnace. Waste gases to electrostatic precipitator and contact acid plant. Blister copper, delivered to 4 anode holding furnaces where it is blown and poled prior to casting into 795 and 760 pound anodes.

REFINERY PRODUCTION (DESIGN CAPACITY)

Anodes charged per day	795	Tons
Cathodes pulled per day	650	Tons
Anode scrap pulled per day	135	Tons
Average weight — Anodes		
Commercial Sections	795	Pounds
Starting sheet section	760	Pounds
Starting sheets per day	5,400	
Starting sheet blanks in cells	2,700	
Average weight — starting sheets	12	Pounds
Anodes per cell	46	
Cathodes per cell	45	
Cathodes pulled per day	3,780	

MISCELLANEOUS

1974 Employees	5,200	
1974 Payroll	$ 66,070,927	
1974 Fringe Benefits	$ 7,500,000	
1974 Hospital & Medical Costs	$ 4,739,925	
1974 Arizona Purchases	$ 45,492,902	
1974 Arizona Taxes	$ 15,230,912	
1974 Copper Produced	115,400	Tons



STRING OF SULFURIC ACID TANK CARS START TO MARKET VIA SMARRCO

San Manuel Arizona Railroad Company

WHOLLY OWNED SUBSIDIARY OF MAGMA COPPER COMPANY

A COMMON CARRIER

Incorporated	September 1953
Track mileage	San Manuel-Hayden Junction 29.42 miles
Freight carried 1974	729,162 Tons
Locomotives	4 ALCO 1600hp Electric diesel road switchers 2 EMD 2000hp Electric diesel road switchers
Employees	35
Schedule	Operates daily to Hayden Junction connection with Southern Pacific.

The Mine

GENERAL INFORMATION

MAGMA COPPER COMPANY

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

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Front Cover Picture: Hoisting shafts at Magma Copper Company's San Manuel mine are designed to lift 62,000 tons of ore per day from production levels as deep as 2,675 feet underground.

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

Geology

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

Intrusion of the Laramide porphyry and its accompanying mineralization-alteration phenomena apparently occurred along a central longitudinal axis which originally was much steeper than the present axis. After the total cylindrical system was formed, it underwent periodic rotation to the northeast and concomitantly was bisected at an acute angle by the San Manuel fault, a normal fault with post-fault rotation, producing two offset segments as presently known. The segment in the lower plate is known as the San Manuel Orebody while the segment in the upper plate has been called the Kalamazoo Orebody.

Production Control

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

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

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

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

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

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

Development drift samples are taken by the Geology Department while mapping the headings. Production area samples are taken by four full time samplers working a 6-day week, who are capable of taking more than 300 samples a day.

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

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

No. 1 Shaft

Depth: 2,829 ft. (for the Third Lift.)
Dimensions: 25′-5⅞″ x 6′*—4 Compartments:
2 Hoisting, 6′-5½″ x 6′-0″.
1 Manway, 5′-0 ⅛″ x 6′-0″.
1 Service Cage, 5′-0″ x 6′-0″.
*—Inside Concrete
Ventilation downcast.
Structural steel sets in reinforced concrete.
Headframe: 100′-6″ to ℄ sheaves.
Two 12′ diameter steel sheaves with wear liners.
Skips: Two, 4-ton capacity each, in counterbalance, Kimberly type.
Hoists: Main Hoist, two 200-hp motors, double drum.
Rope speed = 800 fpm, with Lebus wind.
Rope size = 1⅛″.
Service Hoist: single drum, 200-hp.
Rope speed = 545 fpm.
Rope size = 1″.

This shaft is used to hoist rock from the development headings. Manway compartment contains main pump discharge columns carrying most of the water pumped from the mine and power transmission lines. The service compartment has three 8-in. heavy-duty pipes for passing concrete from the automated concrete batching plant at the collar of the shaft to the underground mining levels and 1 pump line.

3A-3B Shafts

Twin ore hoisting shafts.
Depth: 2,310 ft. (for the Second Lift.)
Dimensions: 29′ x 7′ inside concrete.
Four compartments, each 6′-6″ x 7′-0″.
Ventilation exhaust shafts, 195′ apart.
Structural steel sets poured in reinforced concrete for smooth lining. Reinforced concrete curtain walls between each compartment, with 3′-7½″ x 4′ windows in each set.
In each of the two hoisting compartments steel hat-section guides are of Corten steel. These guides are supported every three ft.
Timber guides in service compartment are supported every 6′-0″.
Headframe: 181′ to ℄ sheaves.
14′ diameter cast steel sheaves.
Coarse Ore Bins: Diameter: 60′
Height: 66′-6″; top of bin 92′ above collar.
Capacity: 750 tons total.
Loading Gates: 2 on each track per bin, air operated.
2 loading tracks.

3A-3B Shafts, continued

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

Loading
Pockets: Two in 3A; one below 1775 Level; one below 2075 Level, capacity = 1.500 tons. One in 3B below 2075 Level, capacity = 1,500 tons.

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

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

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

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

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

3C-3D Shafts

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

Depth: 3C = 2,859 ft. The sinking and furnishing of this shaft was completed April 12, 1971. Hoisting from 3C started in August, 1971.

3D = 3,713 ft. Shaft sinking is complete.

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

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

Ventilation exhaust shafts.

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

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

Headframe: Structural box members of Corten steel.

15′ diameter fabricated steel sheaves.

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

Capacity: 29 tons.

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

Automation: Same as 3A-3B.

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

Hoisting Speed: 2,800 fpm.

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

3C

Service

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

3C-3D Shafts, continued

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

No. 4 Shaft

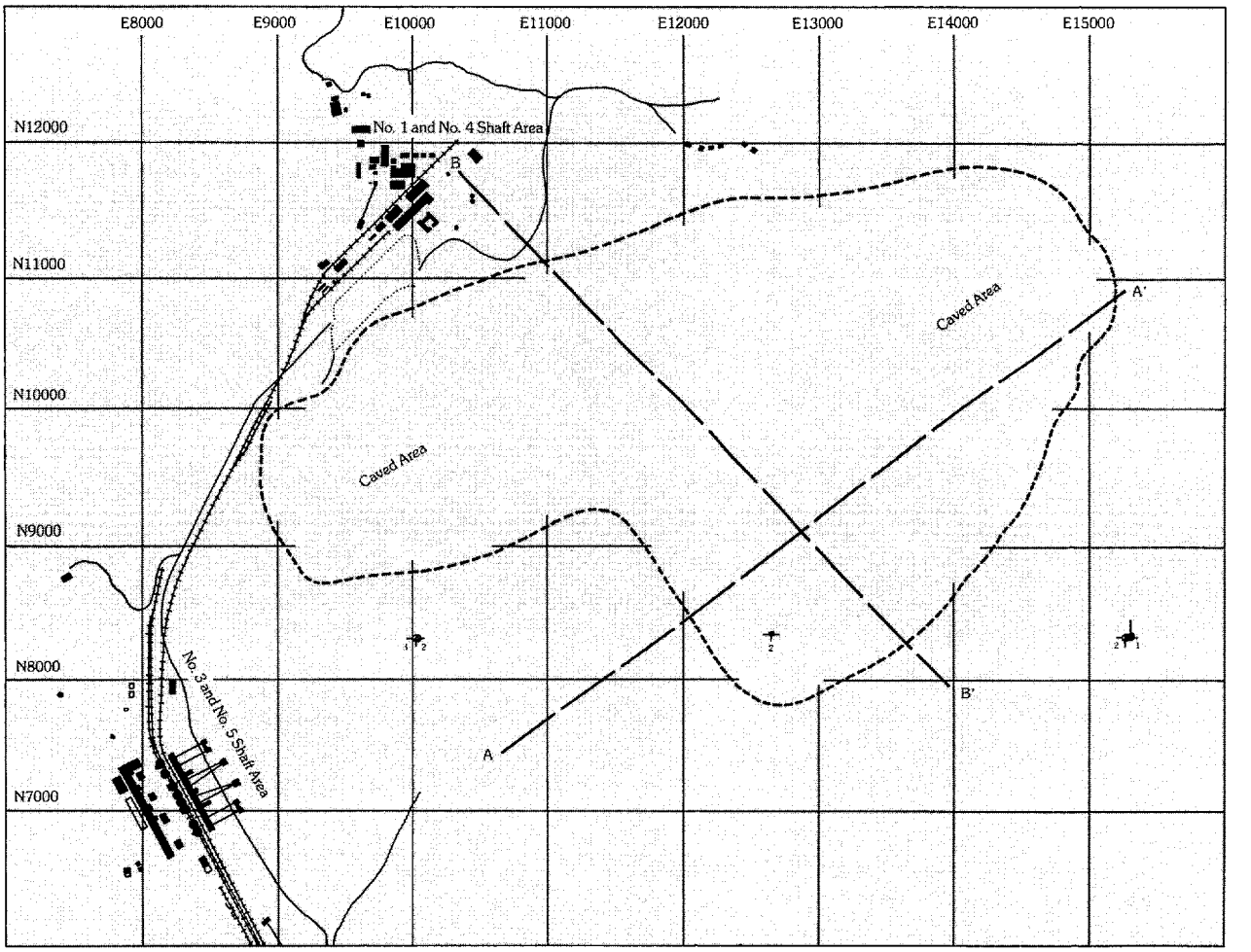
Depth: 2,729 ft.
Dimensions: 26′-6″ x 14′. Structural steel sets are poured in concrete for smooth lining.
Two cage compartments, each 14′ x 8′; two rounded end compartments for manway, pipes, electric cables and ventilation. Manway compartment also contains the main compressed air line supplying the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

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

No. 5 Shaft

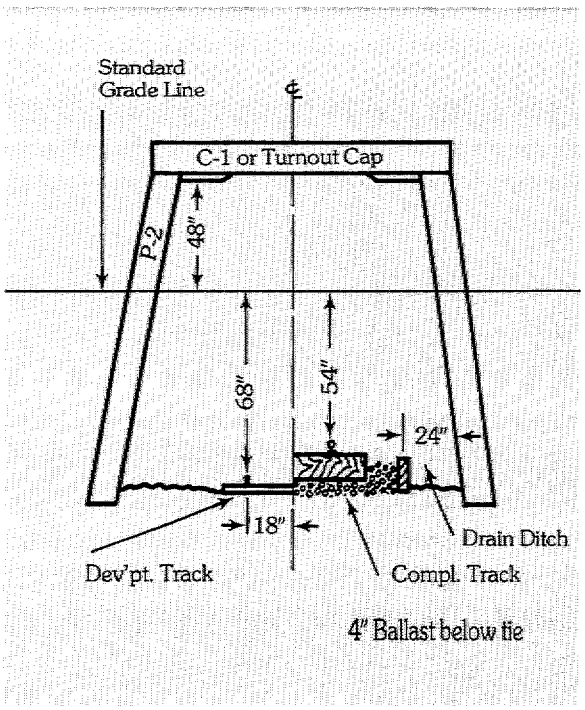
Lining: 24" thick reinforced concrete lining.
Depth: 4,123 ft.
Dimensions: 25 ft. diameter inside the concrete lining.
Of the four hoisting compartments, two will be used for handling men and supplies, and two will be used for hoisting waste rock. The shaft will also have compartments for manway, pipe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

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



Mine Surface Map Showing Caved Areas

1″ = 1200′



Posts: 12" x 12" x 10'-4"
Caps: 12" x 12" x 10'
Sets on 5' centers.
For the lower levels, we are in the process of changing to a set having a longer cap and posts having less batter. T/R (completed) will be 6" lower.
Crews: Single Heading—3 men.
Two Headings—4 men.
44-48 holes drilled per set.
50 lbs. ± of Ammonium Nitrate primed with a stick of 60% Amogel per hole. Initiated by electric blasting caps 0 to 12 delay.

Timber Haulage Drift

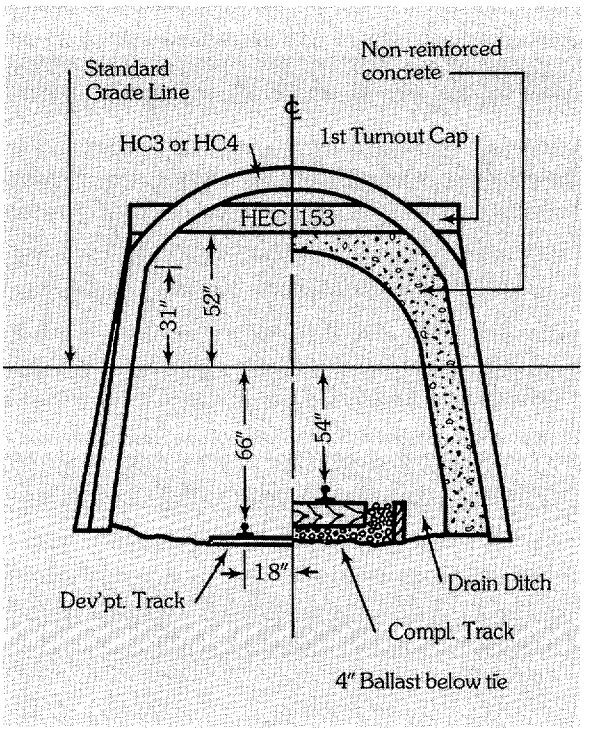
45# Rail for Development.
90# Rail finished track.

Timber Ladder Drift

If 75# rail is used, 64" is the grade.
45# rail for Development.
75# rail finished track.

Rail Measurements

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



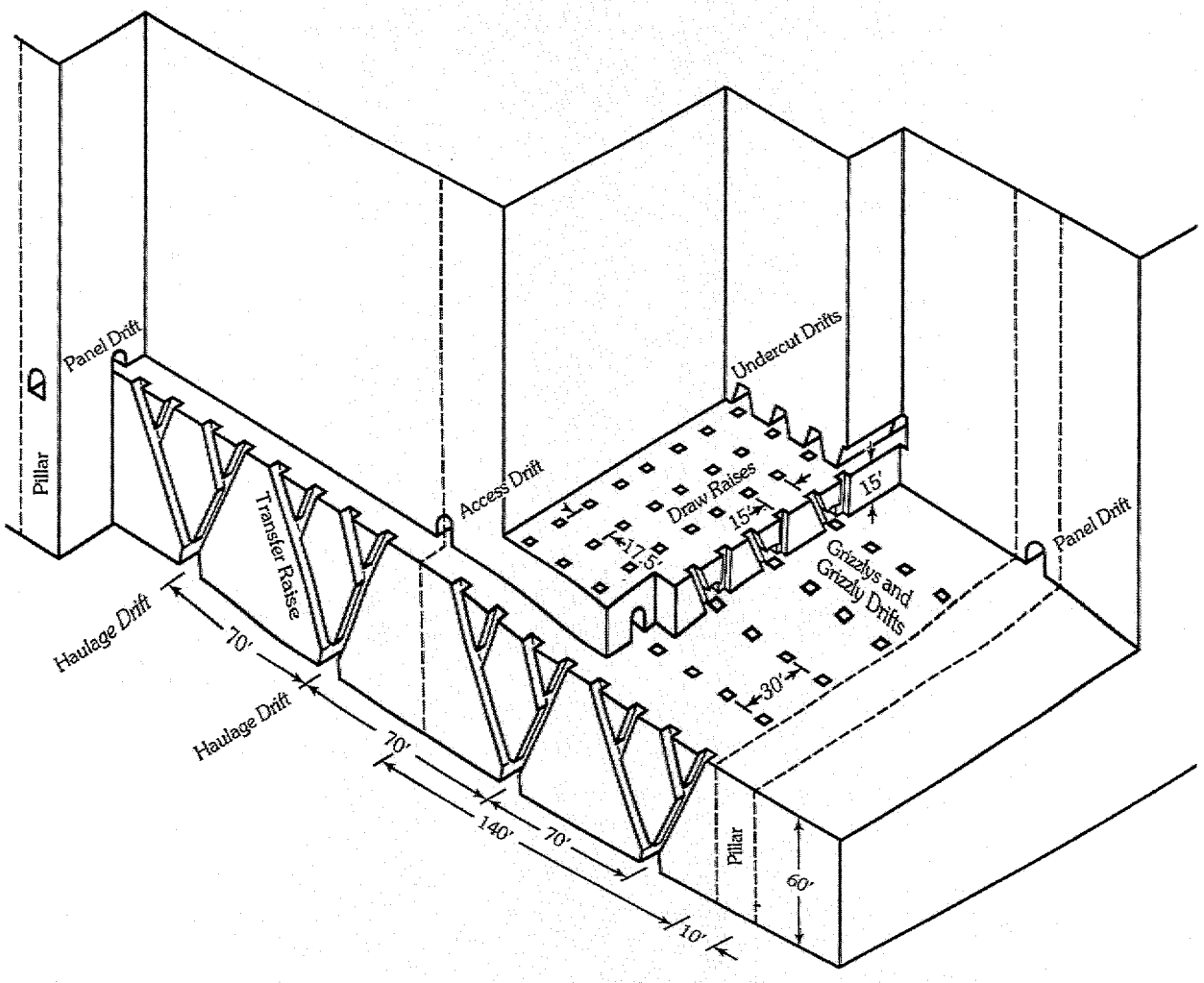
4" or 6" W.F. arch caps and 9'-6" posts for initial ground support.
Sets on 5' centers.
Crews same as Timber Haulage Drift.
On the lower levels, the concrete drifts will have a 1' flat spot in the crown, to allow passage of wider equipment. Completed T/R will also be 6" lower.
Initial Ground Support: 4" Steel Set (HC-3) or 6" Steel Set (HC-4)

Concrete Ladder Drift

If 75# rail is used, 64" is the dev'pt grade.
45# rail for Development.
75# rail finished track.

Concrete Haulage Drift

45# rail for Development.
90# rail finished track.



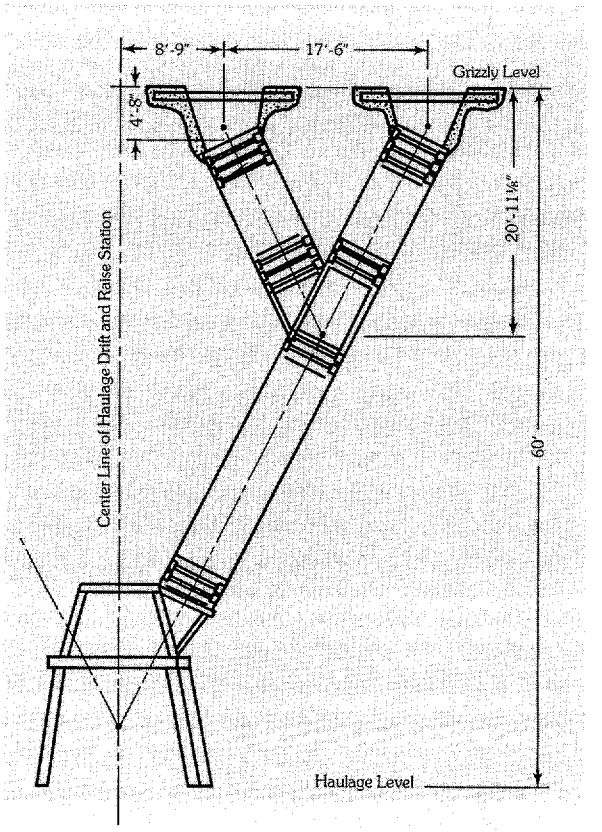
Isometric Diagram of a Block

1" = 80'

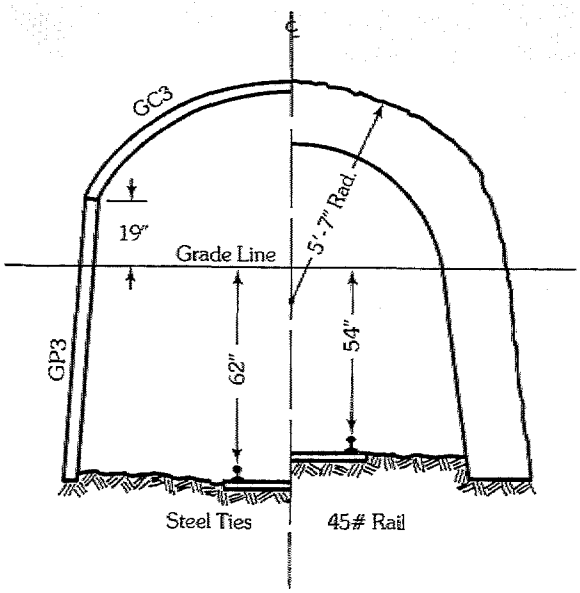
Gravity Flow Transfer Raise

4′ x 4′ inside.
Lining: 6″ x 8″ cribbing, armored with 3″ x 4″ x 3/16″ steel angles and "T"-irons.
Inclination: 63°
Length: 48′
Crews: 2-man crews advance two raises at once, using 3″ stopers. 14 holes drilled 5′ deep; 35 lbs. 60% Amogel used per round, detonated with electric caps. Ventilation with compressed air.

Transfer Raise Stations are cut by the regular drift crew using the same equipment they use to drive the drift.
They are cut as the drift heading is advanced.
Raise Stations are steel pony sets on top of special drift sets. Lined with non-reinforced concrete.



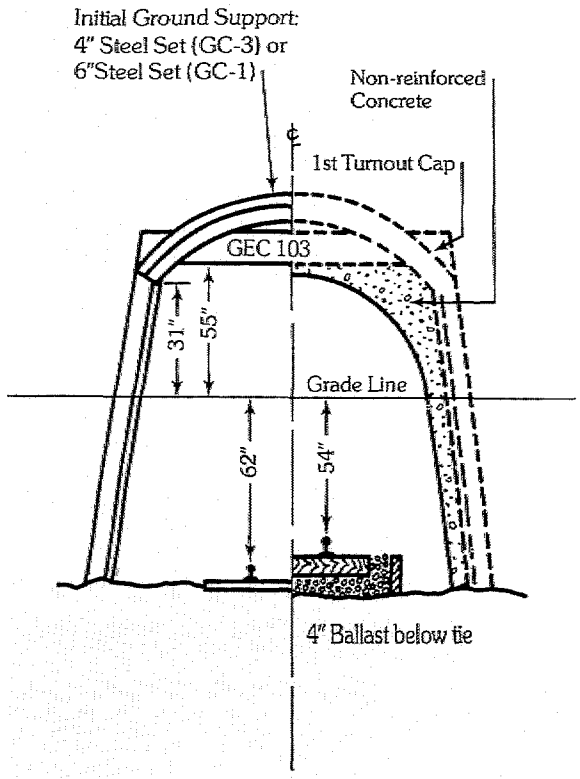
Grizzly Level Primary Development Drifts



Concrete Panel Drift

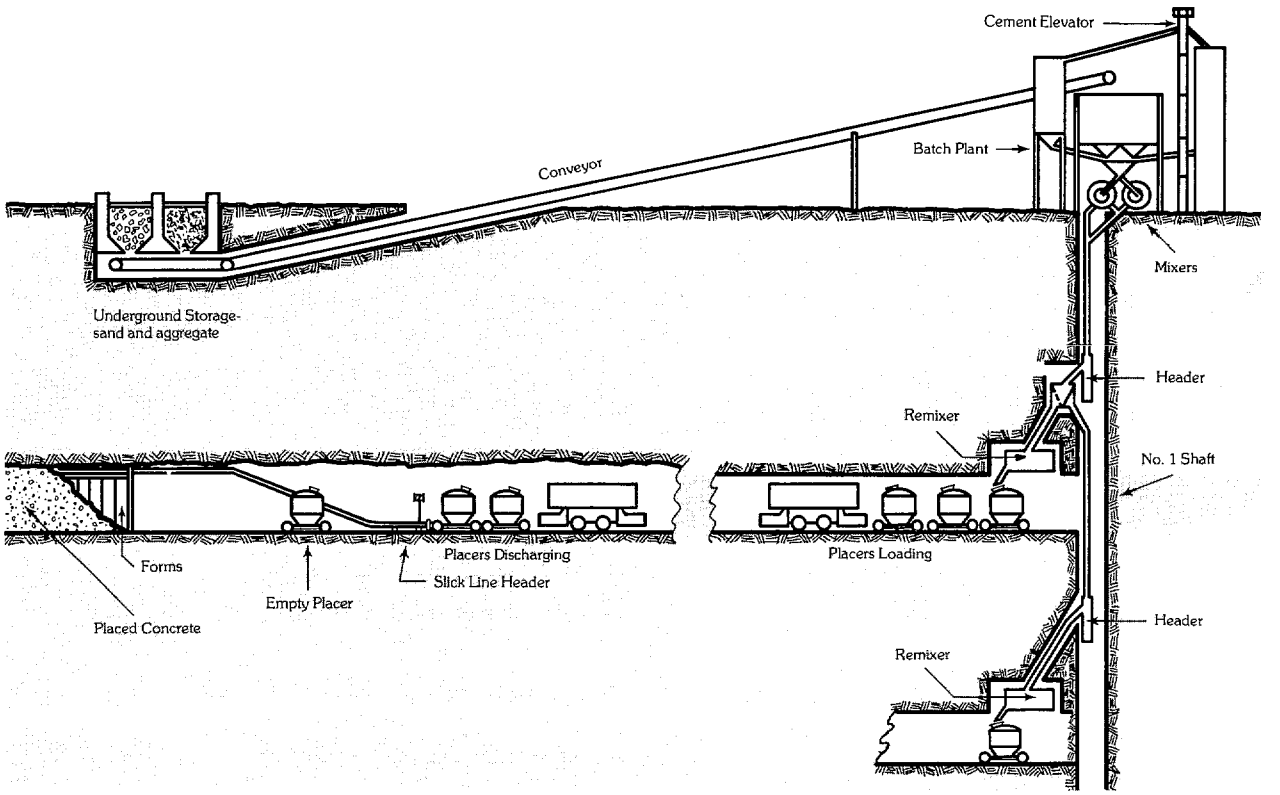
Excavation only:
Rock bolts and steel straps GC-3, GP-3 are used as pre-concrete support.
Size: 10'-3" x 9'-1".
Each round marked on face by Boss.

Two-man crews, or 3 men in two headings.
44-48 holes drilled 6' deep.
40 lbs. ammonium nitrate primed with a plastic booster per hole. Initiated by electric blasting caps 0 to 12 delay.
Ventilation with fans and tubing.



Concrete Fringe Drift

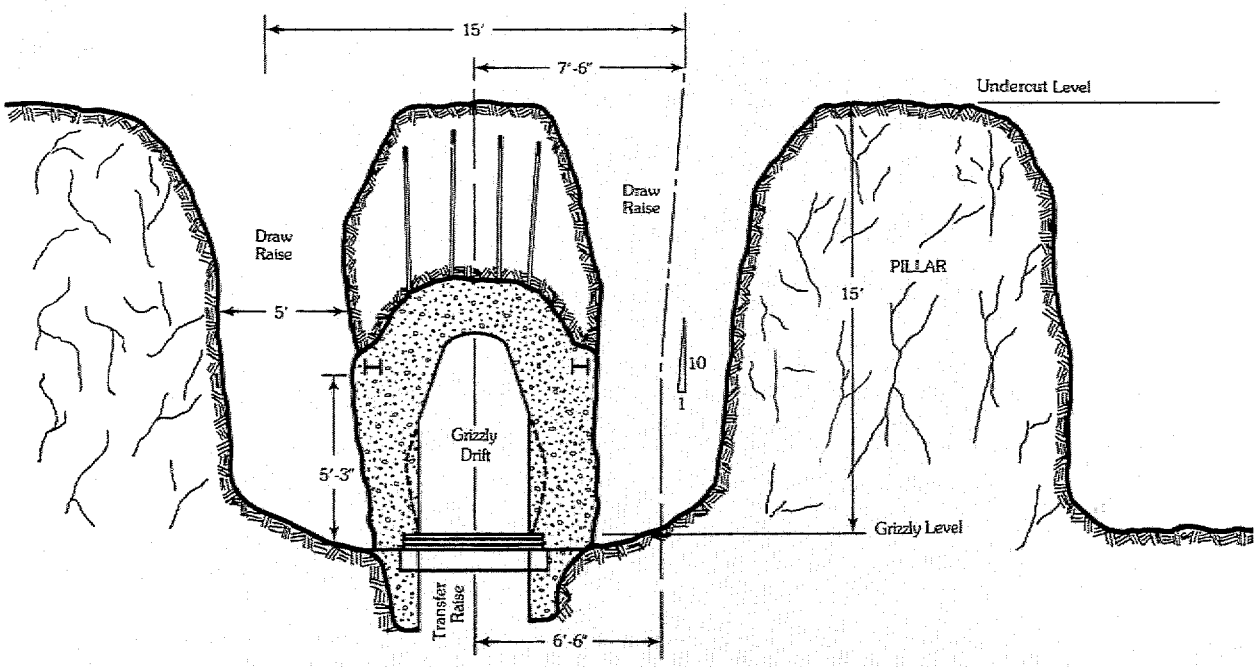
45# rail and steel ties for Development and Finished Track.



Schematic Diagram of Concrete Flow Sheet

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

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

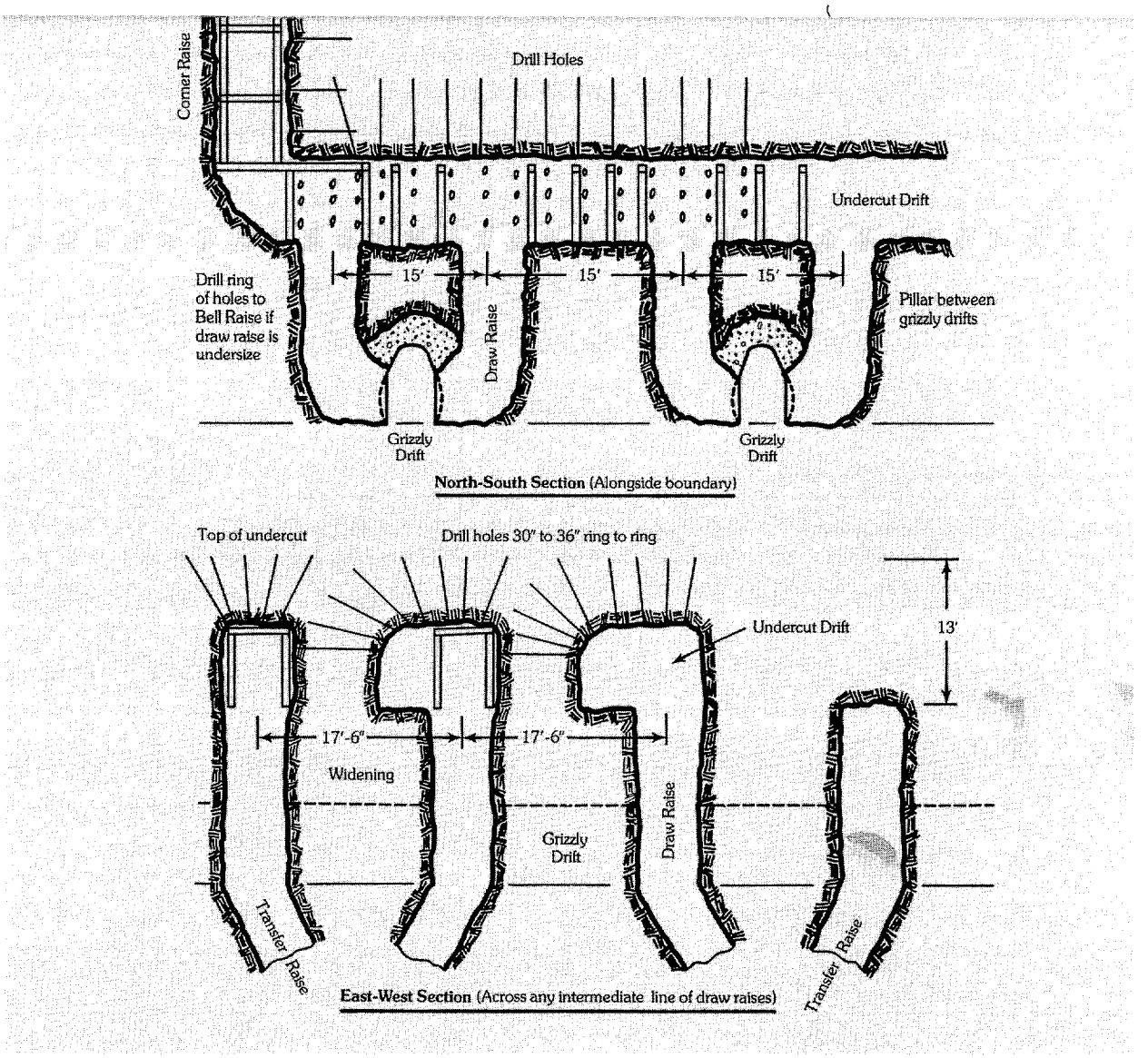


Gravity Flow Draw Raise

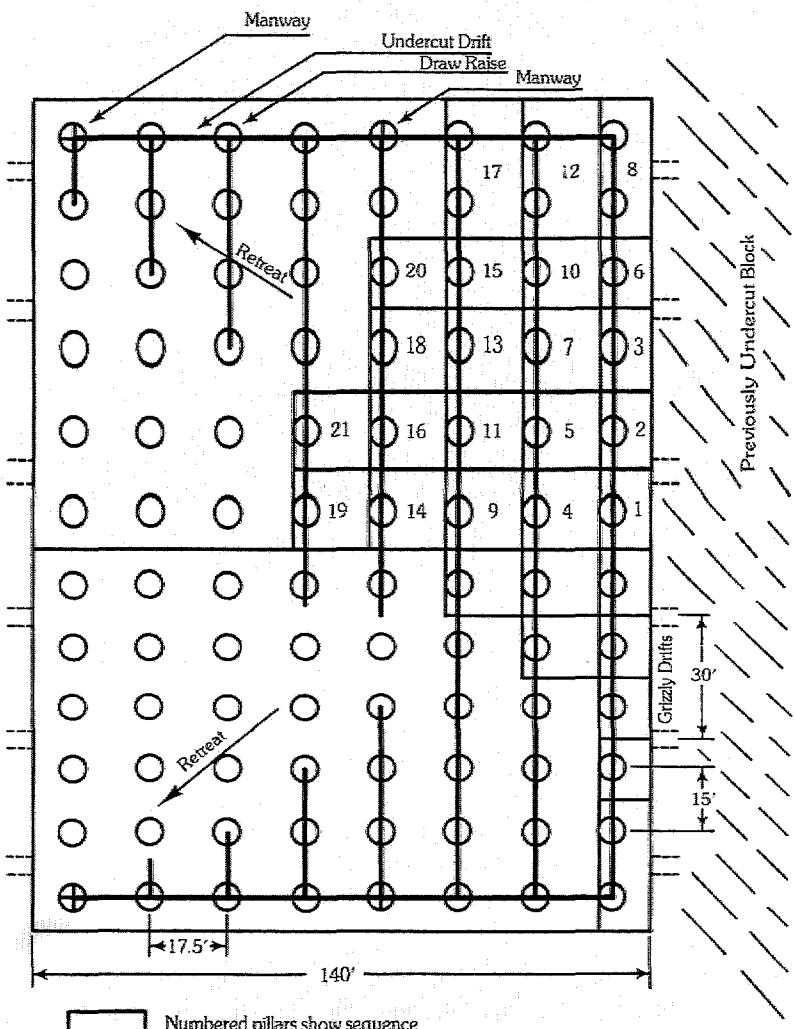
Size: 5' minimum diameter, unlined.
Length: 15'-0" above grizzly. Driven after grizzly drift is concreted.
Crews: 2-man crew drives several raises at once. 11 to 24 holes drilled 4' to 6' deep. 27 lbs. ammonium nitrate with each hole primed with plastic booster. Electrically blasted.

Gravity Flow Grizzly Drift

Excavation only; 8'-4" x 8'-0" between draw points; 9'-6" x 8'-0" at draw points.
Rock bolts and wire mesh used for pre-concrete support.
Size: 5' wide, 6¾' high finished drift with concrete reinforced at the draw points only.
2-man crews used. 13 to 21 holes drilled 6' deep. 30 lbs. ammonium nitrate with each hole primed with plastic booster used per round; electric primer blasted. Drilling is done with Jackleg. Ventilation with air mover.



Undercut Procedure



12 Numbered pillars show sequence in which they were taken. South half of block—same procedure.

Progression of Undercutting

Typical Block

Undercut Procedure

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

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

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

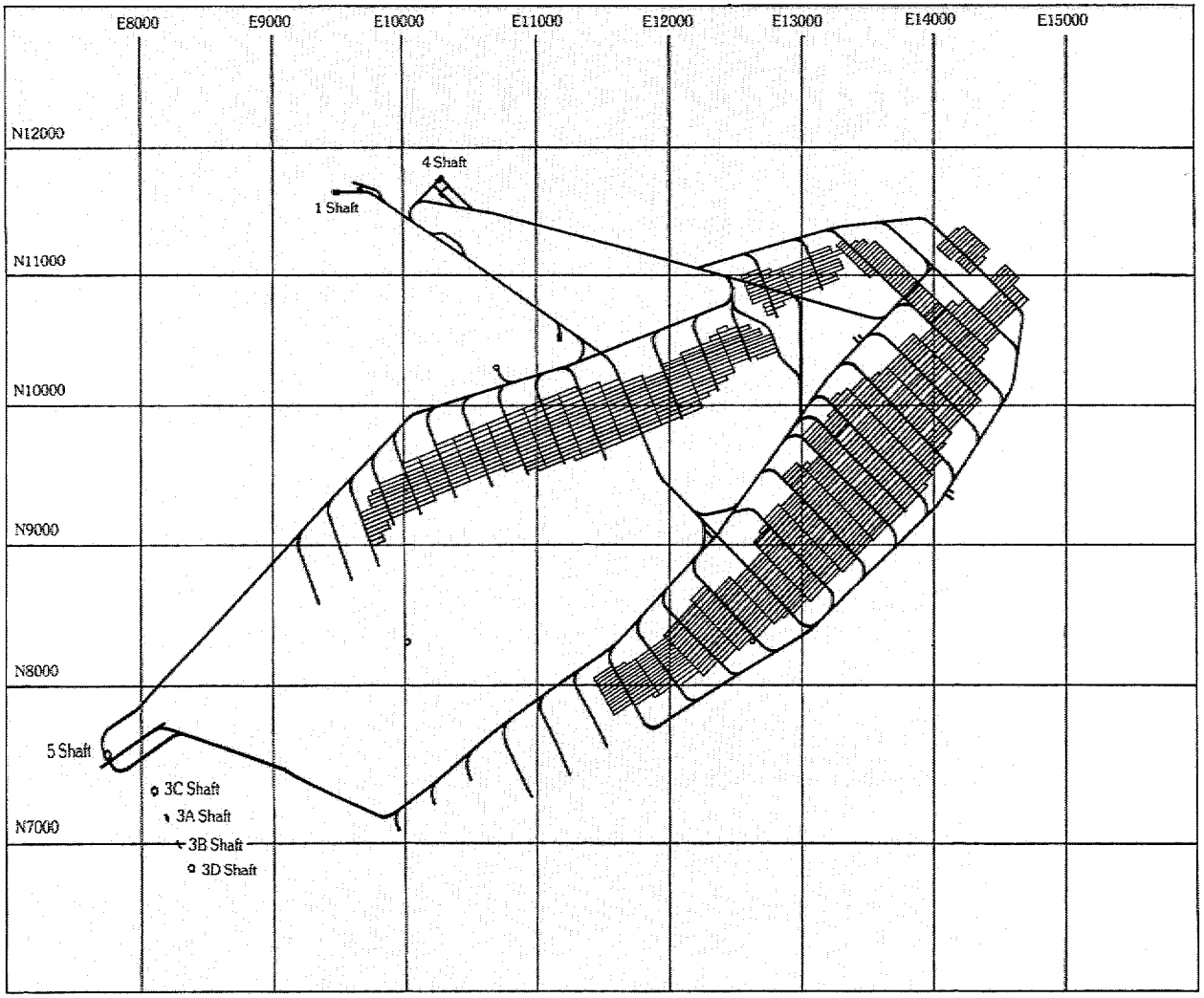
The timber is drilled with wood augers and shot with the undercut round. Generally, a 15-ft. section along the drift length is taken with each blast (from one draw raise to the next). Care is taken to insure that the pillar is completely broken by drawing off sufficient broken muck to observe the effect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

Timber:

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

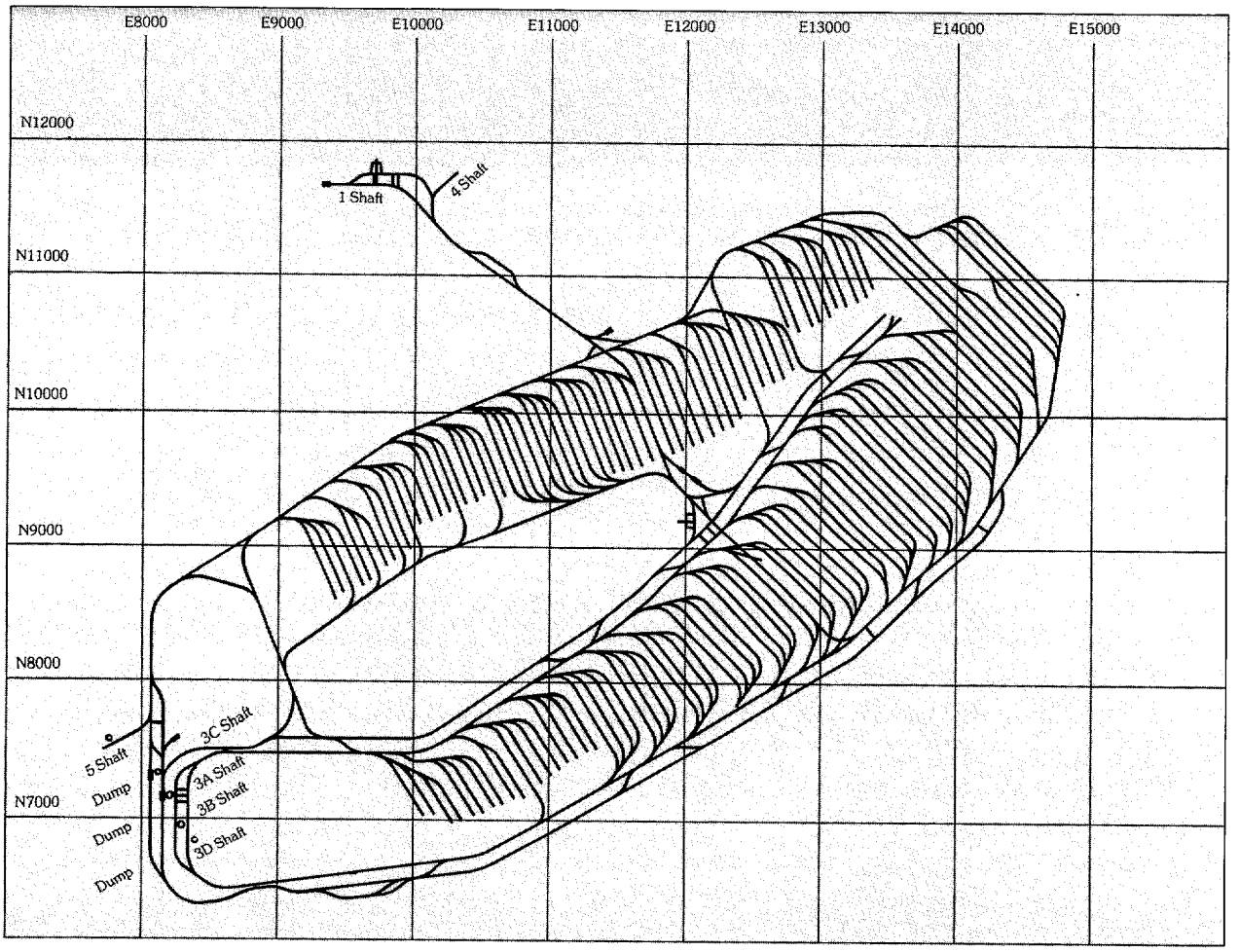
Crews:

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



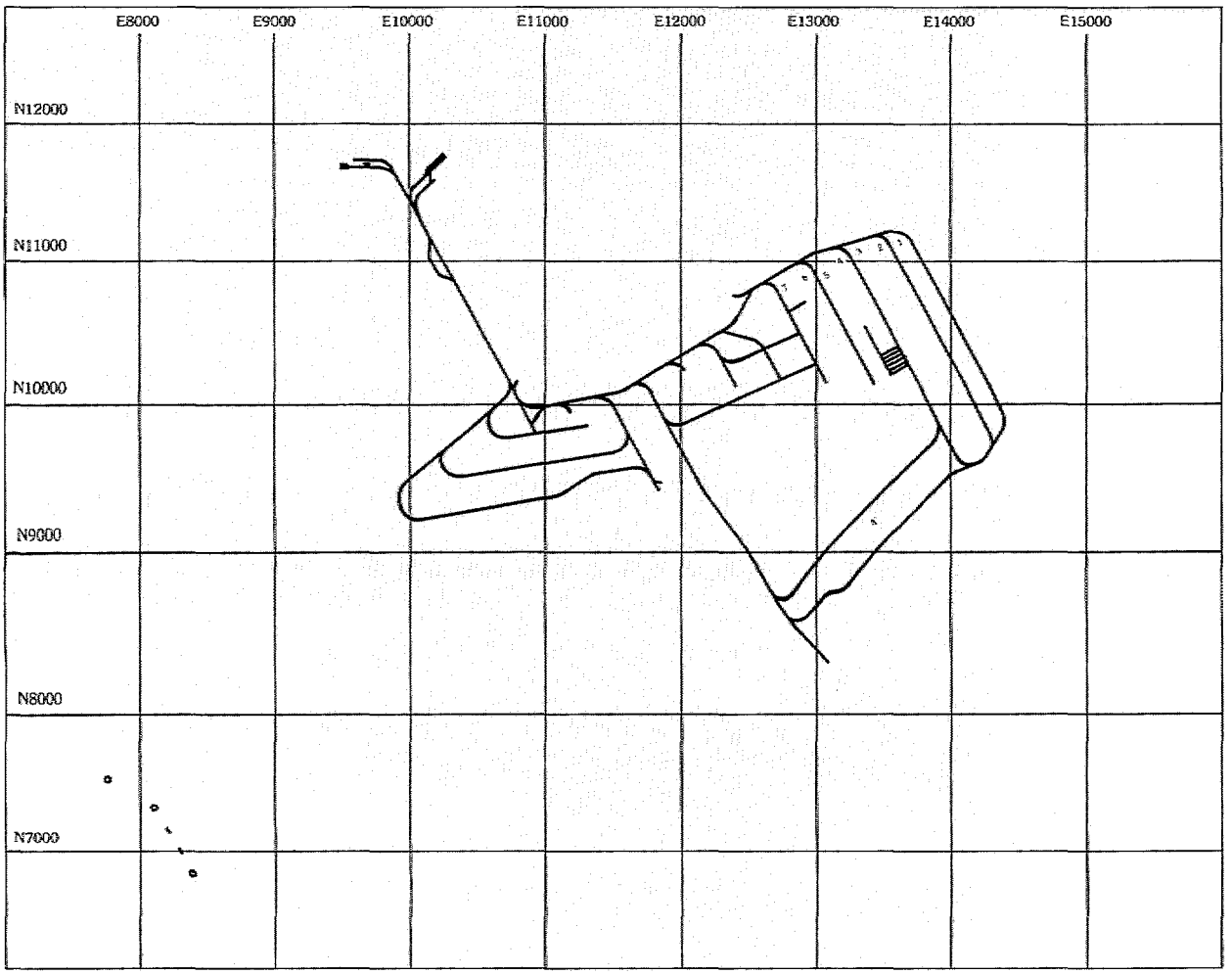
Plan-2015 Grizzly Level

1″ = 1200′



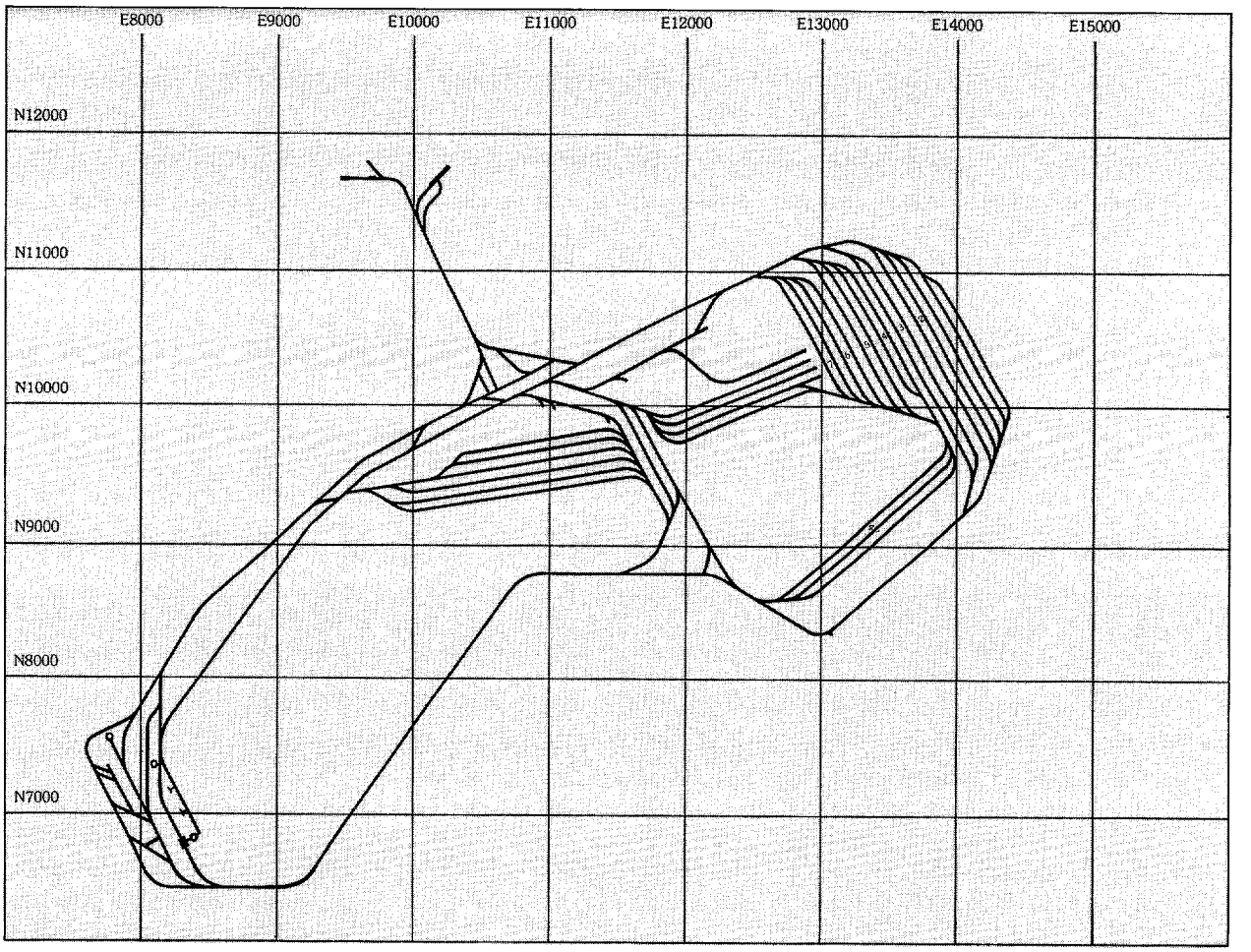
Plan-2075 Haulage Level

1″ = 1200′



Plan-2315 Grizzly Level

1″ = 1200′



Plan-2375 Haulage Level

1″ = 1200′

General Mine Operating Data

Operating Shifts per Day	3
Operating Days per Week	7
Operating Days per Year (8 holidays)	357
Production per Day, Tons	62,500
Production per Year, Tons	22,312,500
Active Undercut Area, Sq. Ft.	446,000
Draw Point Spacing:	
17.5′ East-West x 15′ North-South	
Block Dimensional Data:	
Block Width	140′
Block Length	90′-240′
Present Average Block	140′ x 180′
Ore Height above Undercut Floor	100′-600′
Distance Undercut Floor to Grizzly Level Floor	15′
Distance Floor Haulage to Floor Grizzly Level	60′
Grizzly Bar Spacing	14″
Grizzly Bar Material	Salvaged 90# Rail.
Draw Points (Average per Month):	
Active	1,590
High Pack	65
Held for Repair	80
Held for Grade	80
Total Draw Points	1,815

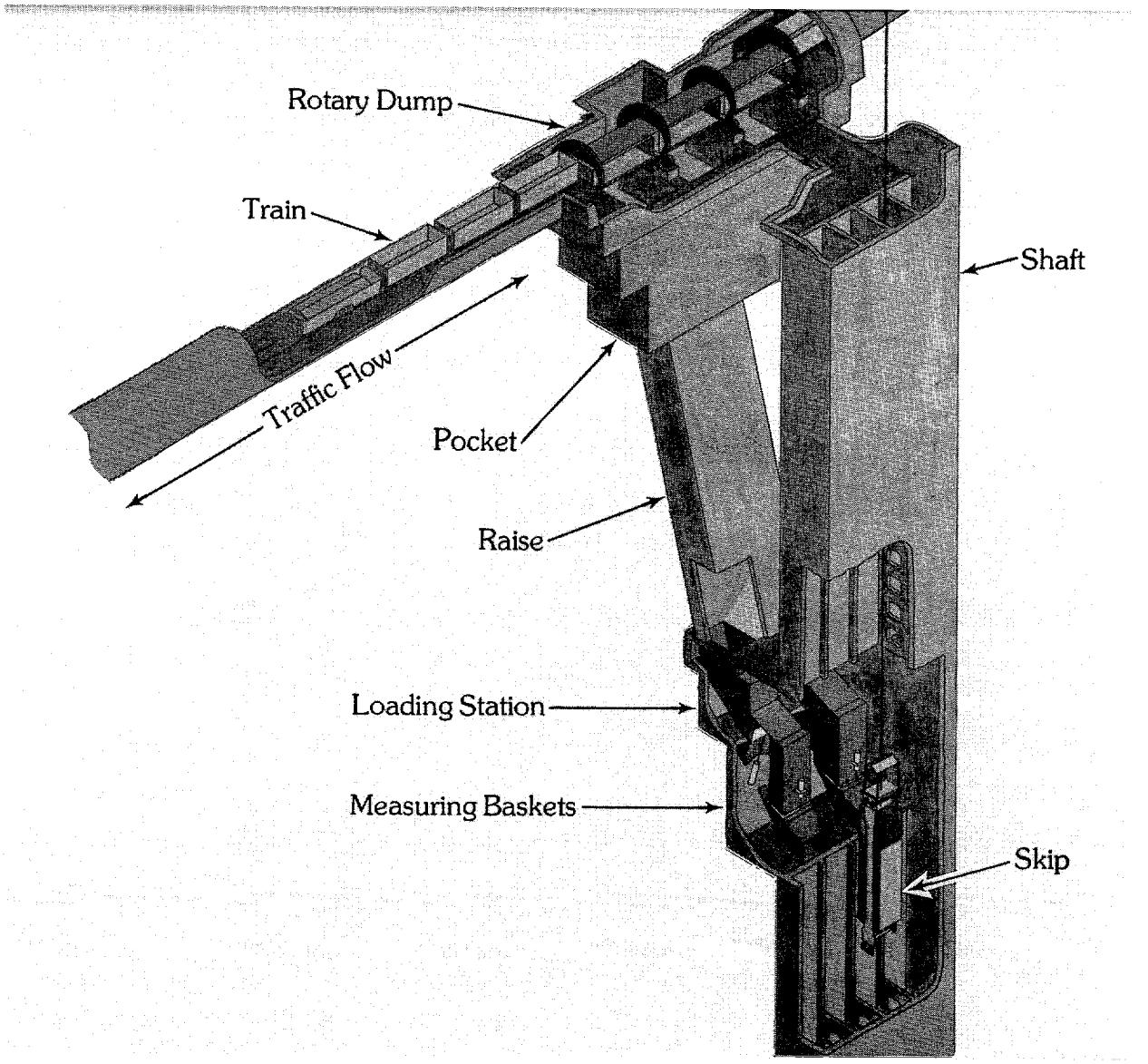
Types of Explosives used:

Secondary Blasting—60% (No. 1) Amogel in 1-lb. bags. Initiation is with zero delay electric blasting caps. These are connected into a trunk line to a central underground location where blasting switches are located.

Primary Blasting—In the larger heading = 50 lbs. ± of Ammonium Nitrate = primed with a stick 1′⅛″ x 12″ 60% Amogel Explosive per hole initiated by electric blasting caps, 0 to 12 delay.

All other development, except transfer raises and undercuts, uses ammonium nitrate with regular delay electric blasting caps. Transfer raises load with 60% Amogel only.

All blasting is done at the middle and end of each shift.


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

Car Dumps

General Mine Operating Data, continued

Car Dumps:

In the dumping cycle the motorman pulls through the dump and spots three cars in the dumper without uncoupling. Carstops rise and lock the train in position. The motorman activates the dumper which rotates 180° and returns to the upright position and the operation is repeated. Three cars are dumped in about one minute, or five minutes per train of 15 cars. Development cars are designed to fit the dumper, but because of their length and type of coupling, they must be uncoupled to dump.

Traffic can flow in both directions through a rotary dump, but dumping is done in one direction only.

Mining Equipment:

Big drifts use a San Manuel-made remote control jumbo with three 8′ booms and three 3″ drifters with 6′ feed shells. The booms are hydraulically operated and are powered by two 1¾ gpm, 11,000 psi hydropumps that feed into a hydraulic manifold.

Mucking is done by a rocker shovel with a steel flight conveyor dumping into 10-ton bottom-dump development cars. The cars are switched by an 8-ton, 40-hp (or 9-ton, 40-hp) storage battery locomotive.

Smaller headings use feedleg drills with 2′ or 4′ single stage legs and stoper drills with 18″ steel change.

Mucking is done by Cavo Rubber Tired 320 overshot direct into muck car, and a 310 1 yrd. hopper type mucker all air motor powered.

Underground Haulage Data:

Haulage locomotives are 23-ton, 4-wheel trolley type; each locomotive with two 125-hp, 275-volt DC motors. They haul fifteen 12 to 13-ton working load cars.

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

Length center to center of coupling: 17′-6″.

Width, overall: 6′-0″.

Height above track: 5′-6″.

Couplers: Rotary and non-rotary couplers equipped with rubber cushioned draft gear.

Track gauge: 36″.

Car loading through air-operated guillotine undercut gates.

Ventilation

460,000 cfm goes down #4 and #1 Shafts from the surface.

364,000 cfm goes down #5 Shaft from the surface.

78,000 cfm Miscellaneous Intakes, in addition to shafts.

92,000 cfm—Sub Level (1715-1775 Levels).

612,000 cfm—2nd Lift (2015-2075 Levels).

147,000 cfm—3rd Lift and Sub Level Development.

Sub-Levels—Three hi-speed Axivane mine fans: One MXC, 1715, 200-hp, 1160 rpm, 5′ diameter; one MXC standby, 1775 200-hp, 1160 rpm, 5′ diameter; and one MXC, 2315, 200-hp, 1160 rpm, 5′ diameter.

2nd Lift—Four hi-speed Axivane mine fans: one MXC, 2075 450-hp, 1160 rpm, 6′ diameter; ine VXC, 2015, 450-hp 1160 rpm, 6′ diameter; two No. 5 Shaft Drift, 2015 Level, 450-hp. 1,160 rmp, 6′ diameter.

Auxiliary ventilation air is directed through operating blocks by means of ventilation doors and Axivane 20-hp, large-volume, low-pressure, low-speed mine fans. Individual working places are ventilated by 10-hp and 20-hp high-pressure, high-speed fans through 24″ ventilation pipe or with venturi type air movers. 60-hp fans are used to supplement the major fans in problem areas.

Communications

On the haulage levels, haulage trains and supply trains are moved on direct orders from a dispatcher by the use of a radio phone system. In addition, radio phones are installed in repair shops and at vantage points for use by supervision.

Draw and haulage operations are coordinated through the dispatcher by an audio paging system.

A standard telephone system consisting of seven circuits aids in coordinating hoisting, maintenance, and service facilities between the surface and the mine underground.

Drainage

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

Mine Water = 7,000 gpm, principally from the 2nd Lift.

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

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

Surface Ore Transportation

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

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

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

Change Room No. 4

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

In the same building is the foreman's office, time office, mine survey office, Environmental engineer's office, dispensary, lamp room, and dust counting laboratory.

Change Room No. 3

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

Compressed Air

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

No. 4 Compressor House

Five 3,500 cfm compressors, delivering at 100 lbs. air pressure, each equipped with 600-hp synchronous motor.

One 1,936 cfm—350-hp synchronous motor.

One 1,596 cfm—300-hp synchronous motor.

Total—21,032 cfm, delivering at 110 lbs. air pressure for approximately 100 lbs. mine working pressure.

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

No. 3 Shaft Hoist House

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

Total compressed air= 44,632.

No. 1 and No. 4 Yards

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

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

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

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

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

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

Mine Power

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

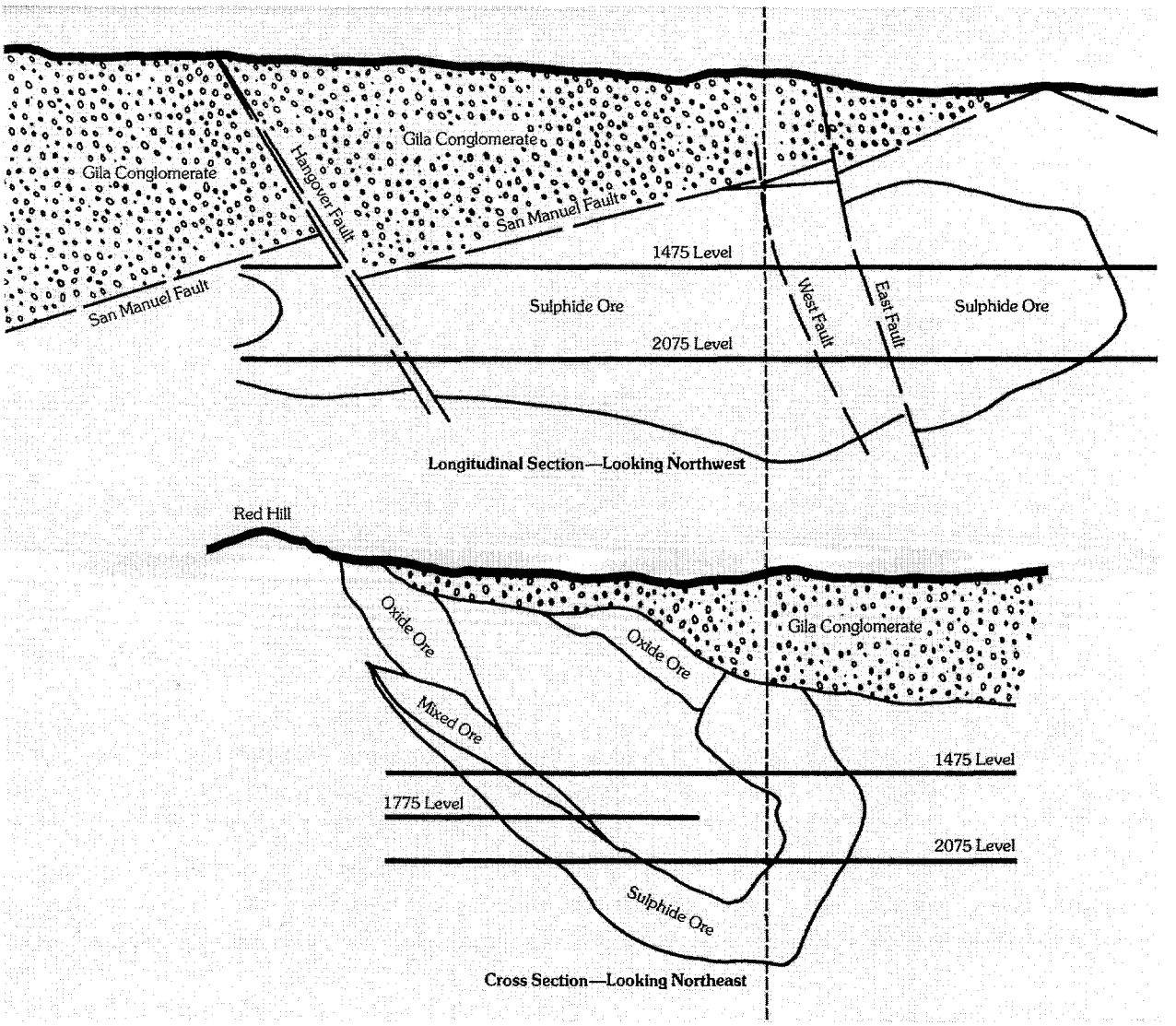
The No. 3 Hoist Area Substation Main Transformer is rated at 50/66.5 MVA, 115/46 Kv, 3-phase. This transformer supplies the 46 Kv bus at the Substation and the feeder to the No. 1 and No. 4 Shaft Area located approximately one mile away. The 46 Kv bus at the No. 3 Hoist Area Substation supplies several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

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

Metal Production – San Manuel Only

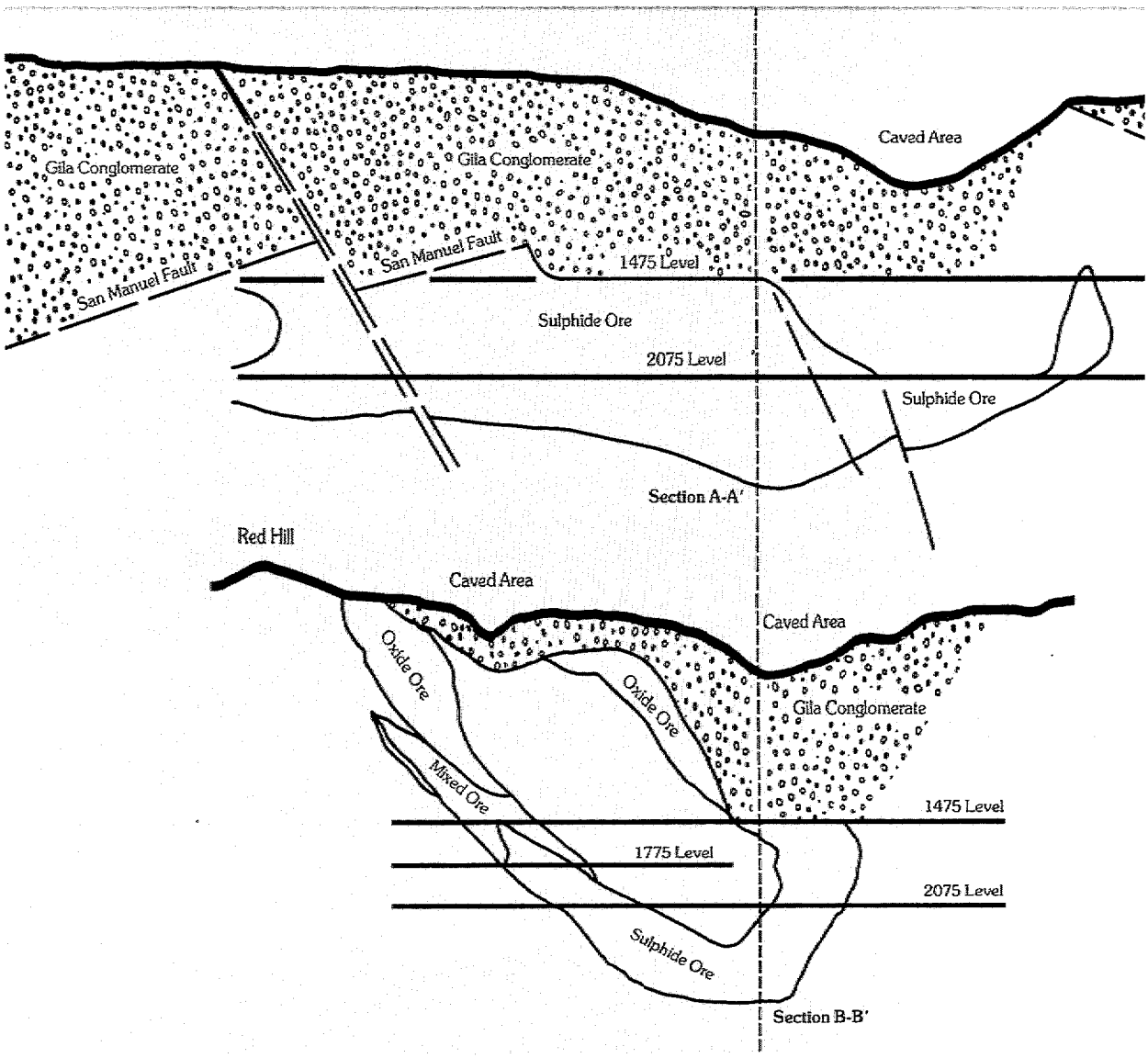
1973—12 months of operation.

Average Daily Mine Production, Dry Tons	62,000
Copper Production, Tons	140,000
Molybdenum Sulfide Concentrate, Tons	4,790



Sections Before Caving

1″ = 1150′



Sections After Caving

CPY: WLK - 2 copies
JHC
RBC
J. H. W.

OCT 16 1975

San Manuel

10/15/75

-2-

from Jack Still

file: San Manuel

Arizona current UG Miners rate is $5.7825/hr or $46.26/shift
Assume 35% of crew is on bonus and earning $30/day over wages:

65% @ $46.26
35% @ $76.26
$56.76, further assuming that payroll load costs are 32%, the $56.76 x 1.32 = $74.92
plus Cost of Living allowance = 3.64
then Mine Dept. cost/MS = $78.56

then average

Tons/MS

$78.56/36 = $2.182 labor cost/ton
$2.182/.65 = $3.35 mining cost/ton

WLK calculation:

$56.76
+ 3.64 Cost of living
$60.40 direct labor

$60.40 ÷ 36 tons per MS = $1.6778 labor

assume labor equals 65% of direct mining cost then,

total direct mining cost = 2.5812
indirect @ 50% = $3.87 total direct + indirect mining cost

J. E. K.

AUG 22 1967

J. H. C.

JUL 14 1967

Ga 16 A, 13, 19E

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

August 11, 1967

MR. WES, JDB, JEK
READ AND RETURN
PREPARE ANSWERS HANDLE
FILE INITIALS

FILE MEMORANDUM

CLOUDBURST FORMATION
SAN MANUEL AREA
PINAL COUNTY, ARIZONA

W.E.S.
AUG 18 1967

S. C. Creasey and others who have worked out the geology of the San Manuel area place the Cloudburst formation in the Laramide, yet state that it is post-mineral with respect to the San Manuel porphyry copper orebody. Creasey (USGS Bull. 1218, p. 55) states: "Fragments of the porphyry are common in the fanglomerates of the Cloudburst Formation, and fragments of altered porphyry derieved from the San Manuel ore deposit occur in the Cloudburst Formation southeast of the deposit in the area bounded by the San Manuel and Mammoth faults."

This post-mineral sequence of andesitic clastic and volcanic materials is an enigma in southern Arizona where the Laramide Silver Bell type of andesitic flows and clastics pre-date the emplacement of most of the porphyry copper orebodies. On August 10, Jim Briscoe and I spent the day in the San Manuel area investigating the character of the Cloudburst formation.

In the wash just south of Mammoth Wash (see ATTACHMENT A), Creasey shows a long dike-like sliver of granodiorite porphyry--probably genetically associated with the San Manuel mineralization--faulted into Cloudburst fanglomerate and volcanics. At the point noted on ATTACHMENT A, we found a clearly exposed intrusive contact between fanglomerate and granodiorite porphyry. The fault shown by Creasey does not exist at this point, and it seems clear that the "faulted sliver" is, in fact, a dike intruding the Cloudburst. The fanglomerate is moderately altered in contact with the relatively fresh granodiorite and contains iron-stained shears parallel the intrusive contact. Further reconnaissance in the locality showed that several granodiorite dikes intrude the Cloudburst here, and locally the Cloudburst materials are altered in contact with these dikes. No mineralized fragments of porphyry or Oracle granite were seen outside the alteration in the Cloudburst immediately adjacent the dikes.

Excellent exposures of the Cloudburst are found in Tucson and Cloudburst washes north of the St. Anthony mine. Here, well-indurated and pervasively epidotized clastics and flows appear to have undergone the aerial metamorphism which surrounds

major porphyry copper deposits in the Southwestern United States. Feldspars are altered and ferromagnesian minerals chloritized. The propylitic alteration (epidote, occasional disseminated grains of pyrite) clearly pre-dates the mid-Tertiary dikes and veins that cut through the area. Briscoe is strongly of the opinion that the Cloudburst here is very similar to premineral andesitic sequences in the Picacho Peak and Owl Head Buttes areas. Likewise, I feel that this Cloudburst sequence closely resembles the Picacho Peak succession, and is similar to certain portions of the Claflin Ranch-Silver Bell andesite breccia interval as seen in the Silver Bell Mountains. Certain portions of the Cloudburst in its name-sake wash are also very reminiscent of parts of the Fresnal conglomerate as seen above the Jupiter mine in the Baboquivari Mountains.

A final stop was made in Section 4, of T9S, R16E over Quintana's Kalamazoo deposit to check an indicated granodiorite porphyry-Cloudburst fanglomerate contact. Contact relationships were not clear here, but the fanglomerate appears to be considerably younger than that seen north of the St. Anthony mine. The matrix is punky and the fanglomerate overall is crumbly. No epidote or other sign of hydrothermal alteration is present. Possible granodiorite porphyry fragments were found midst the vastly predominant Oracle granite detritus.

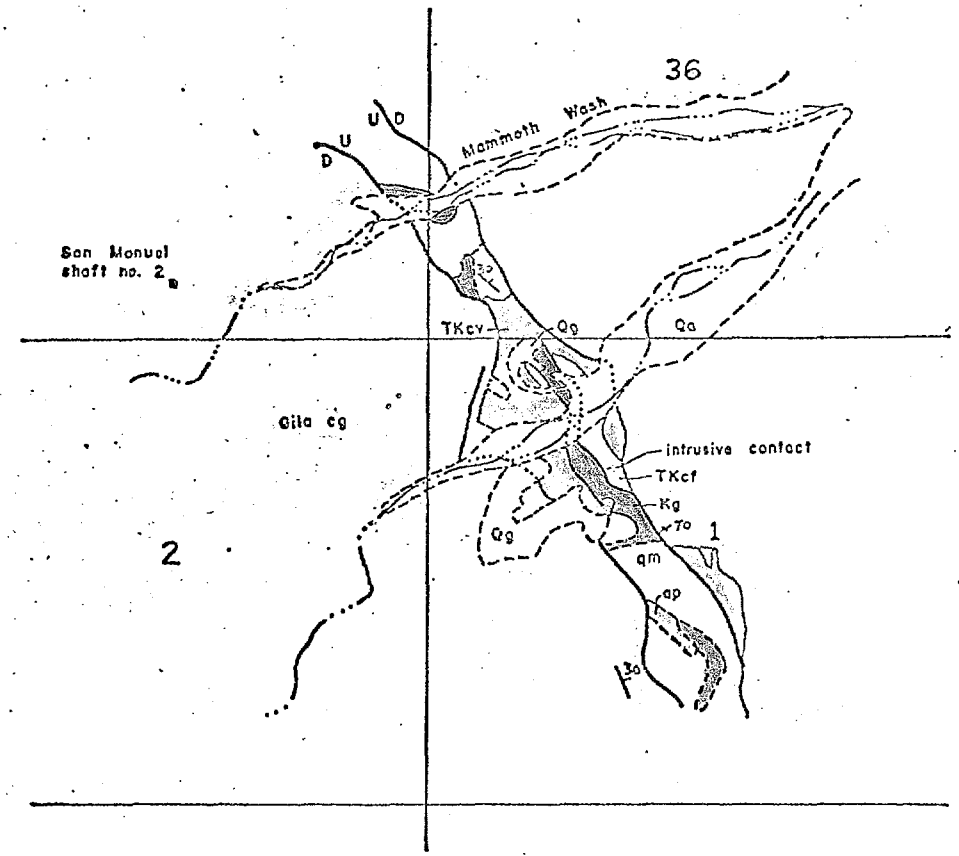
We suggest that the well-indurated Cloudburst seen north and southeast of the San Manuel mine is, at least in part, pre-mineral. We also suggest that the fanglomerate in the Kalamazoo area is of much later origin---possibly Pantano-Minetta equivalent. A long traverse up Cloudburst Wash to the western edge of the area mapped by Creasey would probably turn up evidence one way or the other.

In discussing this situation with John Kinnison, I found that John has previously stated his dissent of the inclusion of the Kalamazoo area fanglomerate within the Cloudburst. Kinnison (memo to J. H. Courtright, May 19, 1966) refers to this fanglomerate as possible lower Gila. Indeed, even Creasey and Leo Heindl (USGS Bull. 1141-E) cannot agree on a triangle of outcrop just east of Red Hill---the former calling it Gila and the latter it Cloudburst!

Barry N. Watson

BARRY N. WATSON

BNW/mcg
Attachment
cc: JABriscoe w/attachment



Qa Quaternary alluvium
Qg Quaternary gravel
TKcf Cloudburst fanglomerate
TKcv Cloudburst volcanics
Kg Granodiorite porphyry
qp Precambrian aplite
qm Precambrian Oracle granite

Map showing location of granodiorite porphyry-Cloudburst fanglomerate intrusive contact. Taken from USGS Prof. Paper 471, Plate 1.

00-160.13.19B

J.H.C.

JAN 10 1967

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

January 11, 1967

MR. W.E.S. ~~S.P.B.~~
READ AND RETURN ✓ to file
PREPARE ANSWERS ____ HANDLE ____
FILE S.M. INITIALS ____

J.R.W.
JAN 9 1967

TO: J. H. COURTRIGHT

FROM: J. E. KINNISON

W.E.S.
FEB 14 1967

SAN MANUEL FAULT
Direction of Displacement

I studied in the field, during the spring of 1964, the San Manuel fault, and concluded that it was a normal fault with the throw directly downdip. My reason was an "indirect"one.

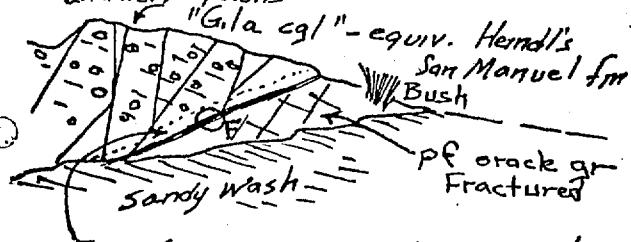
A similar fault, 11 miles north of San Manuel, and approximately parallel to it, is cleanly exposed near the junction of Putnam and Camp Grant washes. Shear cleavage in the fault zone, and antithetic tension joints indicate the movement, and a second exposure contained beds of "Gila Conglomerate" which could be matched and showed a slight normal slip in these tension joints. Xerox copy of my field sketches is attached.

The San Manuel fault is best exposed in Smelter wash, 3 miles southwest of the mine. Joints in the "Gila" are most numerous near the San Manuel fault, and dip in the direction of tension. This, compared to the Putnam wash fault, seemed sufficient to regard the San Manuel as a normal fault. Sulfides (mostly pyrite) in old churn drill holes on the Purcell group, considered also with a few NE fissures with sericitic alteration and a little live limonite, seemed rather conclusive that the faulted segment of San Manuel was on her claims, downdip above the fault.

J. E. KINNISON

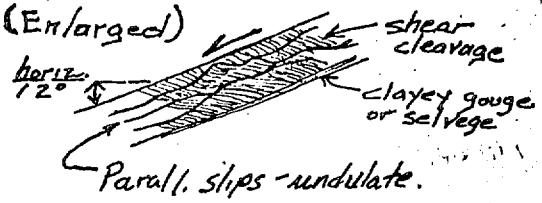
JEK/kw
Attachment

Going SW up Putnam wash, about 3 miles SW of RR, is excellent exp. of low-angle fault.



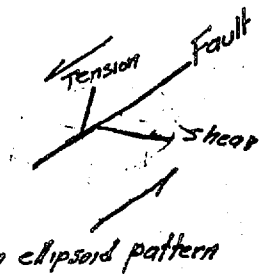
Zone of no distinguishable bd - 3' wide.

F - shown in circle above (Enlarged)



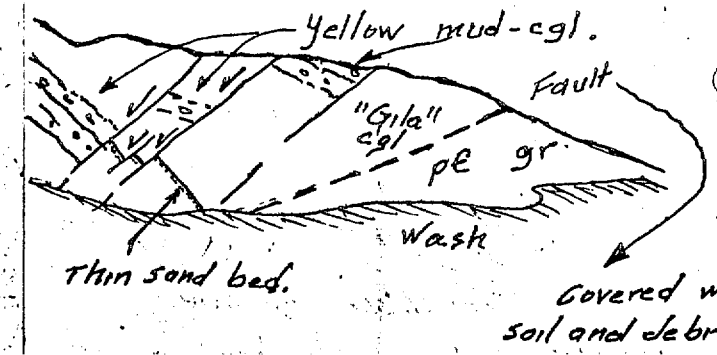
Judged from shear angle, hanging wall moved down.
Also - Antithetic faults are tension angle. Appears to be slight offset on these — Not clear — No "marker" beds.

(over)



COPY OF FIELD SKETCHES. Spring of 1964 J. E. K.

About 3/4 miles upstream, a 2nd exposure - fault plane not well exposed, but direction of antithetic fault movement shown by distinguishable beds - is normal fault slip.



Geology of the San Manuel Mine

by J. D. Pelletier

Manuel file San manuel

Gr 1415 GRIZZLY

1475 HAULAGE

2015 GRIZZLY

2075 HAULAGE

70 million T above 1415

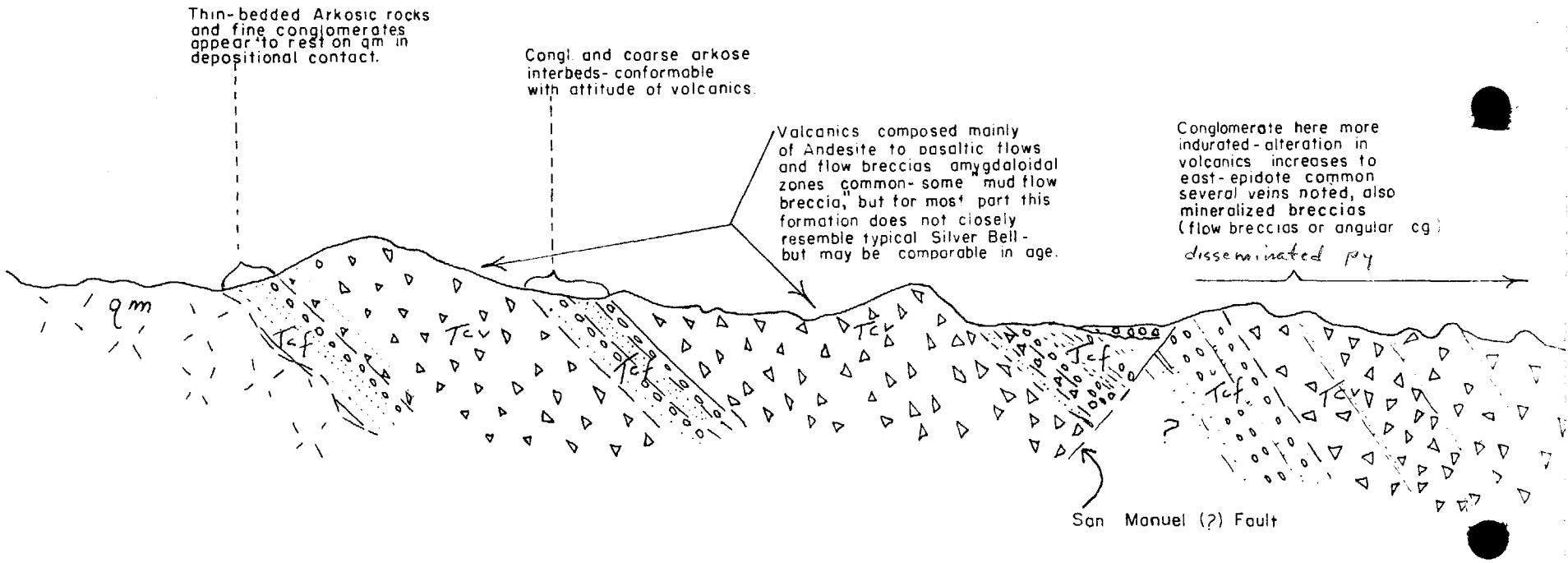
200 " T " 2015

.73 % Cu. Ore Reserve } at present
.72 % Cu. with dilution

MEN	
320	day
250	2nd
250	3rd
820	
180	Surface mine
1000	Total mine

No San Manuel porphyry noted in cloudburst JHC

Alteration - mineralization indicate Cloudburst is pre - porphyry. JHC



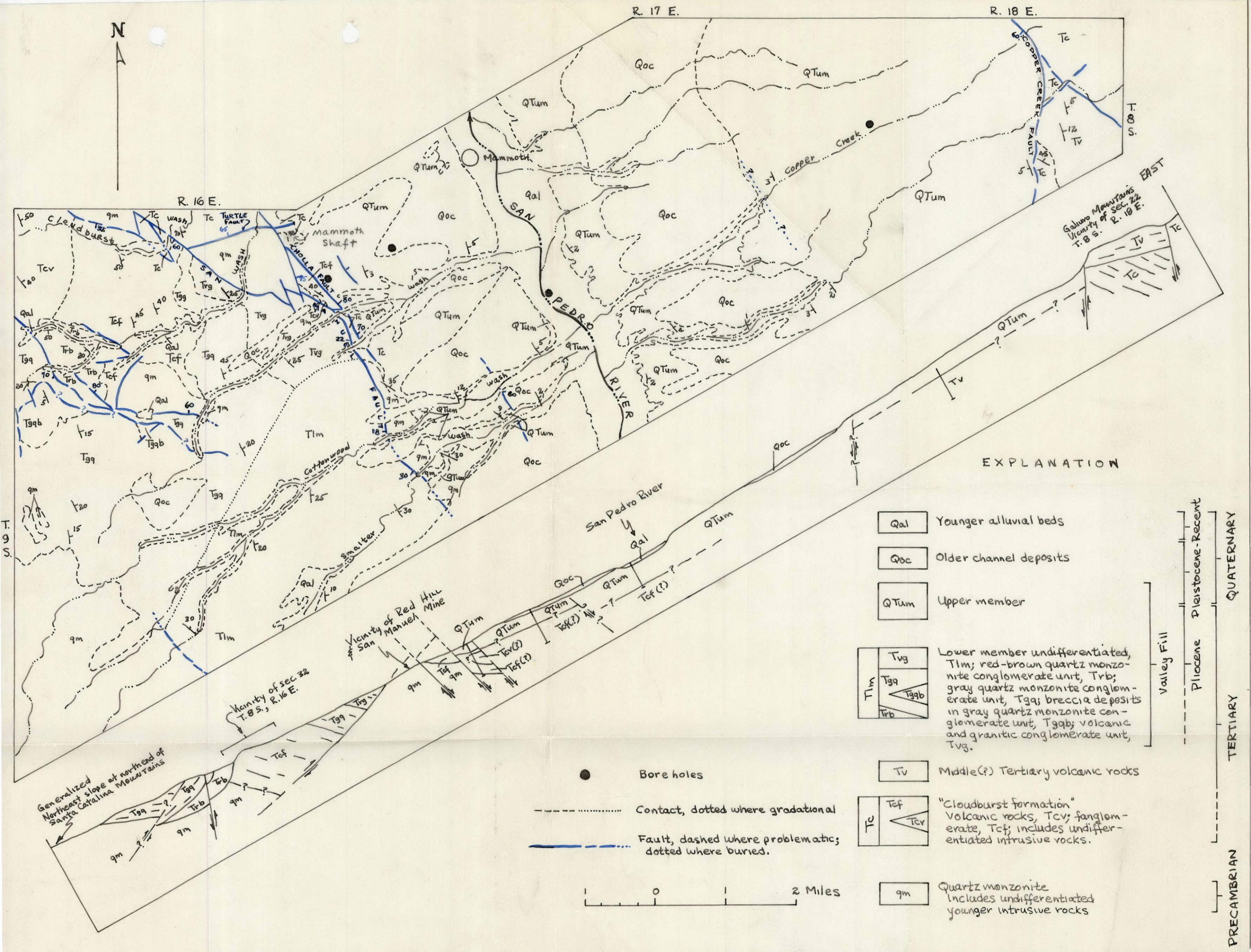
Tc	Cloudburst Formation
Tcf	Cloudburst fanglomerate (composed mainly of qm and volcanic rocks boulders ang to sub rounded
Tcv	Volcanics in Cloudburst
Qm	Pre Cambrin quartz monzonite

Sketch Section
About ½ Mile South of Signal Peak
Section Trends E W Along Cloudburst Wash
N W of San Manual Mine

LOOKING NORTH
SCALE 1" = 2000'

Circa 1963

by JHC



Geology by L. A. Heindl, 1950 and

Generalized geologic map and schematic section of lower San Pedro Valley in the vicinity of Mammoth, Pinal County, Arizona.

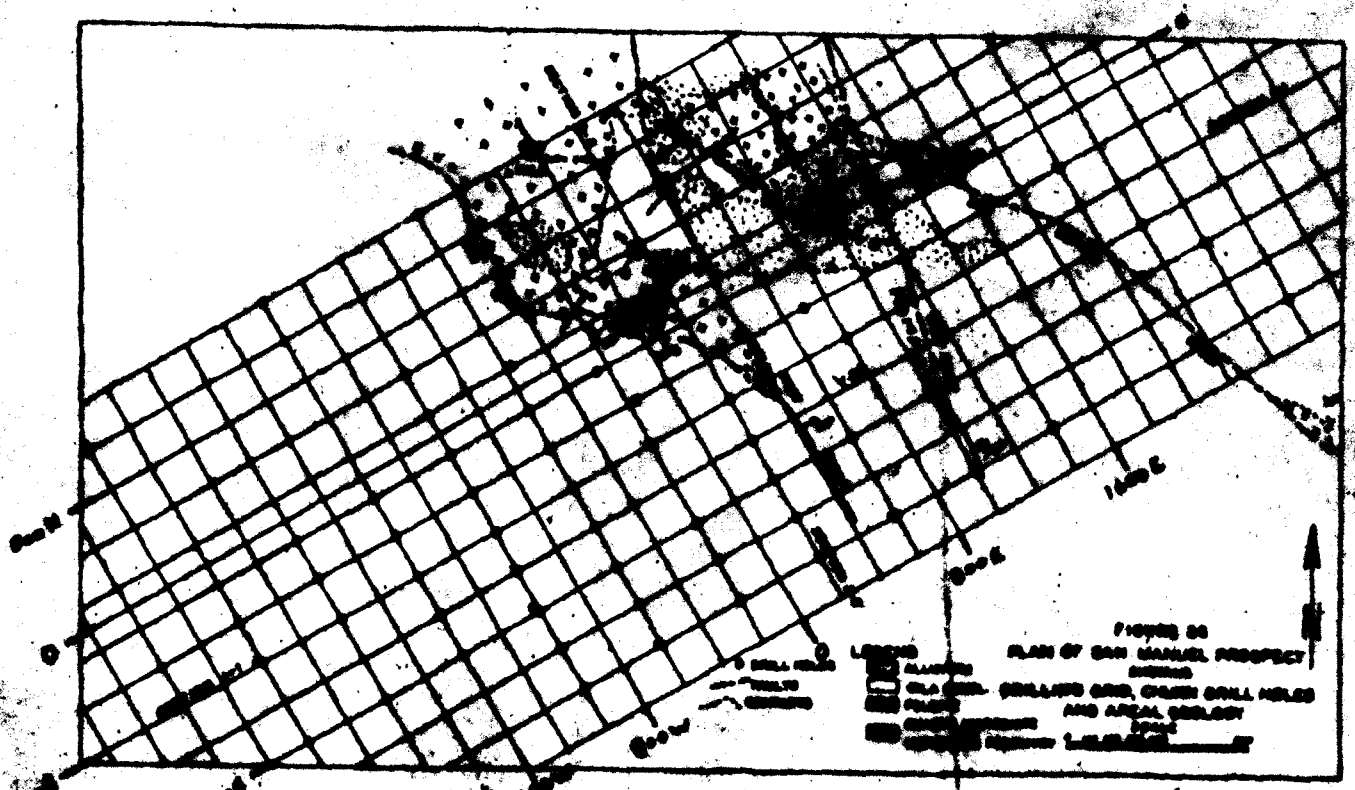


FIGURE 26. - PLAN OF SAN MANUEL PROSPECT. (Steele, 1958)

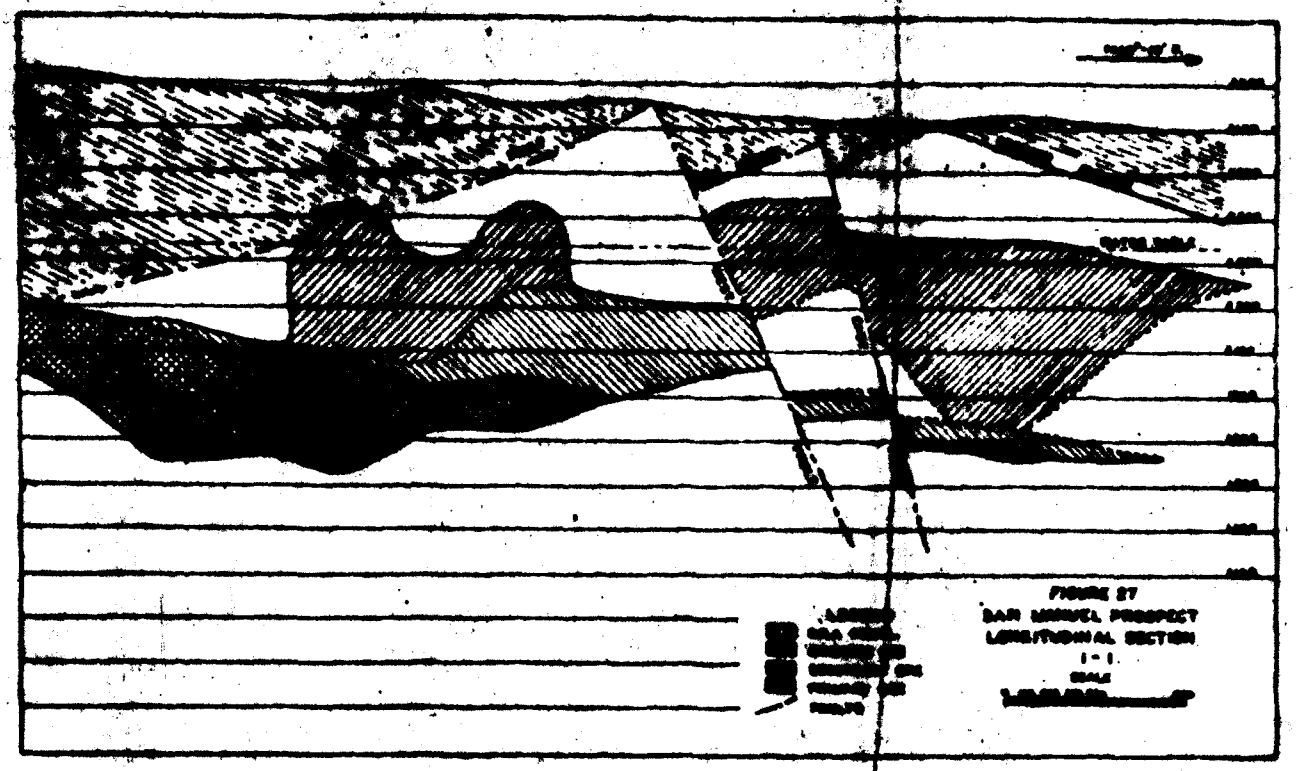
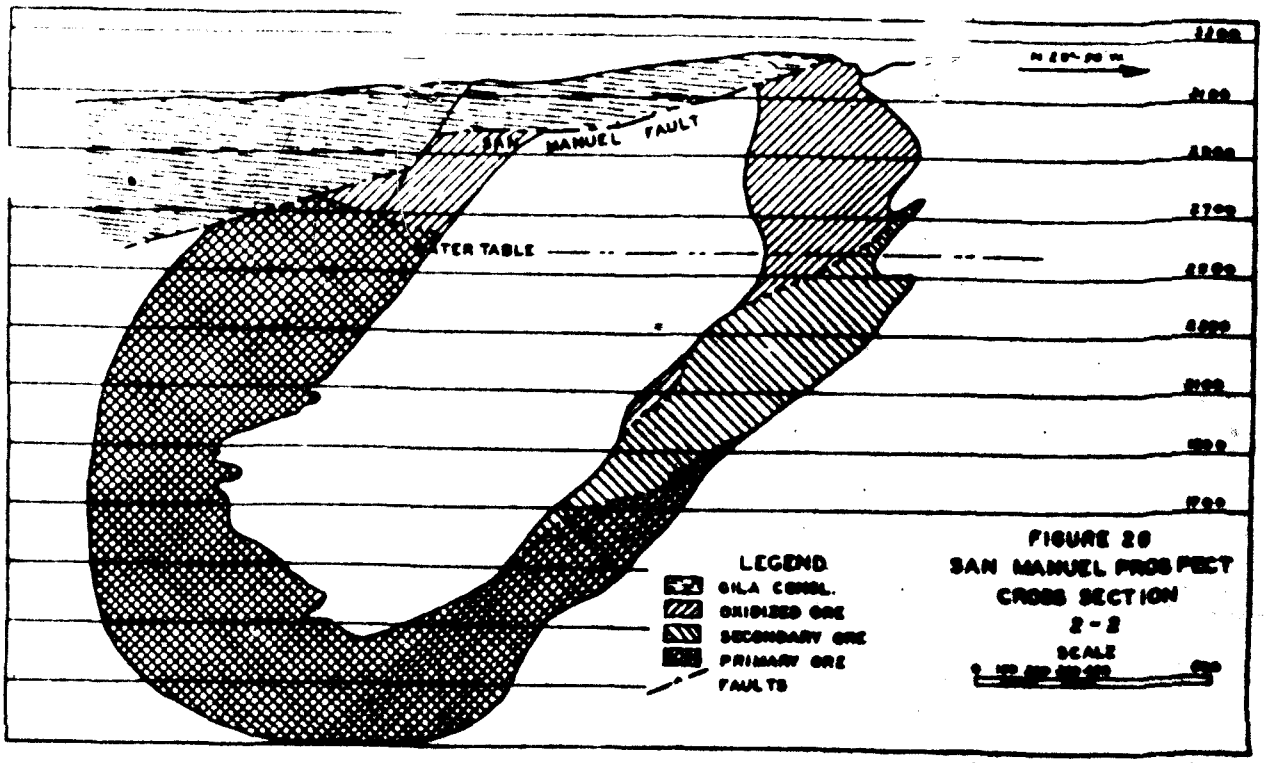
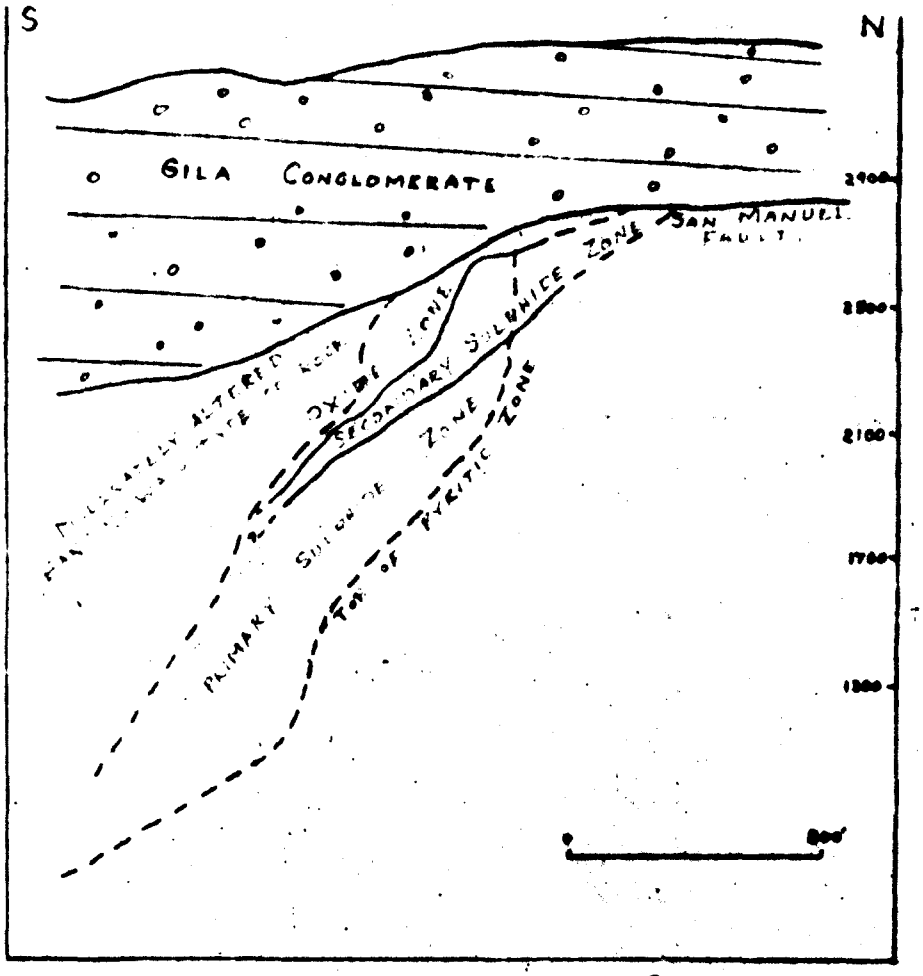


FIGURE 27. - SAN MANUEL PROSPECT, LONGITUDINAL SECTION.

(Steele, 1958)



(Steele, 1952)



CROSS SECTION ALONG 1400 W (AFTER SCHWARTZ, 1949)

J.H. Courtright

GEOLOGY OF THE SAN MANUEL MINE

ROCKS

The San Manuel orebody is a disseminated copper deposit in quartz monzonite, monzonite porphyry, and diabase.

Quartz monzonite, which is Pre-Cambrian[1] in age, is exposed in an area including No. 1 and No. 4 shafts and extending about 2,400 feet southeast from No. 1 shaft. It is also exposed in the bottom of No. 2 shaft and in a zone roughly 500 to 1,200 feet southeast of No. 2 shaft having its long dimension along a northeast-southwest axis. Churn drilling has shown all these exposures to be parts of a contiguous mass of quartz monzonite lying within and beneath the ore zone.

Late Cretaceous[2] monzonite porphyry comprises the bulk of the remaining rock encountered below the conglomerate. In general, the porphyry occurs in two large masses that are separated by a projection of quartz monzonite south of No. 2 shaft. The porphyry masses converge to the east. The north area of porphyry is a sheet-like[3] mass lying above quartz monzonite. The south area has not been bottomed by any drilling south of the orebody and may be a stock.[4] Monzonite porphyry also occurs as dikes cutting quartz monzonite. These dikes become more numerous with proximity to the larger masses of porphyry and generally trend northeast-southwest.

Several diabase dikes, intrusive into quartz monzonite and monzonite porphyry, have been exposed in the mine openings. All the diabase dikes are mineralized similarly to the rocks they intrude.

---

[1] References and notes appear at the end of the paper.

Andesite porphyry dikes have been noted in a few instances. Some of these dikes are unmineralized while others are lightly mineralized with pyrite. The mineralization and hydrothermal alteration in all cases are of a different character than that of the intruded rock. Andesite porphyry is probably, as Schwartz[5] suggests, the intrusive equivalent of the lava flows of the Cloudburst formation, the mineralization being of a later age than the ore mineralization.

The Cloudburst formation was cut by No. 3A and No. 3B shafts and by drifting on the westernmost part of the 1475 Level. This formation contains two members. The upper member is a conglomerate made up mainly of quartz monzonite fragments but containing some fragments of all the older rocks in the area. The matrix tends to be arkosic, but granitic sand and gravel are not uncommon. The conglomerate is poorly cemented but relatively well sorted compared with the overlying Gila(?) conglomerate, having beds of sand and gravel alternating with beds of larger boulders. Slickensides are frequently seen on bedding planes. Tuff beds are found in the conglomerate and in the underlying member which is composed of interbedded flows, flow breccias, and conglomerate. Where not distorted by drag adjacent to the San Manuel fault, the average strike of the conglomerate is N 5° W and the average dip is 30° to the east.

The contact of the Cloudburst formation with the overlying Gila(?) conglomerate in No. 3A shaft was an unconformity. In No. 3B shaft the contact was marked by an irregular tuff bed but here, and in the exposures of this contact on the 1475 Level, the bedding of the two formations is parallel or very nearly parallel and, in the 1475 Level exposures, it was not possible to pin-point the exact contact due to the similarity of the two formations.

A small tuff bed near the bottom of 3A shaft was mineralized with pyrite and a trace of chalcopyrite. This mineralization is later in age than the ore mineralization since the Cloudburst formation is not mineralized where it is seen in depositional contact with mineralized porphyry on the surface.

Rhyolite dikes were intersected in several places on all the levels of the mine. Rhyolite is not mineralized by hypogene copper minerals but is occasionally stained by migratory chrysocholla where the dike is in, or close to, the zone of oxidation. Chlorite was noted coating joint faces of several rhyolite dikes. Rhyolite dikes are known from surface exposures to intrude the Cloudburst formation but do not intrude Gila(?) conglomerate.

Gila(?) conglomerate was cut in the upper parts of shafts Nos. 2, 3A, and 3B, and on the 1475 Level southwest of No. 2 shaft. Fragments composing the upper portion are derived mainly from basic flow rocks while the lower beds are derived from granitic rocks. The Gila(?) conglomerate contains no hypogene mineralization or alteration. The average strike is N 50° W and the average dip is 35° to the northeast.

STRUCTURE

The oldest of the important post-mineral faults is the San Manuel fault. In its underground exposures, this fault has an average strike of N 66° W and an average dip of 26° to the southwest.

Typically, there are from one to three feet of red gouge and slickensides on the fault surface. On the footwall side, immediately beneath the red slickensides, are from five to fifteen feet of gray gouge

with irregular slick faces aligned more or less parallel to the fault and sometimes containing harder fragments with slightly rounded edges. Beneath the gouge, the underlying rock is badly fractured and grades into less fractured, normal rock about 50 to 100 feet below the fault surface.

The conglomerate found in the hanging wall in exposures east of the Hangover fault is not badly disturbed but contains a few small slips close to the fault surface. West of the Hangover fault, besides showing small slips adjacent to the San Manuel fault, the Gila(?) and Cloudburst conglomerates show considerable drag for a distance of 300 feet above the plane of the San Manuel fault.

There are a number of faults which strike N 20° W to N 25° W and dip steeply to the east. These faults exhibit varying amounts of normal fault movement and are younger in age than the San Manuel fault. The most important of these are known as the East fault, the West fault, and the Hangover fault, the latter being in reality a zone of faulting.

A large reverse fault lying between the north and south limbs of ore was intersected by drifting on the 1475 and 1415 Levels. This fault, which is known as the Vent Raise fault, strikes N 59° E and has a dip which varies from vertical to about 70° to the southeast. On the 1475 Level, the Vent Raise fault cut the East fault or a branch of the East fault and is therefor considered to be younger than the northwesterly striking, easterly dipping system of faults.

MINERALIZATION AND HYDROTHERMAL ALTERATION

The ore lies within a mineralized zone having a width on the

order of 8,000 to 9,000 feet and a known length in excess of 9,300 feet. To define ore, an arbitrary assay cut-off of 0.50% copper is used.

The upper and western portions of the orebody are separated into two branches by an area of lean, weakly altered hanging wall rock. These two branches converge at depth so that, in cross section, they may be likened to a "U" or "V" leaning to the northwest. The northwesterly limb of ore is referred to as the North orebody and the southeasterly limb as the South orebody.

The North orebody has a strike of about N 60° E and dips approximately 50° to the southeast. The western portion of the South orebody has a strike very nearly parallel with that of the North orebody, or N 60° E, which gradually swings about to the east where the strike is approximately N 45° E. The dip of the South orebody is variable, the upper portions dipping southeast, and the lower portions arching under to the northwest and joining the North orebody. To the east, the central area of lean material gradually diminishes to a core and then disappears as the two limbs join to form a single mass of ore.

The main primary minerals are chalcopyrite, pyrite, and quartz, with minor amounts of molybdenite. These minerals are distributed quantitatively into three zones which are known as the ore zone, the hanging wall zone, which lies between the North and South orebodies, and the footwall zone, which surrounds the ore and hanging wall zones.

The ore zone, which averages approximately 0.80% copper, contains most of the chalcopyrite, quartz veinlets, and molybdenite. Pyrite is present in about equal proportions to chalcopyrite. The yellow sulfides are finely disseminated through the rock but also appear as veinlets or, more often, scattered on fractures. Molybdenite usually forms a

slick coating on fractures or accompanies quartz veinlets and is present in sufficient quantity to be recovered metallurgically. The ore zone is altered by a "sericite-pyrite-chalcopyrite"[6] type alteration which is recognized in underground exposures by the moderate gray color of the rock, the presence of altered but easily recognizable biotite, and the presence of pyrite and chalcopyrite in moderate quantities.

The hanging wall zone is simply a lean version of the ore zone with lesser amounts of all the primary minerals. This zone is gradational with the ore zone and the amount of mineralization is dependent on the distance from the ore zone. Alteration here is classed as "marginal biotite"[6] type and is recognized by the dark gray appearance of the rock, fresh-looking biotite, and weak pyrite-chalcopyrite mineralization.

The footwall zone is radically different from the ore zone except for the area where it grades into ore. Pyrite is the chief mineral here and occurs in much greater quantities than in the ore zone. The strongest pyrite is found south of the ore zone where it composes about 10% to 20% of the rock by weight. North of the ore zone the pyrite content is somewhat less and gradually diminishes to a very small amount about 1,500 feet north of the ore zone. Chalcopyrite is rarely seen in the footwall zone, and then usually as a tarnish on pyrite. Quartz veinlets are very rare and molybdenite does not occur in visible quantities. The footwall zone is altered by "hydromica-pyrite"[6] type alteration which is characterized by the light gray appearance of the rock, absence of recognizable biotite, and the abundance of pyrite.

A distinctive chlorite[7] alteration occupies an irregular zone within the South orebody, having its long dimension in a northeast-southwest direction, parallel to the long dimension of the South orebody.

The chlorite is found chiefly as a coating on fracture surfaces which is locally very strong, and, in a few places, permeates the rock.

It was originally thought that a close relationship existed between chlorite alteration and the better grade of copper mineralization. A comparison of this zone of chlorite alteration with the better than average grade ore shows many broad similarities, though not always in detail. Due to the fact that chlorite also alters post-mineral rhyolite, it is believed that any similarities that exist are due to a mutual structural control rather than a mutual source of mineralization.

Ore occurs similarly in quartz monzonite, monzonite porphyry, and diabase, in a zone which is roughly coincident with the contact of the large sheet-like mass of monzonite porphyry with the intruded quartz monzonite. This relationship does not hold true at the eastern end of the orebody but here the ore is diminishing in cross-section. It is difficult to relate the ore directly with the intrusion of porphyry since it shows no preference for either rock and does not occur similarly where the large mass of porphyry to the south intrudes quartz monzonite. It may be theorized that the similarity in shape of the sheet-like mass of porphyry and the ore zone, as well as the later chlorite alteration, may be due to a mutual, though unknown, structural control.

OXIDATION AND SECONDARY ENRICHMENT

The upper portions of the orebody, with the exception of the western end, and much of the central lean hanging wall zone have been oxidized or partially oxidized.

The chief minerals resulting from oxidation and enrichment are

chrysocolla, chalcocite, and various iron oxides. Cuprite, native copper, and black copper oxides are frequently seen where the oxidized zone grades into the chalcocite zone. Copper carbonates are very rare, only one small specimen of malachite having been recognized in all the drifting that has been done.

In order to better understand the overall oxidation pattern of the area, as mine openings and diamond drilling make more data available considerable thought has been directed toward separating and classifying stages and types of oxidation.

It is possible to separate oxidized rock into two general types depending upon the color that the iron oxides impart to the rock.

The first type, identified by a deep red or reddish-brown color, is seen at the surface, in the upper parts of shafts No. 1 and No. 4, and in diamond drill holes extending above the top of the sulfide ore at the east end of the South orebody.

This type of oxidation which comprises much of the oxidized ore zone, with the chief ore mineral being chrysocolla, is characterized by complete or nearly complete oxidation of the copper minerals and a relatively sharp line of demarcation between the oxide ore and the underlying sulfide. The absence of leaching and migration of copper from the oxidized zone to form an appreciable enriched chalcocite zone is quite marked in the San Manuel orebody. Thus, the chalcocite zone with variable amounts of oxidation and local enrichment is not important tonnage-wise so that, metallurgically speaking, the ore can be mined as clean sulfide with a minimum of mixed sulfide-oxide ore.

Oxidation of this type occurred in at least three stages: first, during the erosional cycle preceding deposition of the Cloudburst

formation; second, during the erosional cycle preceding deposition of the Gila(?) conglomerate; and, third, during the present erosional cycle. Much of the oxidized ore explored by churn drilling in the central and eastern portions of the mine is probably "red" type oxidation.

The second type of oxidation is characterized by the yellow to tan color of the rock which is probably due to a lack of hematite and the presence of limonite and goethite[8] and is typical of all the oxidized ground encountered in the deeper mine openings. Oxidation of the sulfides is not always complete and many rather large areas of primary sulfide rock or partially oxidized rock are surrounded or nearly surrounded by "yellow" type oxidation. The outer margins of this oxidation generally contain chalcocite as well as primary sulfides and much iron oxide stain, but very few oxide copper minerals. Enrichment is very slight, if any. The copper content is usually not increased to any marked degree and occasionally is less than that of the primary ore. Chalcocite, and sometimes native copper and cuprite, occur along the top and sides of deep tongues of this "yellow" oxidation in about the same quantities in which they are found beneath them so that there is often an inversion of the normal sequence of oxidation with primary ore lying above secondary ore which in turn overlies oxidized ore.

leached

Deep tongues of "yellow" oxidation are known to follow rhyolike dikes, the San Manuel fault, and other northwesterly-trending post-mineral faults. In some cases no structural control is evident but it may be surmised that the path of oxidation was controlled by local differences in permeability of the rock.

This type of oxidation invades the sulfide ore locally along certain faults and in some fringe areas, but has not been found to be of

particular economic importance. The intensity of oxidation of ore minerals and the volume of such material relative to the volume of sulfide ore is so limited that it does not affect stope layout or draw. The distinctive coloration and mineralogical characteristics do, in fact, provide a marker and guide for the stope engineers in evaluating their draw data in some instances.

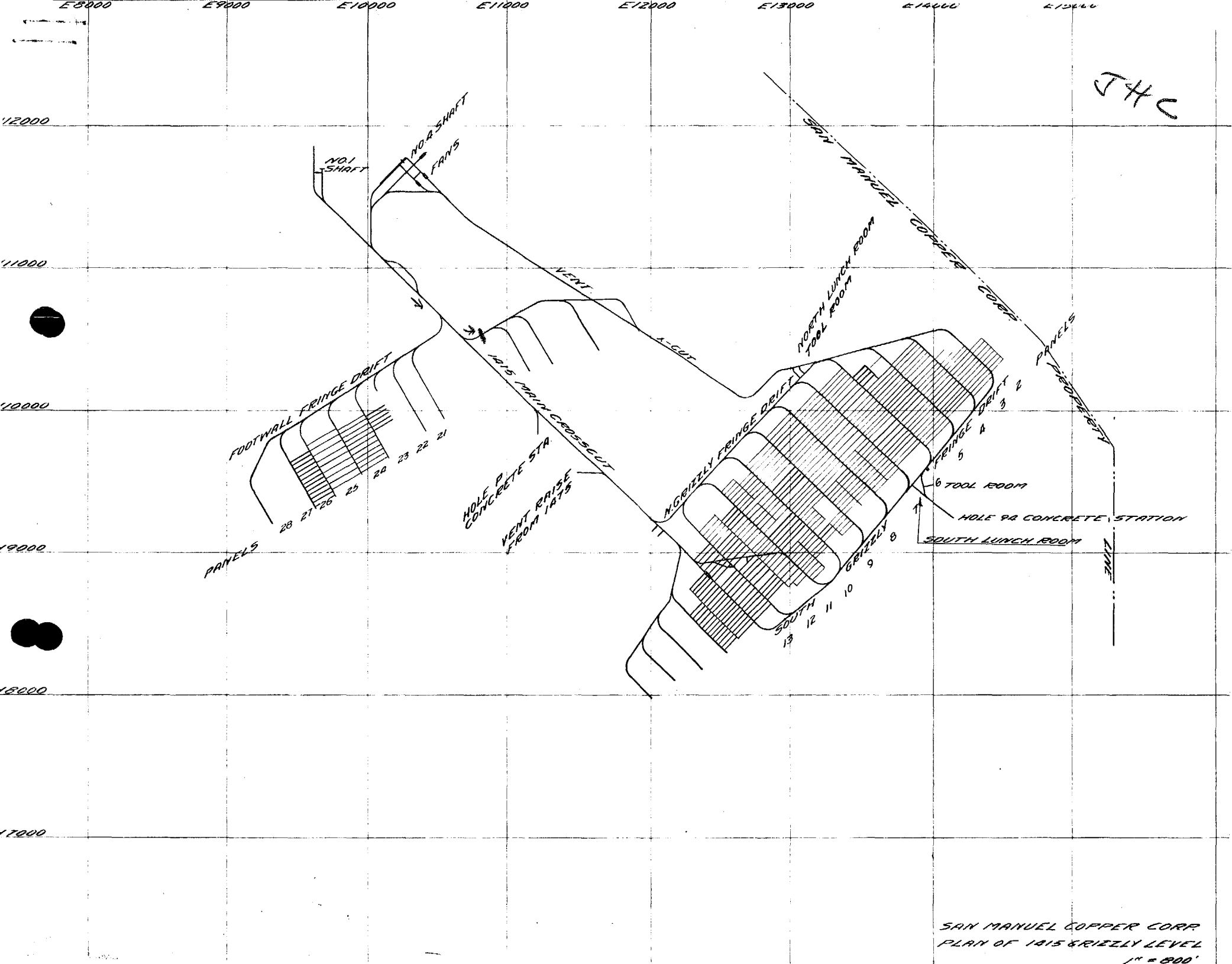
"Yellow" oxidation extended much deeper between the two limbs of ore than in the ore itself and extended deeper than previous oxidations so that, in cross-section, the oxidized zone has the shape of a trough with its sides impinging on the two limbs of ore.

ACKNOWLEDGMENT

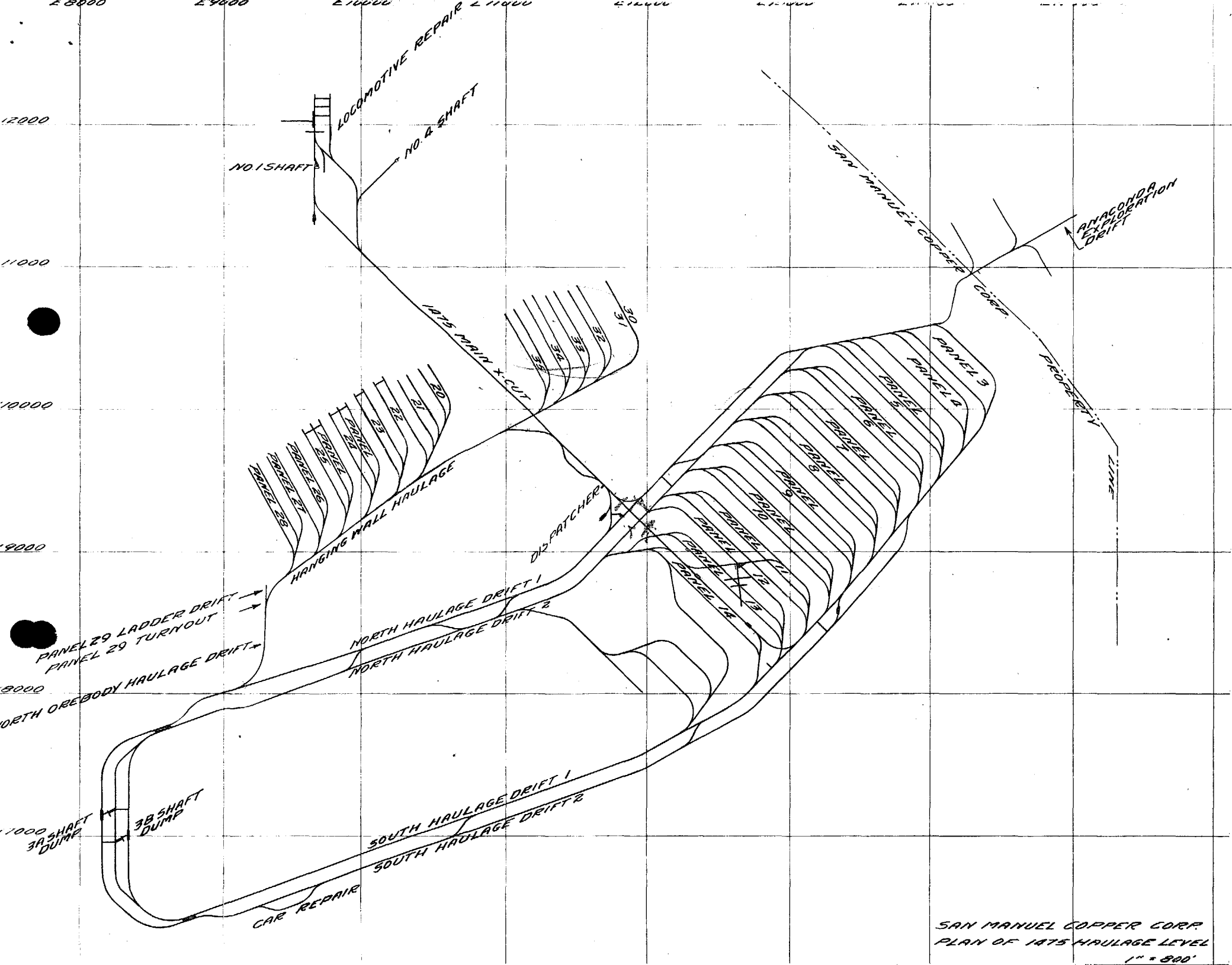
Acknowledgment is due the officers of San Manuel Copper Corp. for permission to use the information presented.

J. D. Pelletier
November, 1956

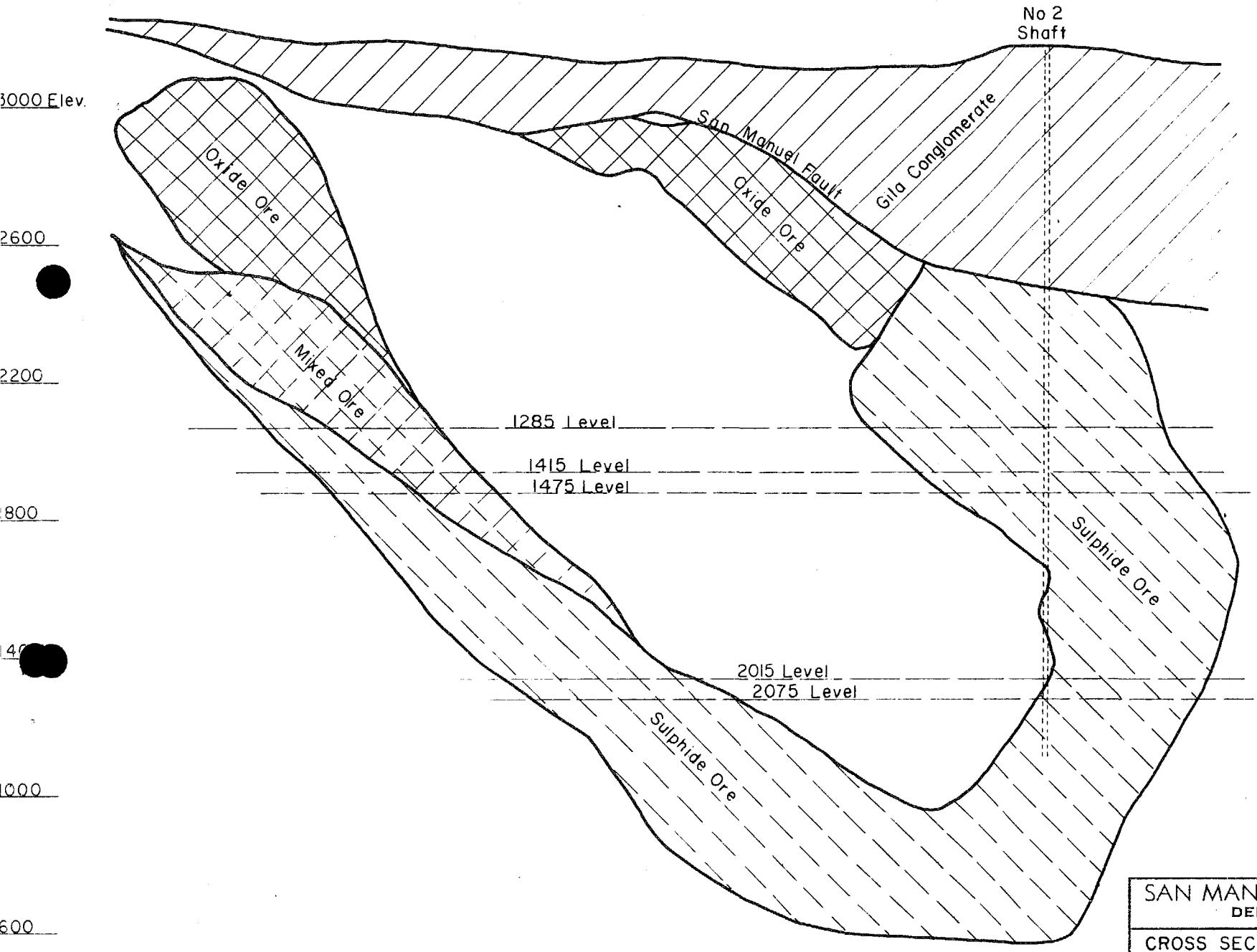
1 Peterson, N. P., Geology and Ore Deposits of the Mammoth Mining Camp Area, Pinal County, Arizona, Arizona Bureau of Mines, Geological Series No. 11, Bulletin No. 144.
2 Creasey, S. C., Personal communication.
3 Schwartz, G. M., Geology of the San Manuel Copper Deposit, Arizona, Geological Survey Professional Paper 256, p.9.
4 Schwartz, G. M., 1953, op. cit., p.9.
5 Schwartz, G. M., 1953, op. cit., p.12.
6 Schwartz, G. M., 1953, op. cit., pp. 19-32.
7 G. M. Schwartz says of a specimen of this material collected on the 1285 Level: The index of refraction 1.59+ and very low birefringence indicate chlorite, but the X-ray pattern is very nearly that of antigorite. (Winchell considers antigorite a member of the chlorite group but most investigators include it in the serpentine group.) I think for the present that we may call it chlorite."
8 Schwartz, G. M., 1953, op. cit., p.37, p.57.
Schwartz, G. M., Oxidation and Enrichment in the San Manuel Copper Deposit, Arizona, Economic Geology, Vol. 44, No. 4, 1949, pp. 273, 274.



SAN MANUEL COPPER CORP.
PLAN OF 1415 & GRIZZLY LEVEL
1" = 800'



SAN MANUEL COPPER CORP.
PLAN OF 1475 HAULAGE LEVEL
1" = 800'

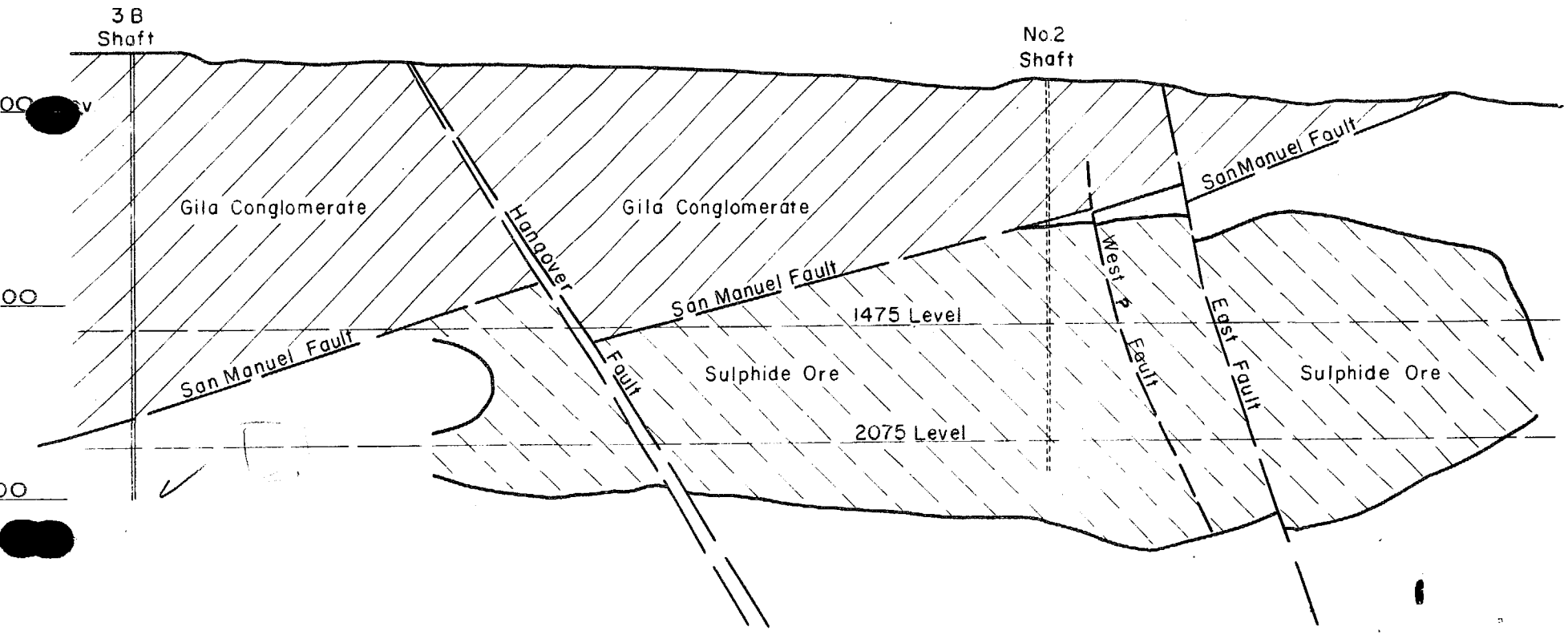


SAN MANUEL COPPER CORP.
DEPT. ARIZONA

CROSS SECTION THRU OREBODY
N 46° W LOOKING NORTHEAST

DRAWN	DATE	DWG. No.
CHKD.	DATE	A
APPD.	SCALE 1"-400'	ACCT.

FIG 2

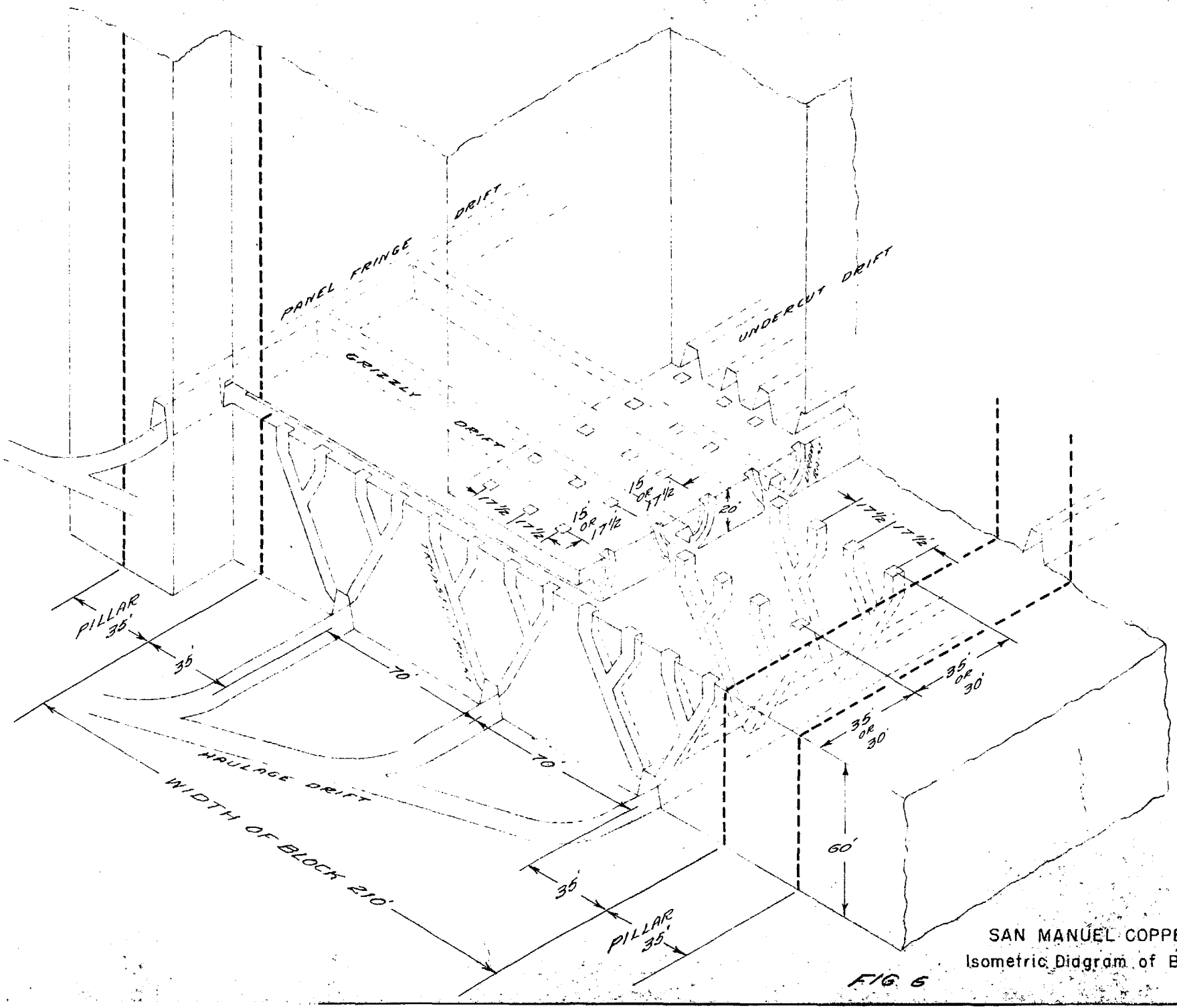


SAN MANUEL COPPER CORP.
DEPT. ARIZONA

LONGITUDINAL SECTION THRU
NO.2 AND 3B SHAFTS
LOOKING NORTHWEST

DRAWN	DATE	DWG. No
CHKD.	DATE	A
APPD.	SCALE 1" = 800'	ACCT.

FIG. 3



SAN MANUEL COPPER CORP.
Isometric Diagram of Block

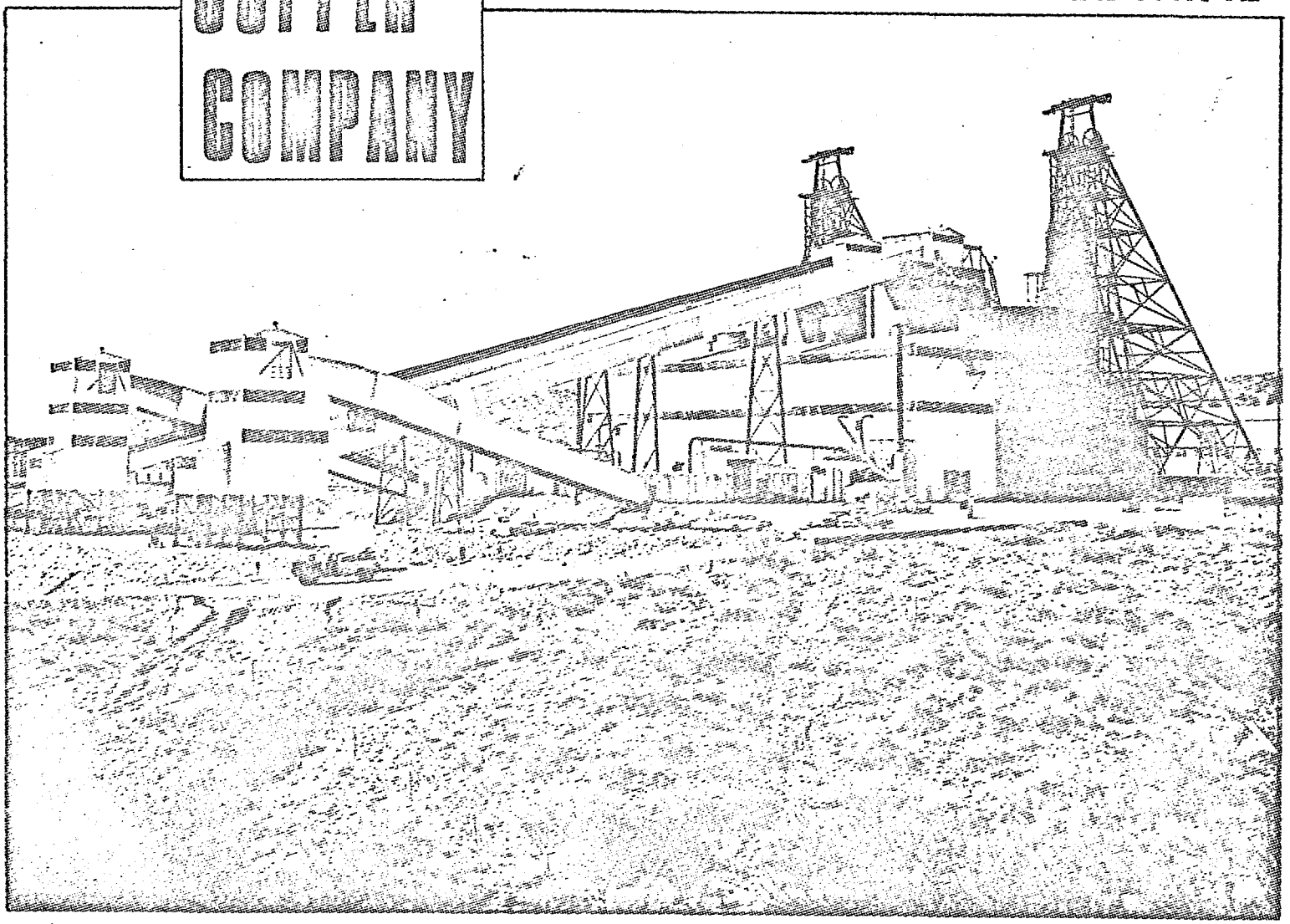
FIG 6

MAGMA COPPER COMPANY

J. H. C.

MAR 23 1972

THE SAN MANUEL MINE



GENERAL INFORMATION BOOKLET

San Manuel Division

San Manuel, Arizona

Orebody

Disseminated mineralization in monzonite porphyry and quartz monzonite.

Principal Sulphide Minerals: Chalcopyrite, chalcocite, pyrite and molybdenite. The grade of the ore is less than 1%.

Overburden: 0 to 1,900 ft. thick. Average over the Southeast (Main) Orebody is 670 ft. thick, and consists mainly of a very competent rock called Gila Conglomerate.

[The last two pages of this booklet show sections of the orebody.]

Mine Power

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

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

The 46 Kv feeder to the No. 1 and 4 Shaft Area feeds three secondary substations supplying all surface and underground power requirements. These include No. 1 and No. 4 hoists, compressor building and all service requirements. In addition, at the powerhouse substation in this area, provision is made to tie in the mine standby generating system to the 46 Kv system.

No. 1 Shaft

Depth: 2,833 ft. (For the Third Lift.)

Dimensions: 25'-5 7/8" x 6' -- 4 Compartments:
2 Hoisting, 6'-5½" x 6'-0".
1 Manway, 5'-0 1/8" (Below 1475).
1 Service Cage, 5'-0" (Below 1475).

Ventilation downcast.

Structural steel sets in reinforced concrete.

Headframe: 100'-6" to ℄ sheaves.
Two 12' diameter steel sheaves.

Skips: 4-ton capacity in counterbalance, Kimberly type.

Hoists: Main Hoist, two 200-hp motors, double drum.
Rope speed = 800 fpm, with Lebus wind.
Rope size = 1-1/8".

Service Hoist, single drum, 200-hp.
Rope speed = 545 fpm.
Rope size = 1".

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

No. 3A-3B Shafts

Twin ore hoisting shafts.

Depth: 2,305 ft. (For the Second Lift.)

Dimensions: 29' x 7' inside concrete.
Four compartments, each 6'-6" x 7'-0".

Ventilation exhaust shafts, 195' apart.

Structural steel sets poured in reinforced concrete for smooth lining. Reinforced concrete curtain walls between each compartment, with 3'-7½" x 4' windows in each set.

No. 3A-3B Shafts -- continued

In each of the two hoisting compartments steel hat section guides are of Corten steel. These guides are supported every three ft.

Timber guides in service compartment are supported every 6'-0".

Headframe:	181' to ℄ sheaves. 14' diameter cast steel sheaves.	
Coarse Ore Bins:	Diameter:	60'
	Height:	66'-6"; top of bin 92' above collar.
	Capacity:	750 tons total.
	Loading Gates:	2 on each track per bin, air operated. 2 loading tracks.
Fine Ore Bins:	Diameter:	65'
	Height:	81'-6"; top of bin 107' above collar.
	Capacity:	10,000 tons total.
	Loading Gates:	6 on each track per bin, air operated. On same two tracks as coarse ore bins.
Loading Pockets:	Two in 3A; one below 1775 SubLevel, capacity = 1,100 tons; one below 2075 Level, capacity = 1,500 tons. One in 3B below 2075 Level, capacity = 1,500 tons.	
Skips:	Bottom-dump Corten steel skips, with alloy steel liners, running on solid rubber tires.	
	Capacity:	23 tons with ± 4.0% moisture.
	Dimensions:	35'-5" long, 6'-1" wide, 6'-3" deep.
	Weight:	30,000 lbs. (Approximate)
Automation:	Skip loading and hoisting are fully automated. Skip loading and dumping are viewed on closed circuit television, and the car dumping and hoisting systems are monitored on a control panel.	
Hoists:	Double drum with Lebus wind; automatic or manual operation; 15' diameter drums having a 109" face, spooling 4,700 ft. of 2-1/4" rope in two layers.	
	Drum Shaft:	27" diameter through drums.
	Hoisting Speed:	2,800 fpm.
	Two 3,000-hp DC motors equipped with MG set consisting of one 4,000-hp motor and two 2,500 KW DC generators. Steel plate flywheel, 44 tons (approximate) for 80% power peak equalization.	

Service hoists are equipped with an 8-passenger cage and 45 cubic ft. skip combination with solid rubber tires running on timber guides. Hoisting rope is 1-1/8". The cage and skip are counterbalanced by an 8,400-lb. counterweight in the shaft manway.

No. 3A-3B Shafts -- continued

Primary Crusher: The 265' x 50' crusher building houses two 42 x 65 gyratory crushers. There are two 96" x 62'-0" pan feeders, with a capacity of 1,500 tons per hour; one fed from the 3A, and the other from 3B coarse ore bins. 48" conveyor belts transfer the crushed ore from the crusher building to transfer towers (222'), and back to the fine ore bins (421'). Skip dumping, fine ore bin capacity, and transfer belts are viewed on closed circuit television. The entire automated crusher is monitored from control panels at each crusher location.

No. 3C-3D Shafts

Identical ore hoisting shafts. 3C is 195 ft. north of 3A; 3D is 195 ft. south of 3B.

Depth: 3C = 2,859 ft. The sinking and furnishing of this shaft was completed April 12, 1971. Hoisting from 3C started in August, 1971.
3D = 3,700 ft. Shaft sinking is in progress.

Dimensions: 22'-0" inside diameter, circular, concreted.
Two ore hoisting compartments, service cage, manway and pipe compartments.

Ventilation exhaust shafts.

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

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

Headframe: Structural box members of Corten seeel.
15' diameter cast steel sheaves.

Skips: Bottom - dump Corten steel skips, alloy steel liners with solid rubber tires running on Corten steel box-section guides.
Capacity: 29 tons.
Dimensions: Length, 37'-4½"; Width, 6'-8"; Depth 6'-3½"; Weight: 30,860 lbs.

Automation: Same as 3A-3B.

No. 3C-3D Shafts -- continued

Hoists: Double drum with Lebus wind; automatic or manual operation, 15' diameter drums having a 109" face, spooling 2-1/4" wire rope.
Hoisting Speed: 2,800 fpm.
Each hoist has two 3,500-hp DC motors powered from a MG set consisting of one 6,000-hp 514 rpm synchronous motor driving two 2,800 KW generators. MG set has no flywheel.

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

No. 4 Shaft

Depth: 2,730 ft.

Dimensions: 26'-6" x 14'. Structural steel sets are poured in concrete for smooth lining.

Two cage compartments, each 14' x 8'; two rounded end compartments for manway, pipes, electric cables and ventilation. Manway compartment also contains the main compressed air line supplying the mine.

Man and supply shaft, and downcast ventilation.

Cages: 2 decks, 50 men per deck.
Inside dimensions: 6'-9½" x 13'-6".
Rated Capacities: 20,000 lbs. supplies per deck.
12,000 lbs. men per deck.
Cage Weight: 20,000 lbs. (approximate)

Headframe: 109 ft. to ℄ sheaves.
Two 14' cast steel sheaves.

Hoist: Double drum.
15' diameter, 90" face drums.
2-1/4" hoisting rope.
Maximum hoisting speed: 1,500 fpm.
Single reduction drive, two 700-hp DC motors equipped with MG set consisting of one 1,750-hp AC motor and two 600-KW DC generators. Hoisthouse equipped with 30-ton crane, with 5-ton auxiliary.

No. 5 Shaft

Depth: 4,368 ft. at final sinking.

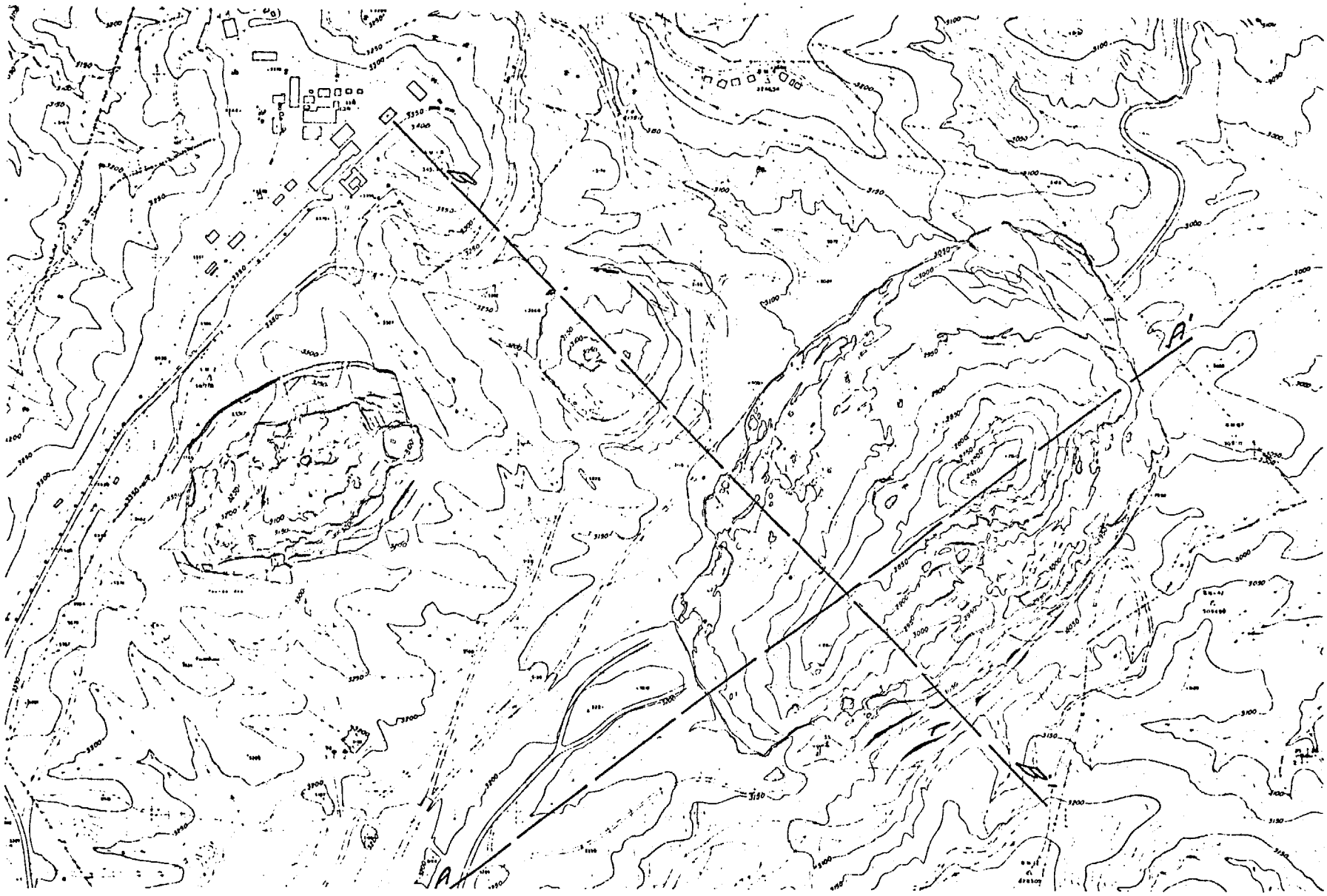
Dimensions: 25' diameter inside the concrete lining.

Of the four hoisting compartments, two will be used for handling men and supplies, and two will be used for hoisting waste rock. The shaft will also have compartments for manway, pipe lines, electric cables, and concrete transportation lines.

Man and supply shaft, downcast ventilation.

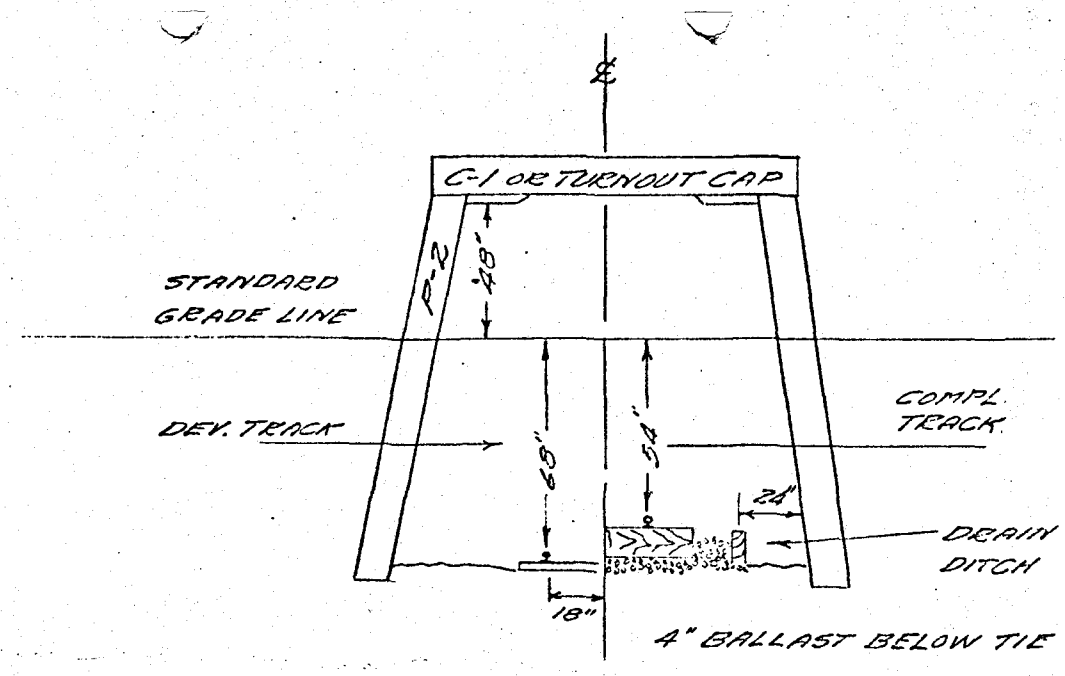
Hoists: Double drum production hoist powered by one 1,000-hp DC motor.
9' diameter, 103.5" face.
1-3/8" hoisting rope.
Hoist speed: 1,925 fpm.
Skip capacity: 5.5 tons.
A static thrystor rated at 1,000 KW will replace the normally-used MG set to supply power to the production hoist motor.

Service Hoist: Double drum service hoist (for men and materials), powered by two DC motors, each having 1,000-hp.
15' diameter, 105" face.
2-1/8" rope.
Hoist speed: 1,856 fpm.
Man cage: Similar to that at No. 4 Shaft.



Mine surface map showing caved areas.

1" = 800'



POSTS: 12" x 12" x 10'-4"
CAPS: 12" x 12" x 10'
Sets on 5' centers.

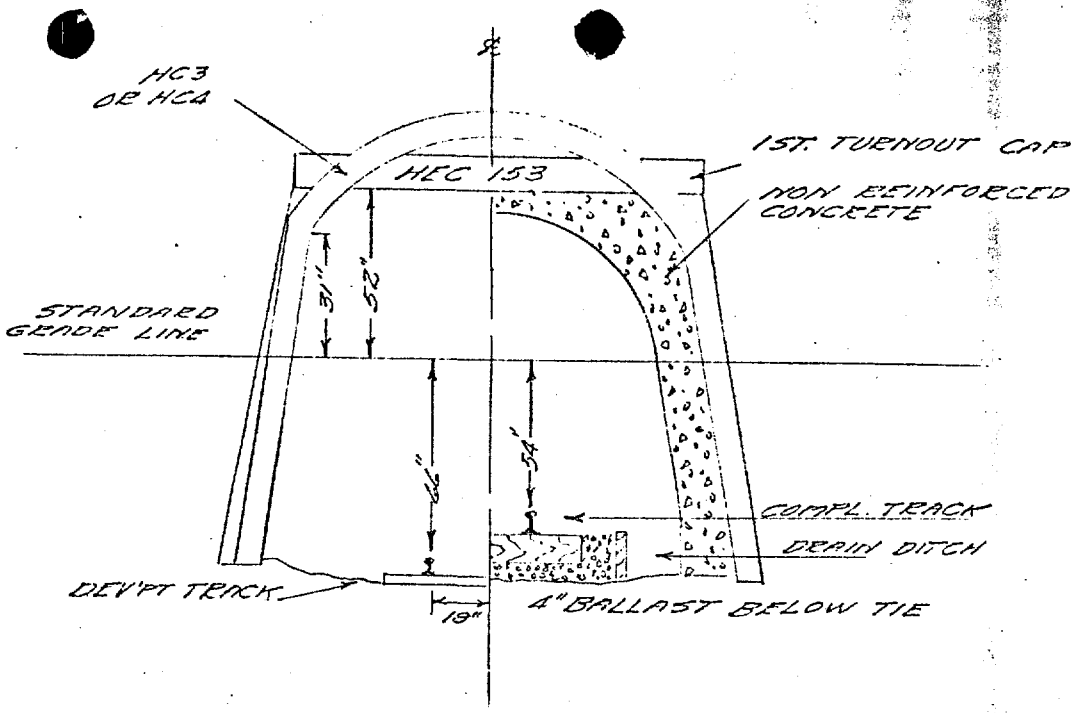
CREWS: Single Heading - 3 men.
Two Headings - 4 men.
44-48 holes drilled per set.
50 lbs. ± of Ammonium Nitrate primed with a stick of 60% Amogel per hole. Usually fuse blasted.

Timber Haulage Drift - 45# Rail for Development.
- 90# Rail finished track.

Timber Ladder Drift - If 70# rail is used, 64" is the grade.
45# rail for Development.
70# rail finished track.

Rail Measurements

3-3/4" for 45# rail.
4-5/8" for 70# rail.
5-5/8" for 90# rail.

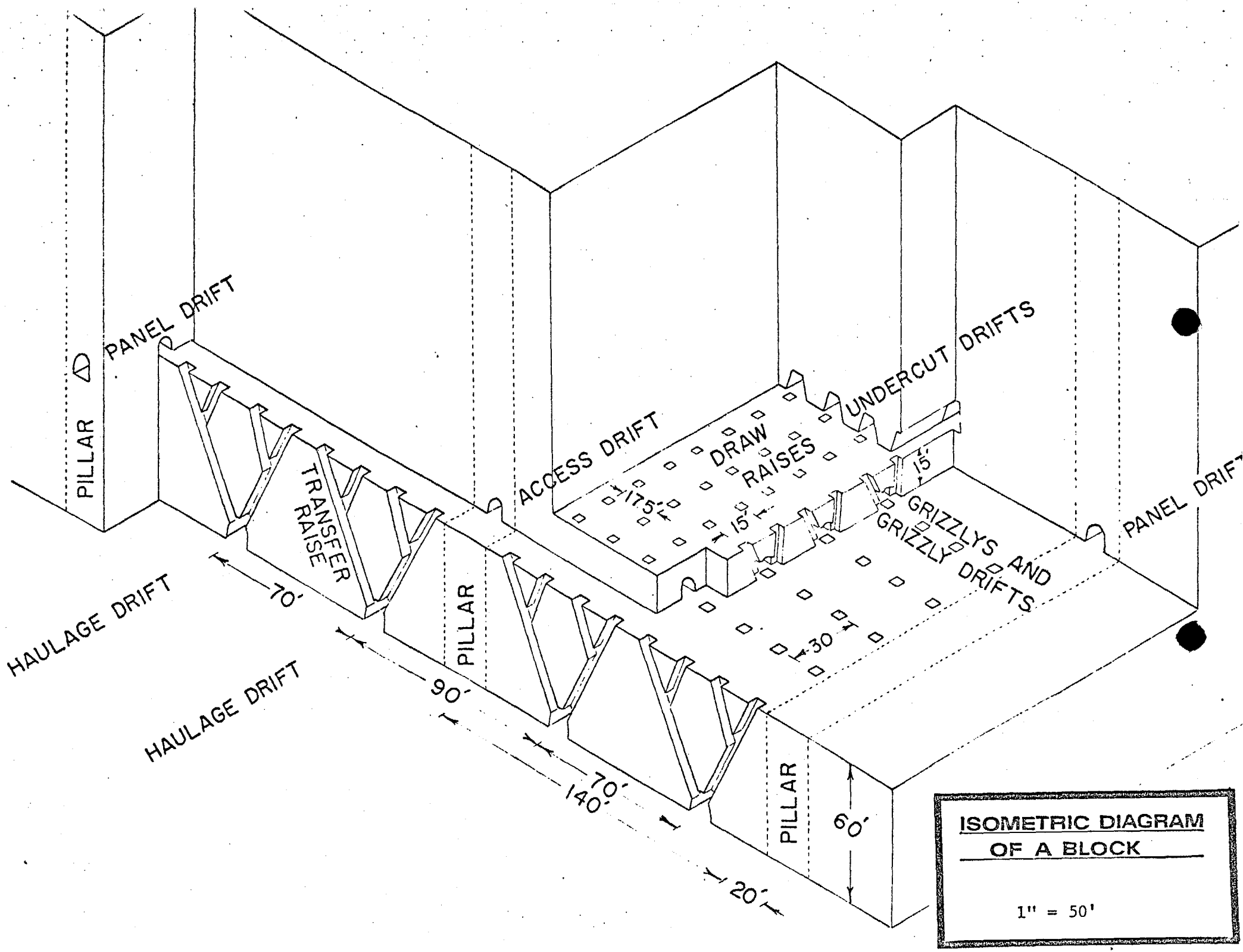


- 4" or 6" W.F. arch caps and
  9'-6" posts for initial
  ground support.
  Sets on 5' centers.
  Crews same as Timber Haulage Drift.

  Initial Ground Support
  4" Steel Set (HC-3) or
  6" Steel Set (HC-4)

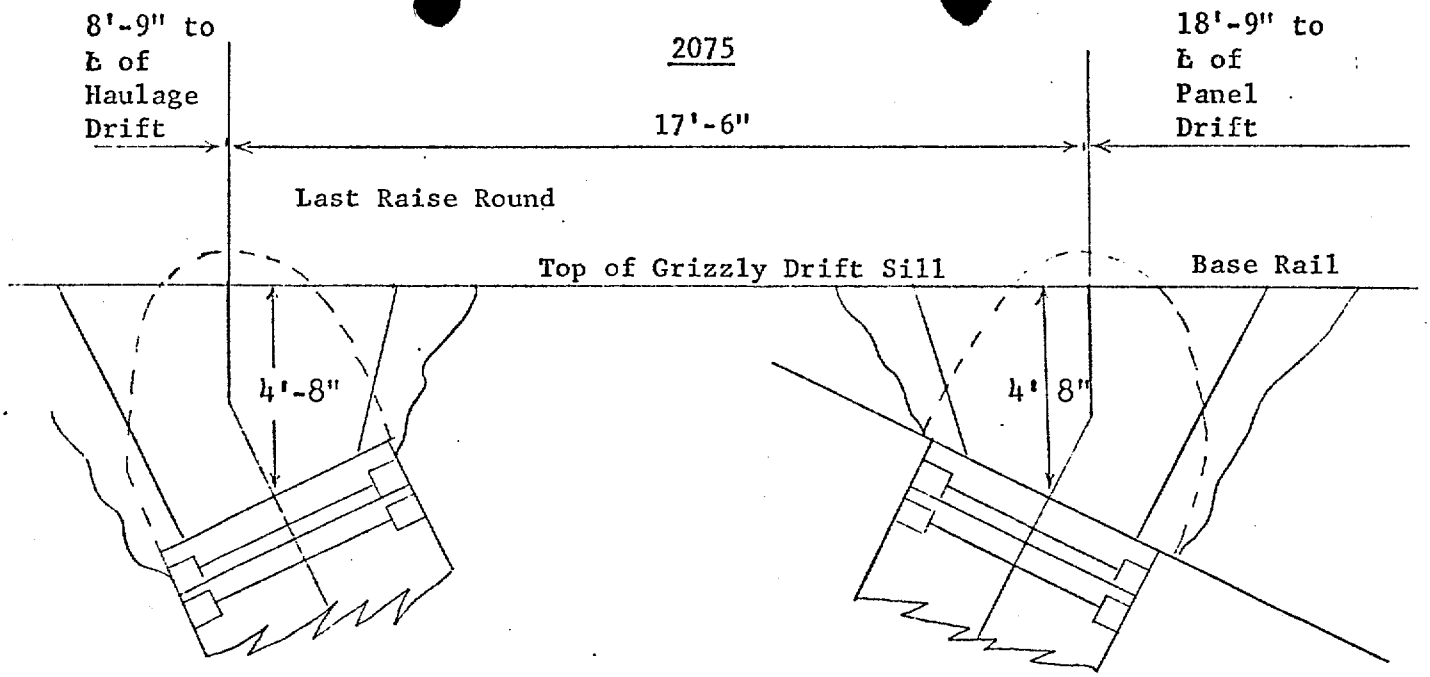
Concrete Ladder Drift - If 70# rail is used, 64" is the dev'pt grade.
45# rail for Development.
70# rail finished track.

Concrete Haulage Drift - 45# rail for Development
90# rail finished track.


PANEL DRIFT
PILLAR
TRANSFER RAISE
ACCESS DRIFT
DRAW RAISES
UNDERCUT DRIFTS
GRIZZLYS AND GRIZZLY DRIFTS
PANEL DRIFT
HAULAGE DRIFT
HAULAGE DRIFT
PILLAR
PILLAR
70'
90'
70'
140'
20'
60'
17.5'
15'
15'
30'
ISOMETRIC DIAGRAM OF A BLOCK
1" = 50'

BLOCK DEVELOPMENT

Gravity Flow Transfer Raise



4' x 4' inside.

LINING: 6" x 8" cribbing, armored with 3" x 4" x 1/4" steel angles and "T"-irons.

INCLINATION: 63°

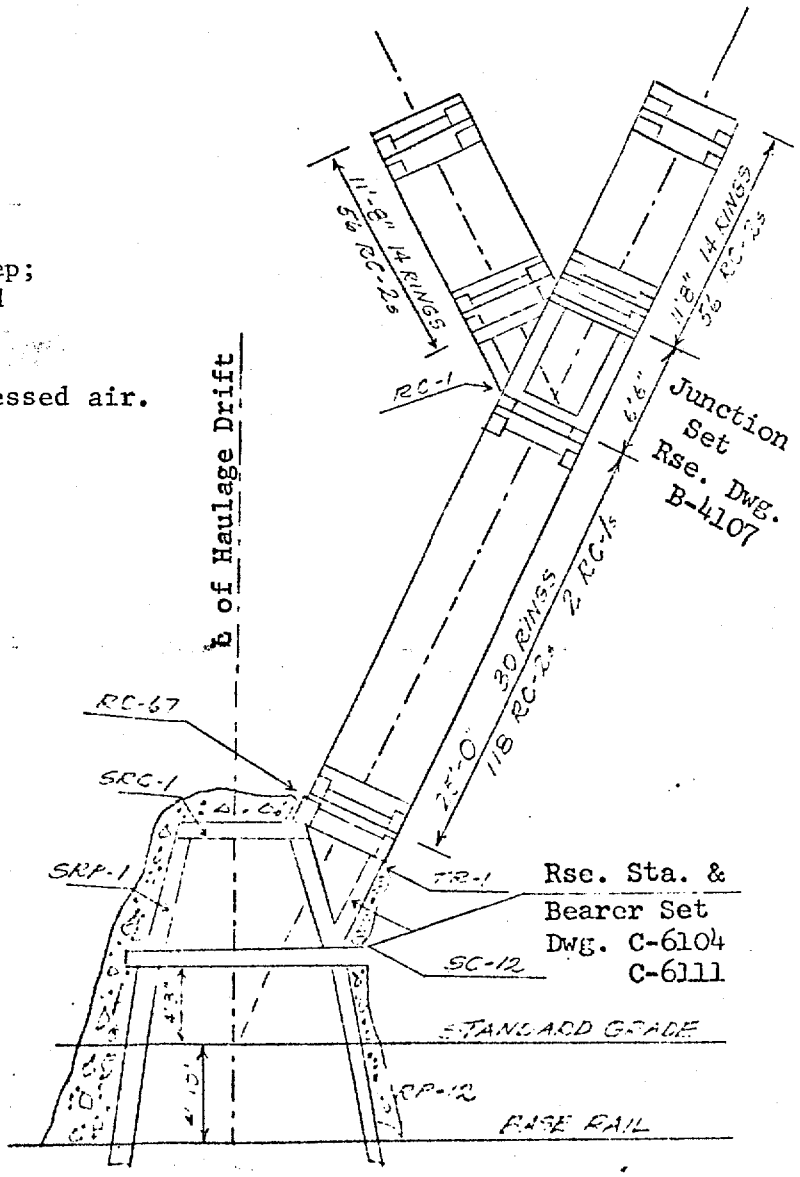
LENGTH: 48"

CREWS: 2-man crews advance two raises at once, using 3" stopers. 14 holes drilled 5' deep; 35 lbs. 60% Amogel used per round, detonated with electric caps. Ventilation with compressed air.

Transfer Raise Stations are cut by the regular drift crew using the same equipment they use to drive the drift.

They are cut as the drift heading is advanced.

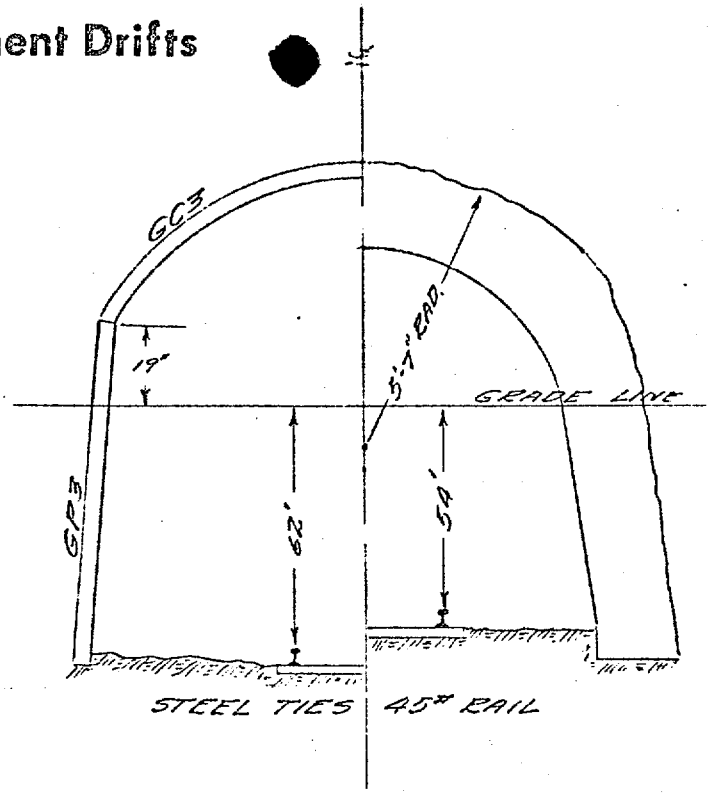
Raise Stations are steel pony sets on top of special drift sets. Lined with non-reinforced concrete.



Grizzly Level Primary Development Drifts

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

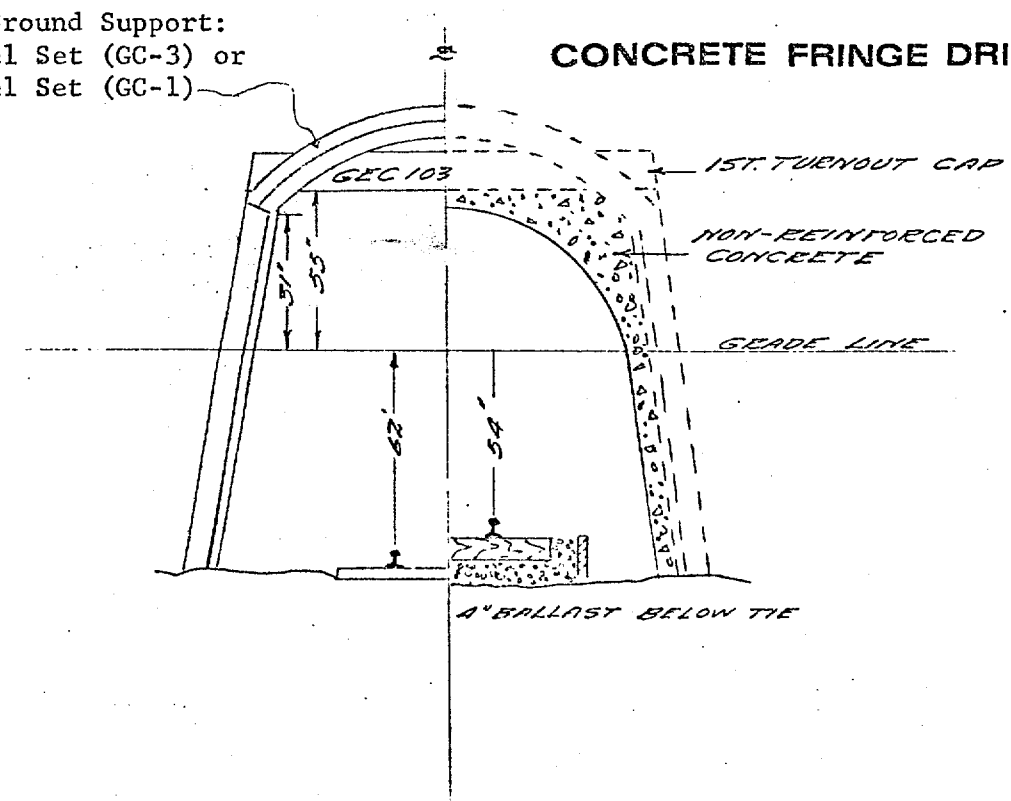
Two-man crews, or 3 men in two headings.
44-48 holes drilled 6' deep.
40 lbs. ammonium nitrate primed
with a stick of 60% Amogel per
hole. Usually fuse blasted.
Ventilation with fans and tubing.



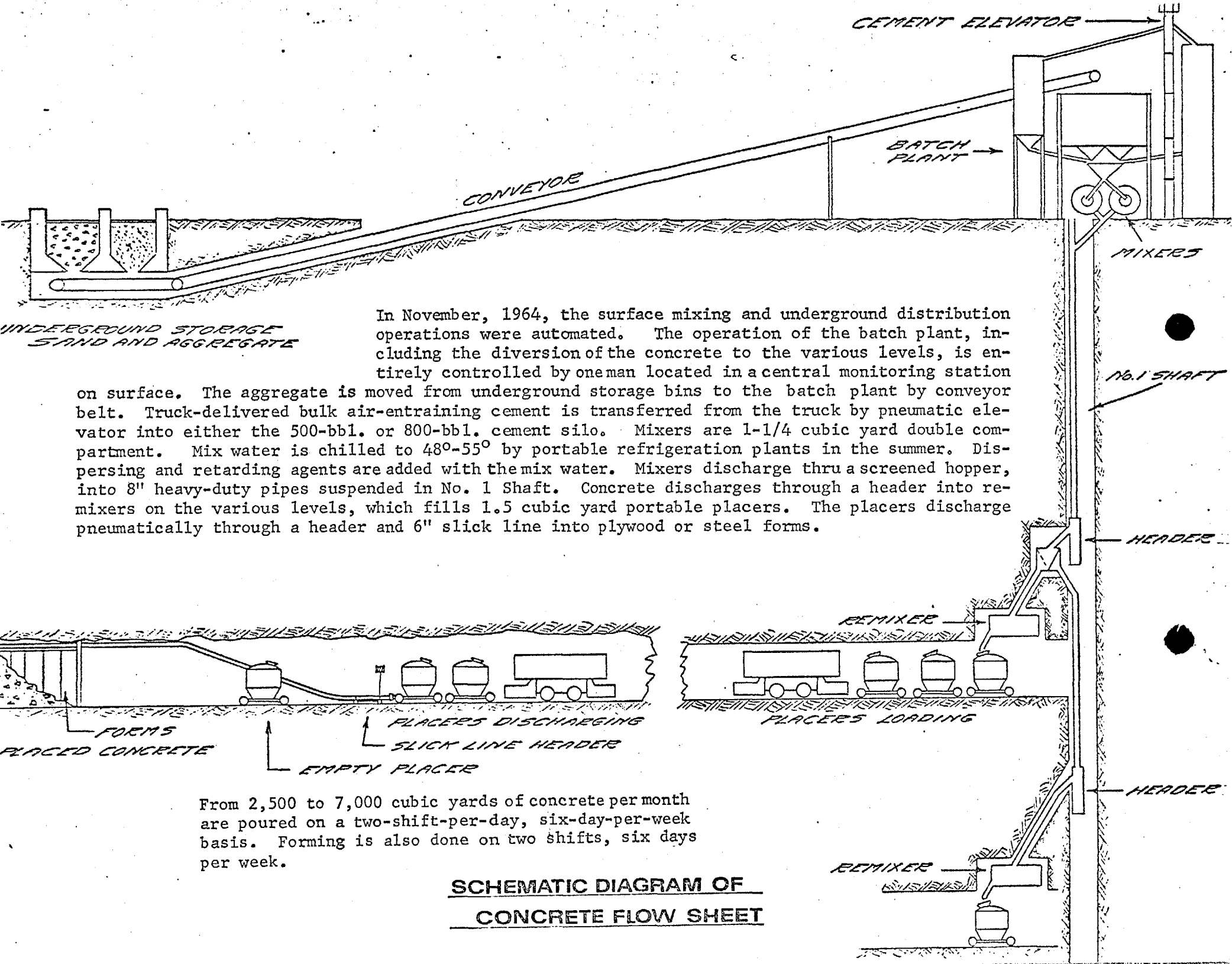
CONCRETE PANEL DRIFT

Initial Ground Support:
4" Steel Set (GC-3) or
6" Steel Set (GC-1)

CONCRETE FRINGE DRIFT



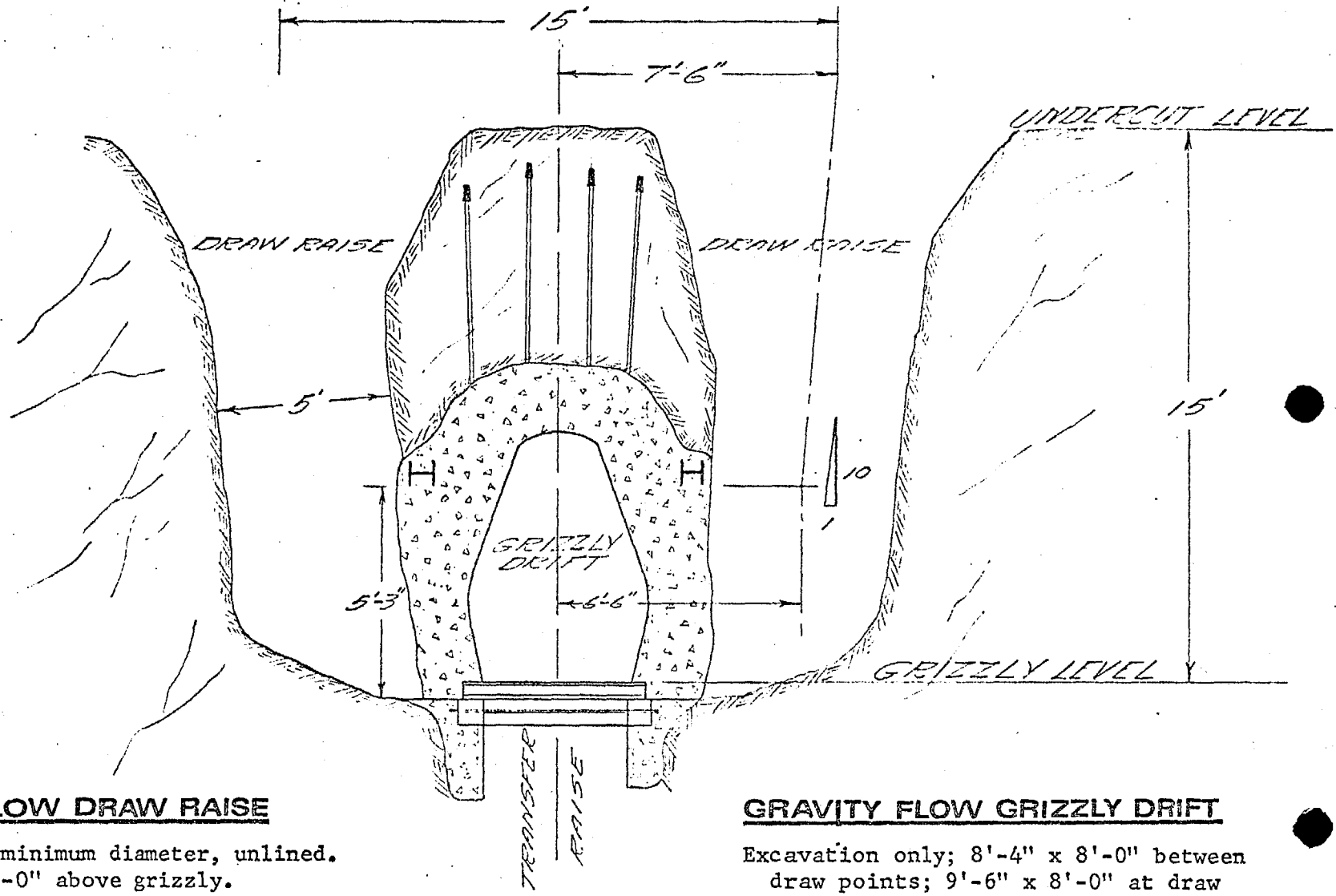
45# rail and steel ties for
Development and Finished Track.



In November, 1964, the surface mixing and underground distribution operations were automated. The operation of the batch plant, including the diversion of the concrete to the various levels, is entirely controlled by one man located in a central monitoring station on surface. The aggregate is moved from underground storage bins to the batch plant by conveyor belt. Truck-delivered bulk air-entraining cement is transferred from the truck by pneumatic elevator into either the 500-bbl. or 800-bbl. cement silo. Mixers are 1-1/4 cubic yard double compartment. Mix water is chilled to 48°-55° by portable refrigeration plants in the summer. Dispersing and retarding agents are added with the mix water. Mixers discharge thru a screened hopper, into 8" heavy-duty pipes suspended in No. 1 Shaft. Concrete discharges through a header into remixers on the various levels, which fills 1.5 cubic yard portable placers. The placers discharge pneumatically through a header and 6" slick line into plywood or steel forms.

From 2,500 to 7,000 cubic yards of concrete per month are poured on a two-shift-per-day, six-day-per-week basis. Forming is also done on two shifts, six days per week.

SCHEMATIC DIAGRAM OF CONCRETE FLOW SHEET



GRAVITY FLOW DRAW RAISE

Size: 5' minimum diameter, unlined.
Length: 15'-0" above grizzly.
Driven after grizzly drift is concreted.

Crews: 2-man crew drives several raises at once. 11 to 24 holes drilled 4' to 6' deep. 27 lbs. ammonium nitrate with each hole primed with a stick of 60% Amogel. Electrically blasted.

GRAVITY FLOW GRIZZLY DRIFT

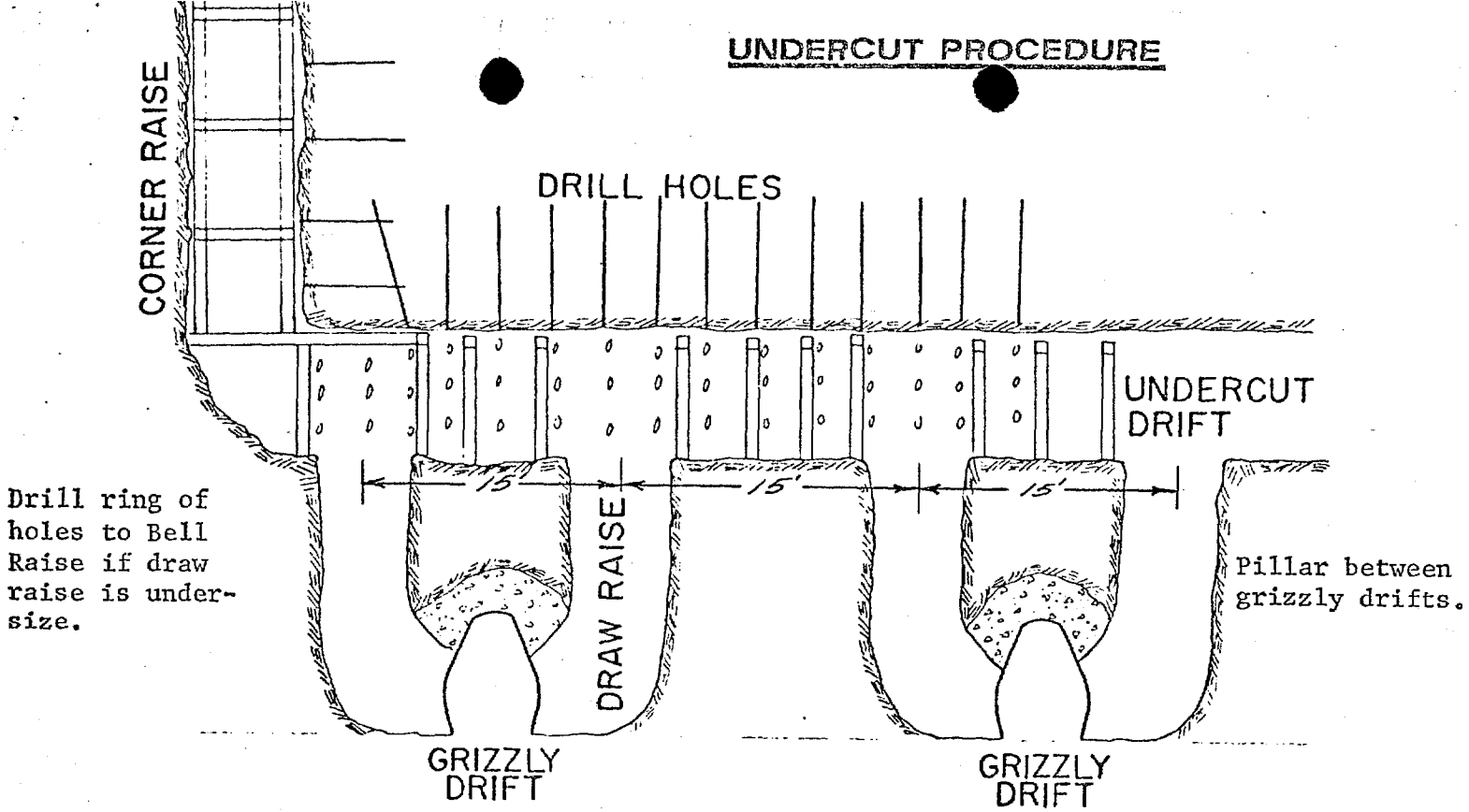
Excavation only; 8'-4" x 8'-0" between draw points; 9'-6" x 8'-0" at draw points.

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

Size: 5' wide, 8-3/4' high finished drift with concrete reinforced at the draw points only.

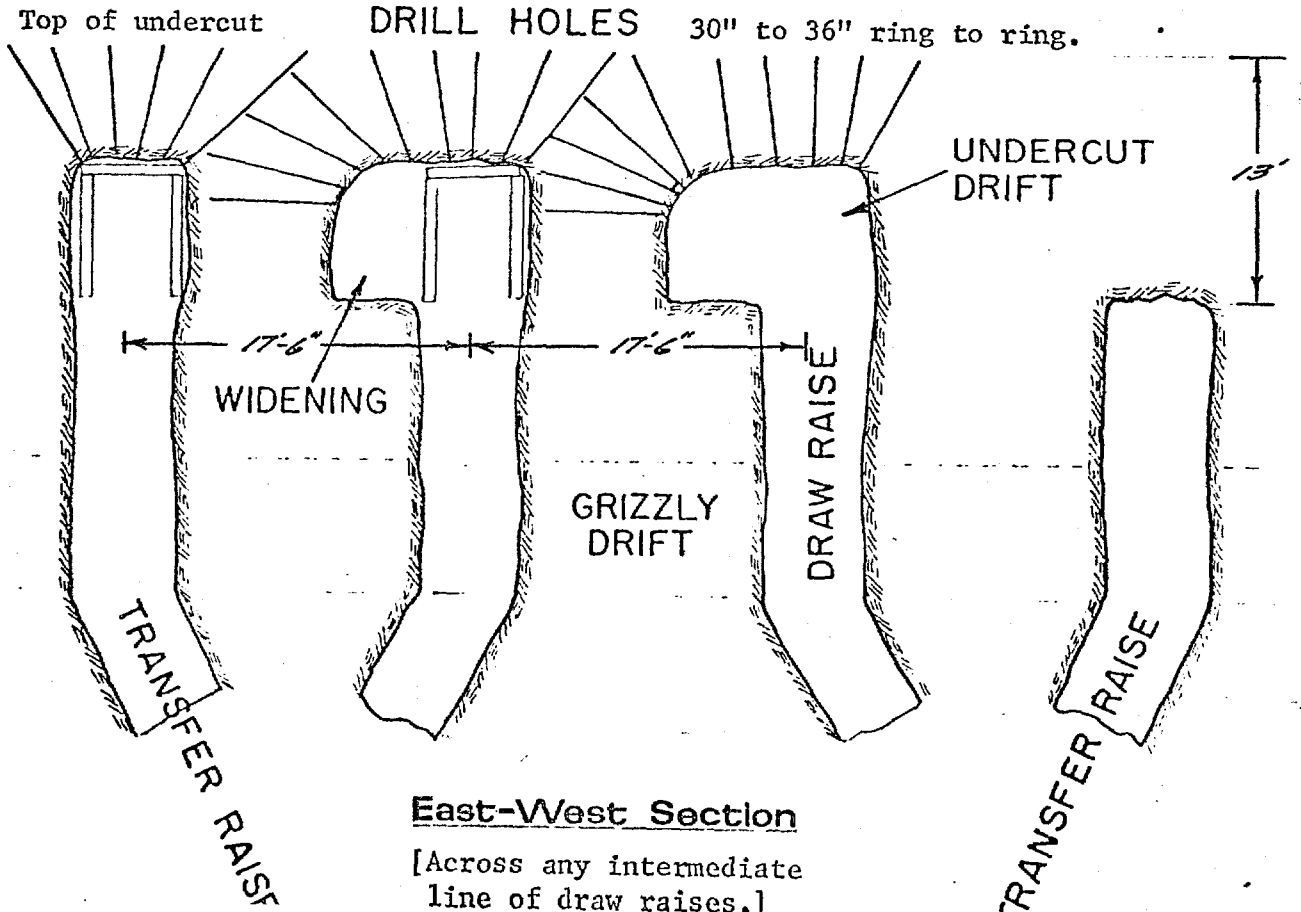
2-man crews used. 13 to 21 holes drilled 6' deep. 30 lbs. ammonium nitrate with each hole primed with a stick of 60% Amogel powder used per round; electric primer blasted. Drilling is done with jackleg. Ventilation with air mover.

UNDERCUT PROCEDURE



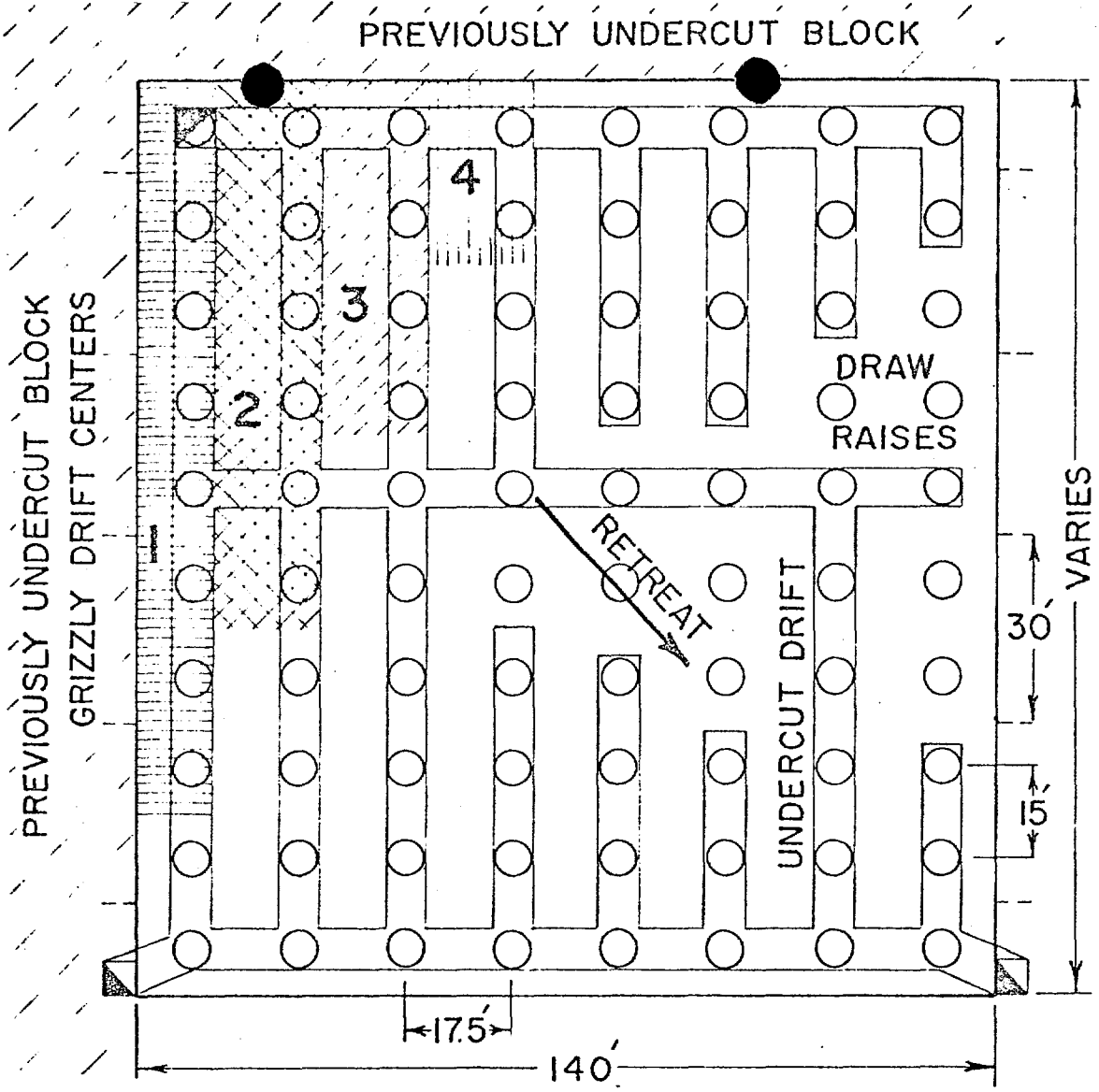
North-South Section

[Alongside boundary]

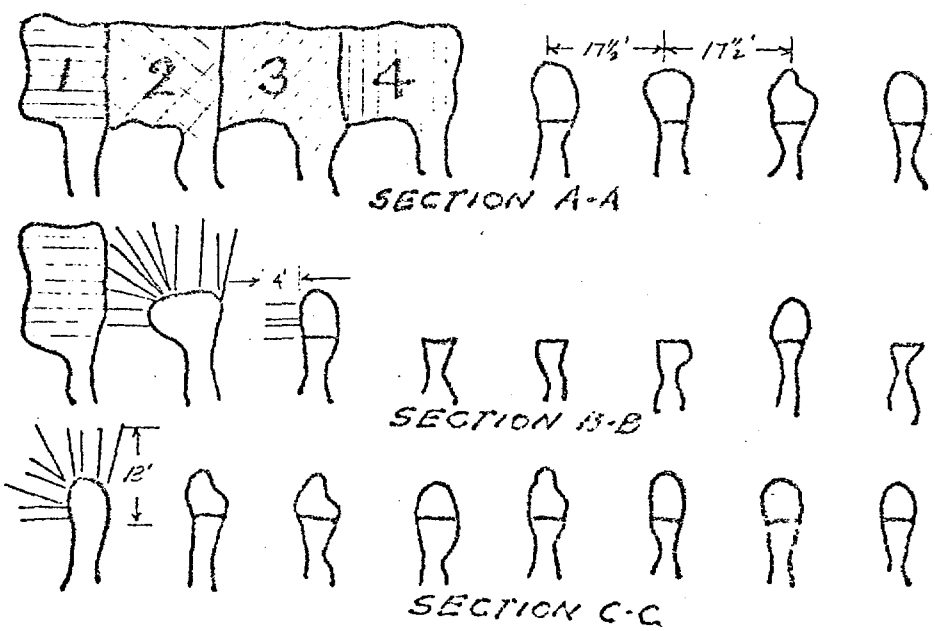


East-West Section

[Across any intermediate line of draw raises.]



Plan



Sections

PROGRESSION OF UNDERCUTTING

Typical Block

UNDERCUT PROCEDURE

Undercut drifts are 5 x 7 timbered with 6" round posts and 6" x 8" caps. These drifts are driven over the tops of all the draw raises, 15 ft. above the grizzly drift floor at right angles to the grizzly drifts. Access undercut drifts are driven parallel to the grizzly drifts over the tops of the northernmost and southernmost draw raises, and in blocks with five or more grizzly lines, an additional access undercut drift is usually driven across the center of the block. Corner raises are driven unless the rock is relatively soft--or where the block joins an older block. Undercut pillar work usually begins before the drifts are all completed to prevent excessive drift repair and maintenance.

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

Undercut pillar crews start the cave by drilling and blasting out a pillar between drifts or at a boundary of the block. The pillar crews retreat away from this initial cave, breaking the ground into the caved area. Before each pillar is blasted, the drift is widened on one side about four ft. and timbered if necessary. The remaining pillar, about eight ft. thick, is drilled out to a height of 13 ft. above the floor of the undercut, and the pillar and widened drift are shot. The timber is drilled with wood augers and shot with the undercut round. Generally, a 15-ft. section along the drift length is taken with each blast (from one draw raise to the next). Care is taken to insure that the pillar is completely broken by drawing off sufficient broken muck to observe the effect of the blast before the next adjoining pillar is shot. Millisecond delay electric caps are used in pillar blasting, and are wired in series - parallel, with not more than 25 primers in any one series. Circuits are tested with a galvanometer before being connected to the power source. All blasting lines go through an interrupter switch and from this switch to the main pillar blasting switch, which is a completely independent circuit.

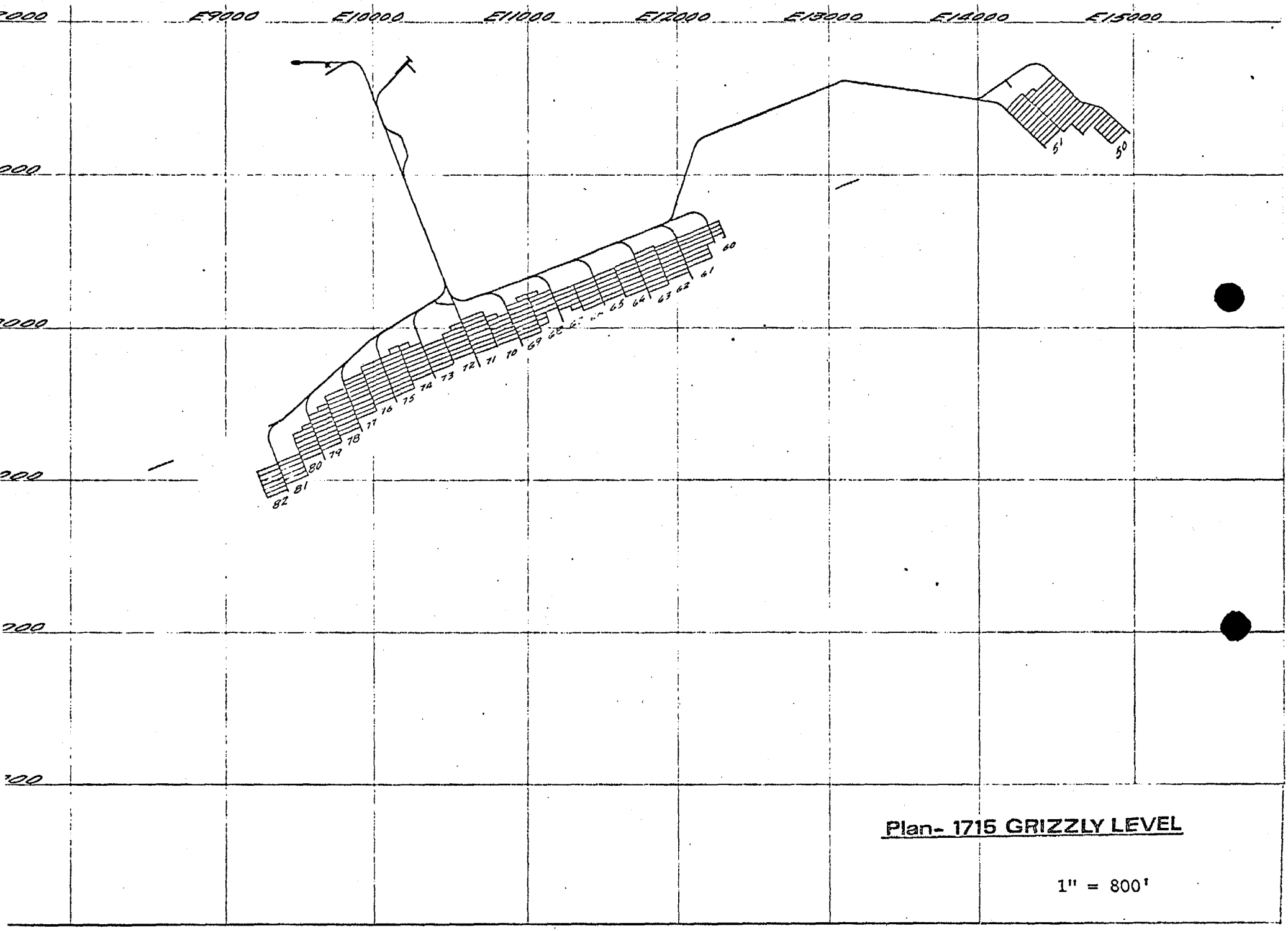
TIMBER:

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

CREWS:

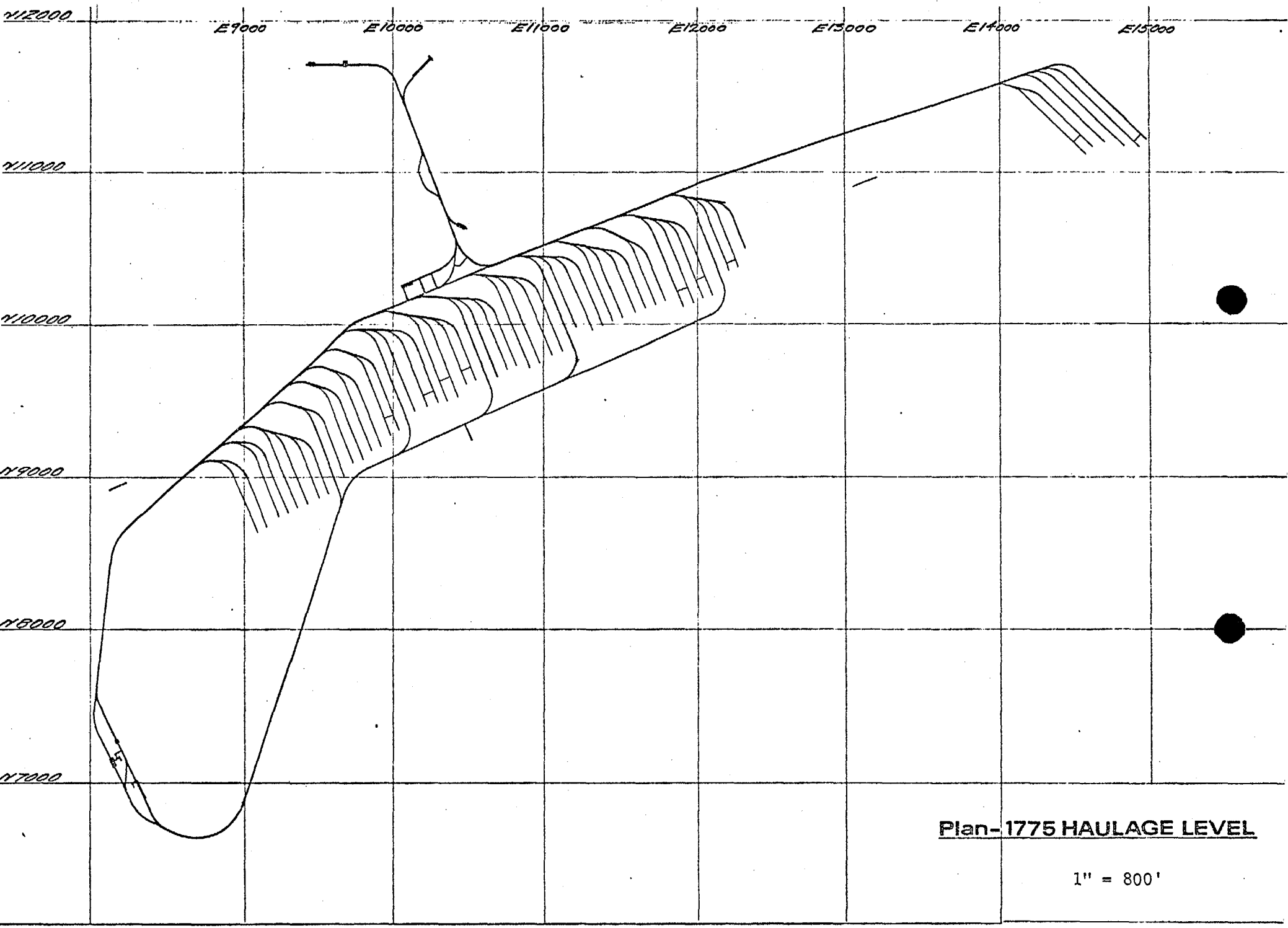
2-man crews drill 10 to 18 jackleg holes, and 20 to 30 stoper holes per shift, depending on draw raise spacing and ground condition. Undercutting proceeds on a 3-shift, 6-day per week basis.

45% N.G. powder or ammonium nitrate, primed with a stick of 60% Amogel is used with millisecond electric blasting.



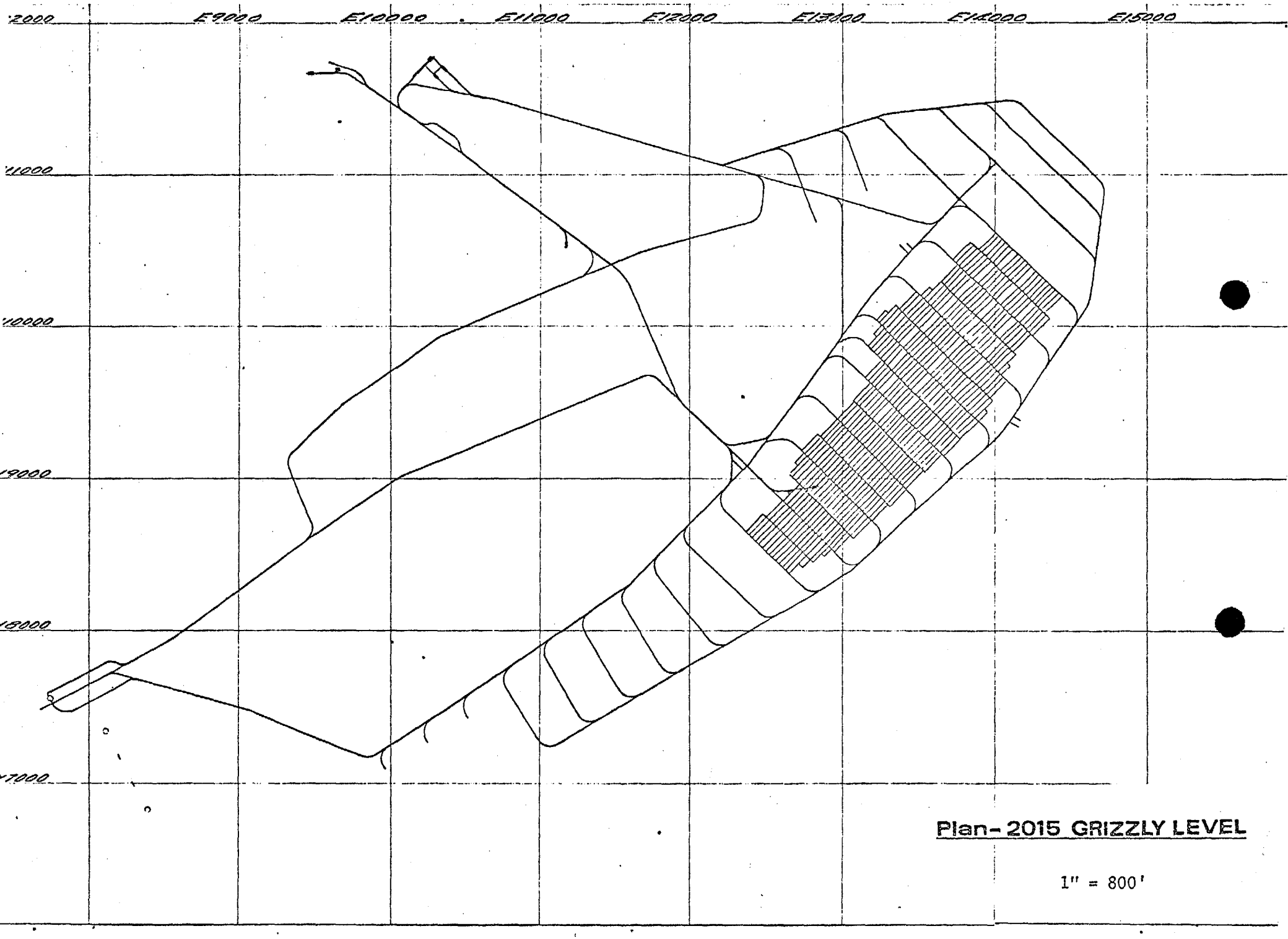
Plan- 1715 GRIZZLY LEVEL

1" = 800'



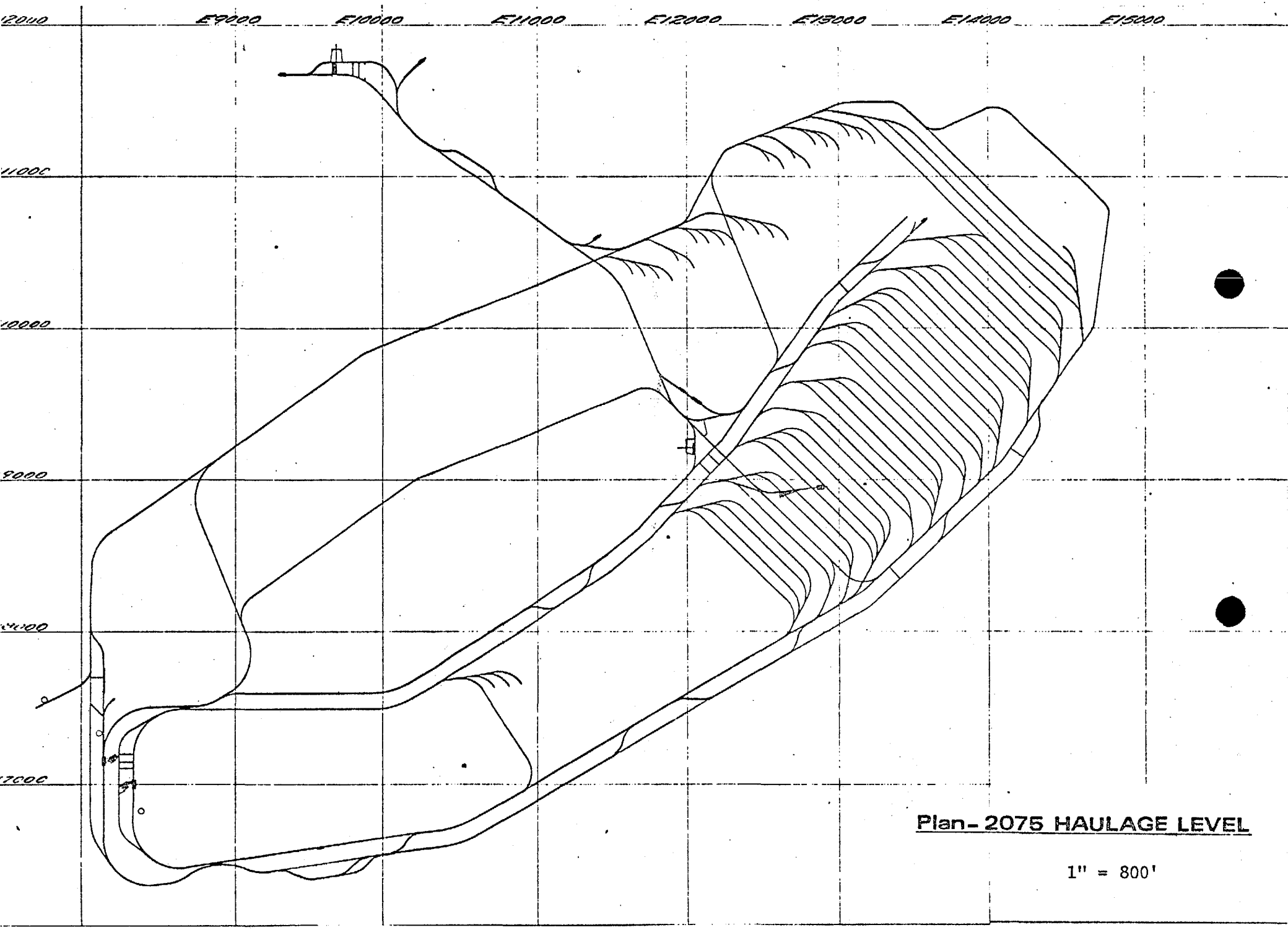
Plan-1775 HAULAGE LEVEL

1" = 800'



Plan- 2015 GRIZZLY LEVEL

1" = 800'



Plan- 2075 HAULAGE LEVEL

1" = 800'

GENERAL MINE OPERATING DATA

Operating Shifts per Day	3
Operating Days per Week	7
Operating Days per Year (7 holidsys)	358
Production per Day, Tons	43,000
Production per Year, Tons	15,800,000
Active Undercut Area, Sq. Ft.	368,000

Draw Point Spacing:
17.5' East-West x 15' North-South

Block Dimensional Data:

Block Width	140'
Block Length	90' - 240'
Present Average Block	140' x 180'
Ore Height above Undercut Floor	100' - 600'
Distance Undercut Floor to Grizzly Level Floor	15'
Distance Floor Haulage to Floor Grizzly Level	60'
Grizzly Bar Spacing	14"
Grizzly Bar Material	Salvaged 90# Rail.

Draw Points (Average per Month):

Active	1,350
High Pack	50
Held for Repair	80
Held for Grade	20
Total Draw Points	1,500

Types of Explosives Used:

Secondary Blasting -- 45% (No. 3) Amogel in 1 - 1/8" x 6" sticks or 60% (No. 1) Amogel in 1 - lb. bags. Initiation is with zero delay electric blasting caps. These are connected into a trunk line to a central underground location where blasting switches are located.

Primary Blasting - In the larger headings an ammonium nitrate explosive is used, except in wet holes. Initiation is by a 1-1/8" x 6" stick of 60% Amogel which, in turn, is ignited by a fuse cap.

An 8-ft. length of fuse with a spitter cord fuse igniter on the end opposite the cap is ignited with a hot wire fuse lighter.

All other development, except transfer raises, uses ammonium nitrate with regular delay electric blasting caps. Transfer raises load with 60% Amogel only.

All blasting is done at the middle and end of each shift.

Mining Equipment:

Big drifts use a San Manuel-made jumbo with three 8' booms and three 3" drifters with 6' feed shells. The booms are hydraulically operated and are powered by two 1-3/4 gpm, 11,000 psi hydropumps that feed into a hydraulic manifold.

Mucking is done by a rocker shovel with a steel flight conveyor dumping into 10 - ton bottom - dump development cars. The cars are switched by an 8-ton, 40-hp (or 9-ton, 40-hp) storage battery locomotive.

Smaller headings use feedleg drills with 2' or 4' single stage legs and stoper drills with 18" steel change.

Development slushing is handled by air-powered, double-drum slushers.

Underground Haulage Data:

Haulage locomotives are 23-ton, 4-wheel trolley type; each locomotive with two 125-hp, 275-volt DC motors. They haul fifteen 12- to 13-ton working load cars.

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

Length center to center of coupling: 17'-6".
Width, overall: 6'-0".
Height above track: 5'-6".
Couplers: Rotary and non-rotary couplers equipped with rubber cushioned draft gear.
Track gauge: 36".
Car loading through air-operated guillotine undercut gates.

Car Dumps:

In the dumping cycle the motorman pulls through the dump and spots three cars in the dumper without uncoupling. Carstops rise and lock the train in position. The motorman activates the dumper which rotates 180° and returns to the upright position and the operation is repeated. Three cars are dumped in about one minute, or five minutes per train of 15 cars. Development cars are designed to fit the dumper, but because of their length and type of coupling, they must be uncoupled to dump.

VENTILATION

530,000 cfm goes down #4 and #1 Shafts from the surface.
180,000 cfm goes down #5 Shaft from the surface.
50,000 cfm Miscellaneous Intakes, in addition to shafts.

170,000 cfm - SubLevel (1715-1775 Levels).
530,000 cfm - 2nd Lift (2015-2075 Levels).

Sub-Level - Two hi-speed Axivane mine fans: One MXC, 1715, 200-hp, 1160 rpm, 5' diameter; one MXC, 1775 200-hp, 1160 rpm, 5' diameter.

2nd Lift - Four hi-speed Axivane mine fans: One MXC, 2075 450-hp, 1160 rpm, 6' diameter; one VXC, 2015, 450-hp 1160 rpm, 6' diameter; one VXC, 2015, 200-hp, 1160 rpm, 5' diameter; one #5 Shaft VXC, 2015, 450-hp 1160 rpm, 6' diameter.

Auxiliary ventilation air is directed through operating blocks by means of ventilation doors and Axivane 20-hp, large-volume, low-pressure, low-speed mine fans. Individual working places are ventilated by 20-hp, high-pressure, high-speed fans through 24" ventilation pipe or with venturi type air movers.

COMMUNICATIONS

On the haulage levels, haulage trains and supply trains are moved on direct orders from a dispatcher by the use of a radio phone system. In addition, radio phones are installed in repair shops and at vantage points for use by supervision.

Draw and haulage operations are coordinated through the dispatcher by an audio paging system.

A standard telephone system consisting of seven circuits aids in coordinating hoisting, maintenance, and service facilities between the surface and the mine underground.

DRAINAGE

Newly opened areas show an appreciable flow of water which is carried out of the working area by air-operated sump pumps, with a capacity of 150

gpm at 100' head. Mine underground was planned so that water drains either to No. 1 Shaft or to 3A and 3B Shafts.

No. 1 Shaft is pumping 3,200 gpm, principally from the 2nd Lift;
700 gpm, from 3B Shaft Bottom;
Present pumping is 3,900 gpm Total.

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

To prevent surface drainage from entering the mine, surface washes leading to the cave area are either diverted or dammed up to hold the water for evaporation.

SURFACE ORE TRANSPORTATION

Cars:	100 tons capacity, 35 to 40 per train.
Locomotive:	125-ton, 1,600-hp, diesel-electric.
Trackage:	132-lb. rail, 7-mile haul to receiving bin at reduction plant, level track.

CHANGE ROOM NO. 1

Accommodates 1,900 employees with lockers, showers, and toilet facilities. Heated with gas space heaters.
In the same building is the foreman's office, time office, safety engineer's office, dispensary, lamp room, and dust-counting laboratory.

CHANGE ROOM NO. 2

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

COMPRESSOR HOUSE

Five 3,500 cfm compressors, delivering at 100 lbs. air pressure, each equipped with 600-hp synchronous motor.
One 1,936 cfm - 350-hp synchronous motor.
One 1,596 cfm - 300-hp synchronous motor.
Total = 21,032 cfm, delivering at 110 lbs. air pressure for approximately 100 lbs. mine working pressure.
Four natural gas powered compressors each having a 3,200 cfm capacity. "Outdoor" type.

NO. 1 and NO. 4 YARDS

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

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

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

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

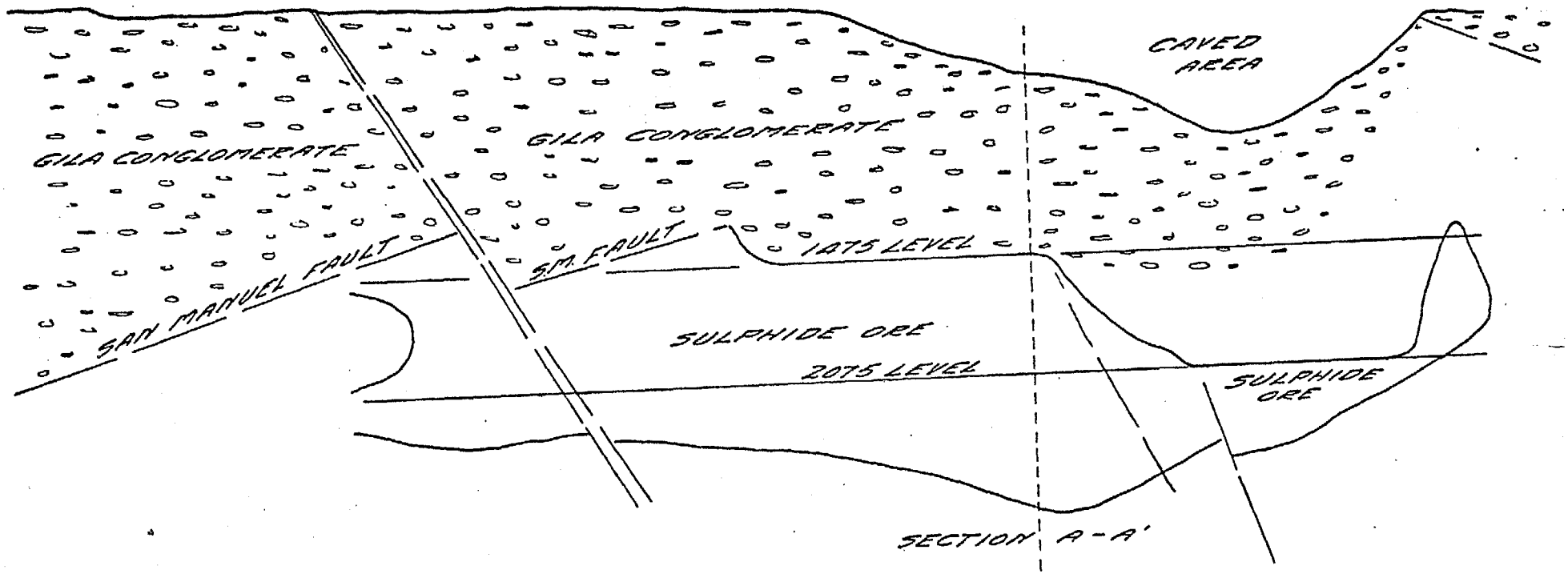
A large explosives magazine is maintained to supply the mining operation.

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

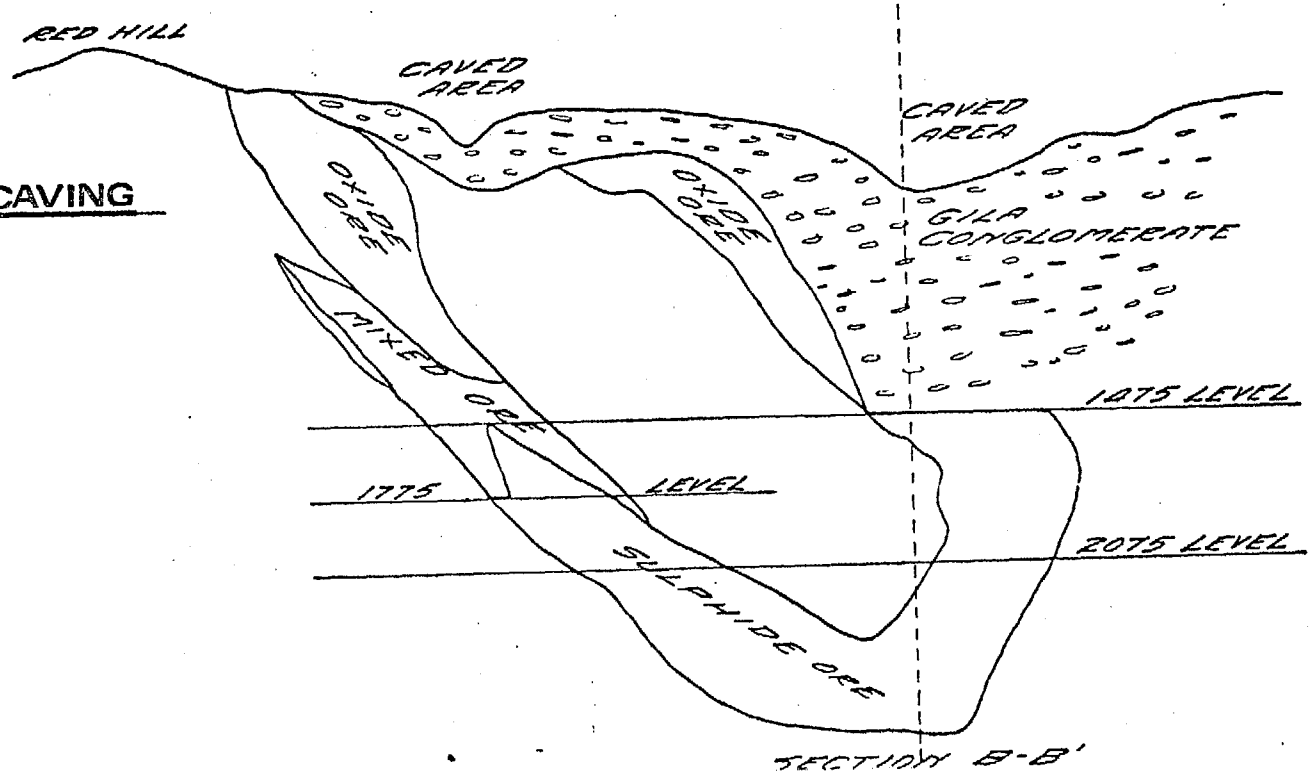
METAL PRODUCTION—San Manuel Only

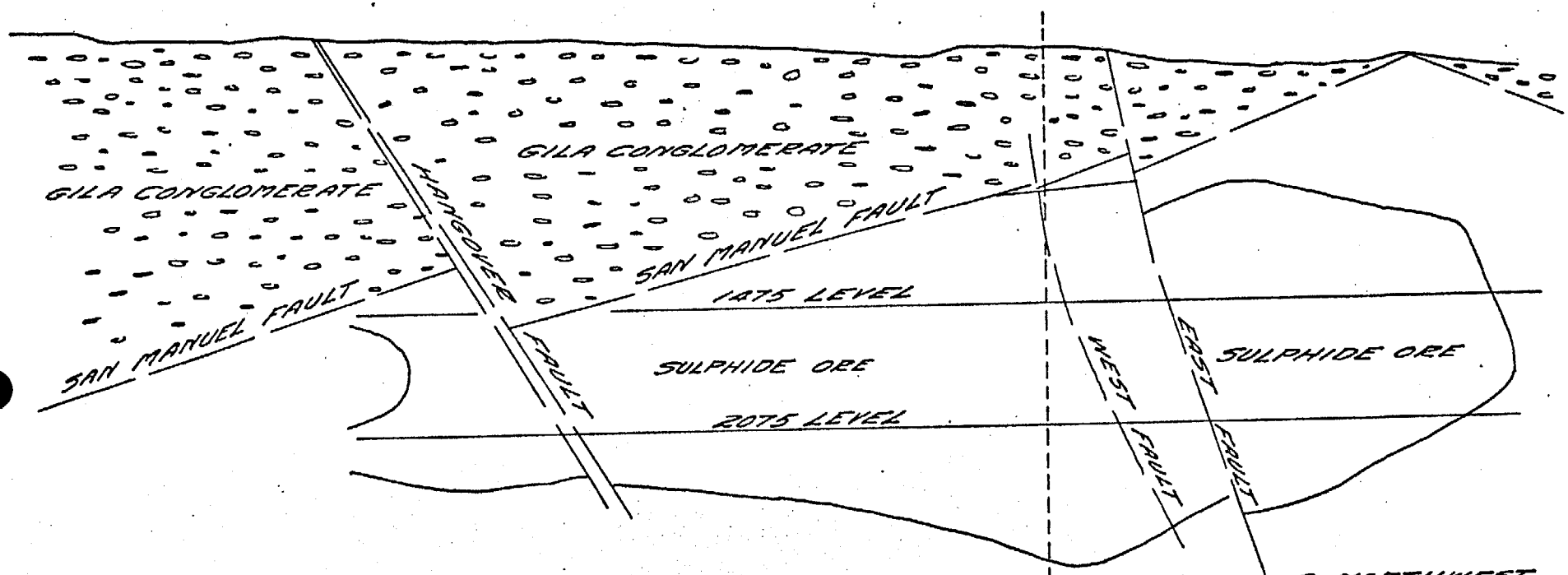
1970 - 12 months of operation.

Average Daily Mine Production, Dry Tons	43,227
Copper Production, Tons	95,000
Molybdenum Sulfide Concentrate, Tons	2,960

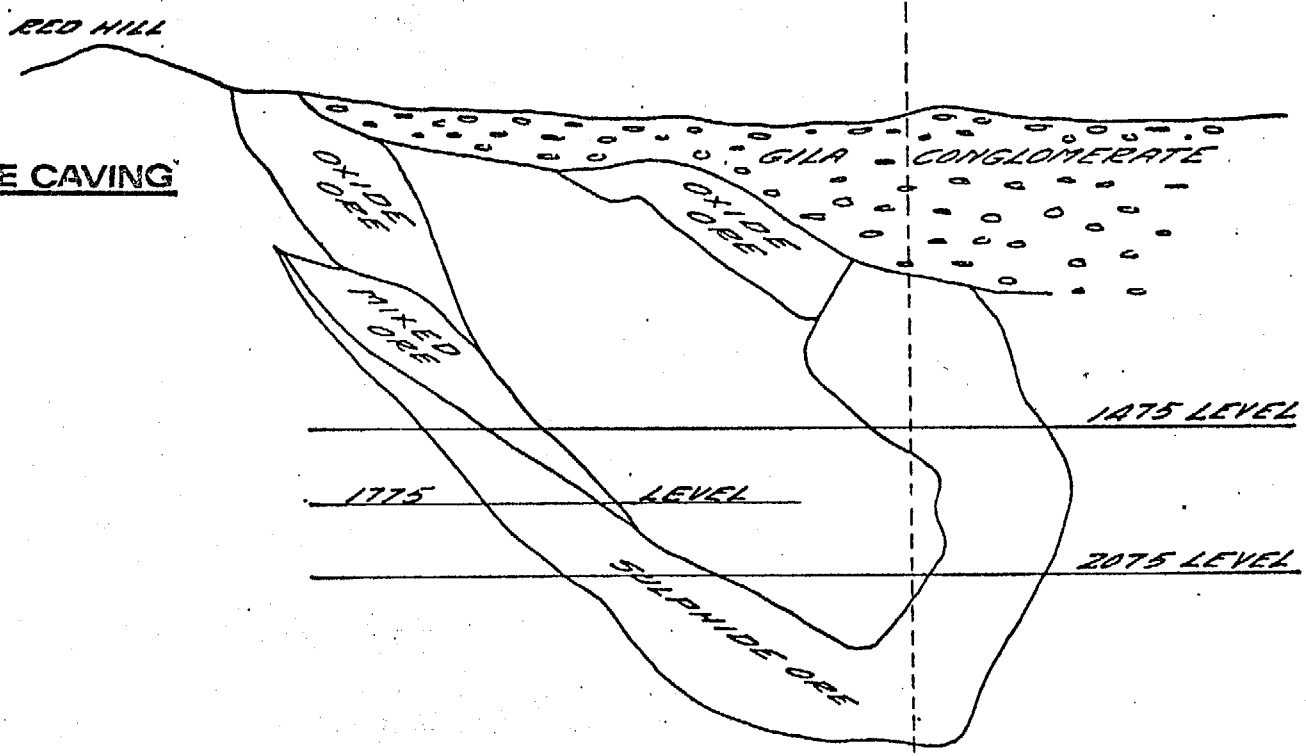


SECTIONS AFTER CAVING





LONGITUDINAL SECTION - LOOKING NORTHWEST

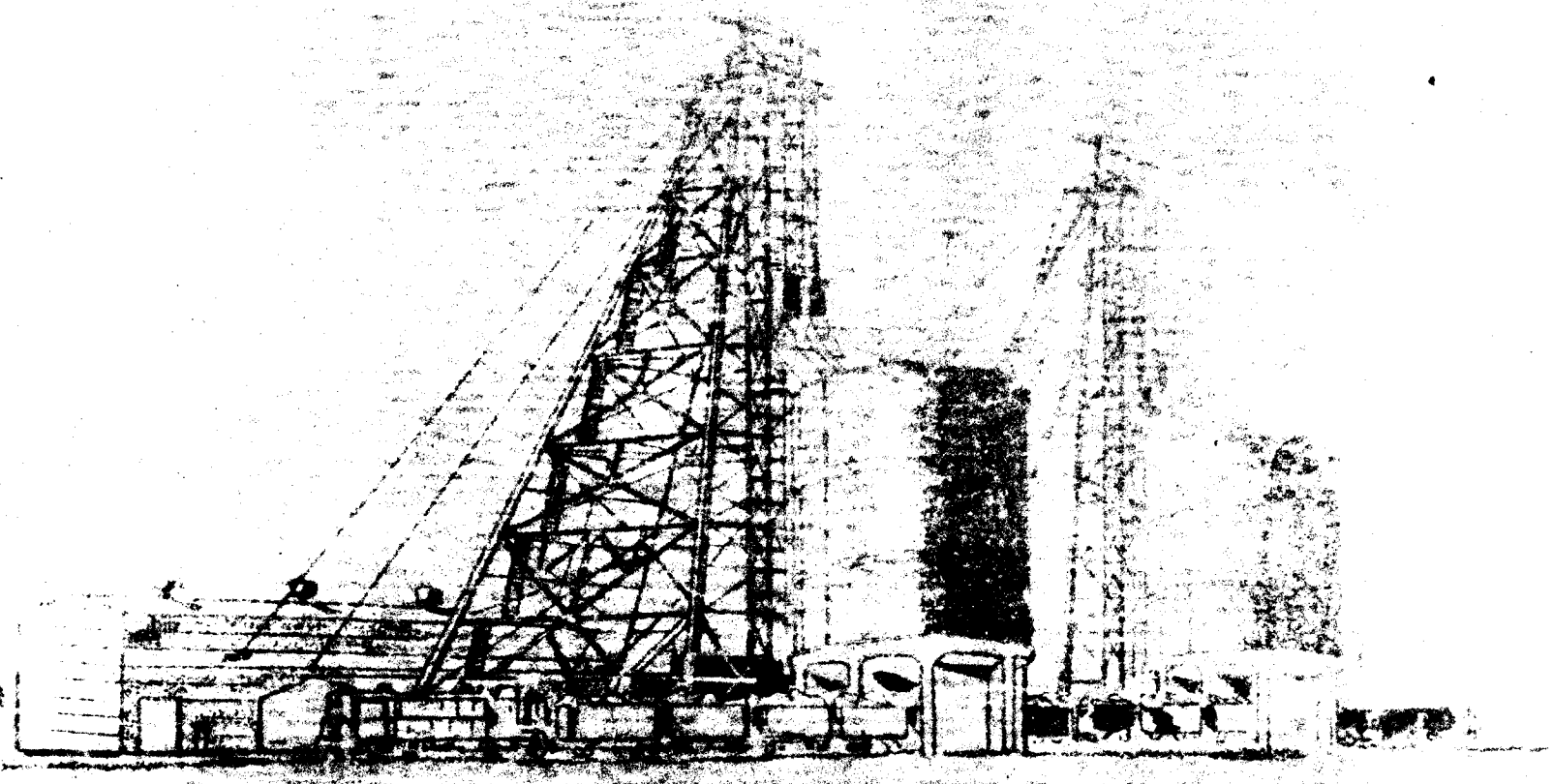


CROSS SECTION - LOOKING NORTHEAST

SECTIONS BEFORE CAVING

1" = 800'

Magma Copper Company
San Manuel Division



MAGMA COPPER COMPANY
San Manuel Division
San Manuel, Arizona

October, 1963

ORE BODY

Disseminated mineralization in monzonite porphyry and quartz monzonite.

Principal Sulphide Minerals: Chalcopyrite, Chalcocite, Pyrite, and Molybdenite.

ORE RESERVES:

Sulphide: 457,900,000 tons at 0.747% Cu; 0.02 MoS_2
Oxide: 130,000,000 tons at 0.700% Cu
Small amounts recoverable Ag and Au.

OVERBURDEN: 0 to 1900 feet thick. Average over the Southeast ore body is 670 feet thick, and consists mainly of a very competent rock called Gila Conglomerate.

(Shown as the last two pages of this pamphlet are sections of the orebody.)

PRIMARY DEVELOPMENT

NO. 1 SHAFT:

Depth: 2,262 feet. (For Second Level)

Dimensions: 25' - 5 7/8" x 6' - 4 Compartments:
2 hoisting, 6'-5 3/8" x 6'-0"
1 manway, 5' x 6'
1 service hoist, 5' x 6'

Structural Steel Sets and Reinforced Concrete.

Headframe: 100 -6" to 8 sheaves.
Two 12' diameter steel sheaves.

Skips: 4-ton capacity in counter-balance.

Hoist: Nordberg Hoist, two 200-h.p. motors.
Rope Speed = 800 f.p.m., with LeBus wind.

Chippy Hoist: Two speed - remotely controlled from the cage.

No. 1 Shaft—continued

Ventilation Downcast: Used to hoist waste muck and for auxiliary hoisting. Manway compartment contains main compressed air line supplying the mine, pump discharge-columns carrying most of the water pumped from the mine, and power transmission lines. Service compartment has three 8" heavy duty pipes for concrete transportation. Ventilation downcast 120,000 c.f.m.

NO. 3A-3B SHAFTS

Twin Ore Hoisting Shafts, 195 feet apart.

Depth: 2,305 feet. (For Second Level)

Dimensions: 29' x 7' inside concrete.
Four compartments, each 6'-6" x 7'-0".

Ventilation Exhaust Shafts.

Structural Steel Sets buried in concrete for smooth lining. Concrete curtain walls between each compartment with 3'-7½" x 4' windows in each set.

Steel guides supported every three feet in hoisting compartments.

Timber guides in chippy compartment supported every 6'-0".

Headframe: 181' to B sheaves, 14' diameter cast steel sheaves.

Ore Bins: Diameter: 60'
Height: 66'-6", top of bin 92' above collar.
Capacity: 5,000 tons total capacity.
Loading Gates: 4 on each track per bin, air operated.

Loading Pockets: Two: one below First Level; one below Second Level.
Capacity of each = 1,500 tons.

Skips: Bottom-dump, Lake Shore Jeto skips.
Capacity: 20 tons dry ore; 21 tons wet ore.
Dimensions: 33'-5" long, 6'-1" wide, 6'-6" deep.
Weight: 30,000 lbs. (Approximate)

3B Shaft - 2075 Level
Automation: Semi-automated car dumping. Motorman positions and dumps his own train in the Rotary Dump by a series of switches along the drift. Skip loading and hoisting are fully automated. Skip loading is viewed on a closed circuit television arrangement and the entire automated system is monitored on control panel.

No. 3A-3B Shafts -continued

Hoists: Nordberg Double Drum, with LeBus wind; automatic or manual operation; 15' diameter face drums with 3,700 feet of 2¼" rope capacity in two layers.
Drum Shaft: 27" diameter through drums.
Hoisting Speed: 3,000 f.p.m.
Two 3,000-h.p. D.C. motors equipped with M.G. set consisting of one 4,000-h.p. motor and two 2,500 KW D.C. generators. Steel plate flywheel.
Flywheel Weight: 44 tons (approximate) for 80% power peak equalization.

Chippy Hoists are equipped with an 8,400 lb. counterweight, running on timber guides backed with 4" W.F. beam. Counterweight is equipped with safety dogs and is hoisted with a 2-part rope, 7 x 18 non-rotating, 3/4" diameter.

NO. 4 SHAFT

Depth: 2,158 feet. (For Second Level)

Dimensions: 26'-6" x 14'. Structural steel sets buried in concrete for smooth lining.

Two cage Compartments, each 14' x 8'; rounded end compartments for manway, pipes, electric cables and ventilation.

Men and Supply Shaft and Downcast Ventilation - 370,000 c.f.m.

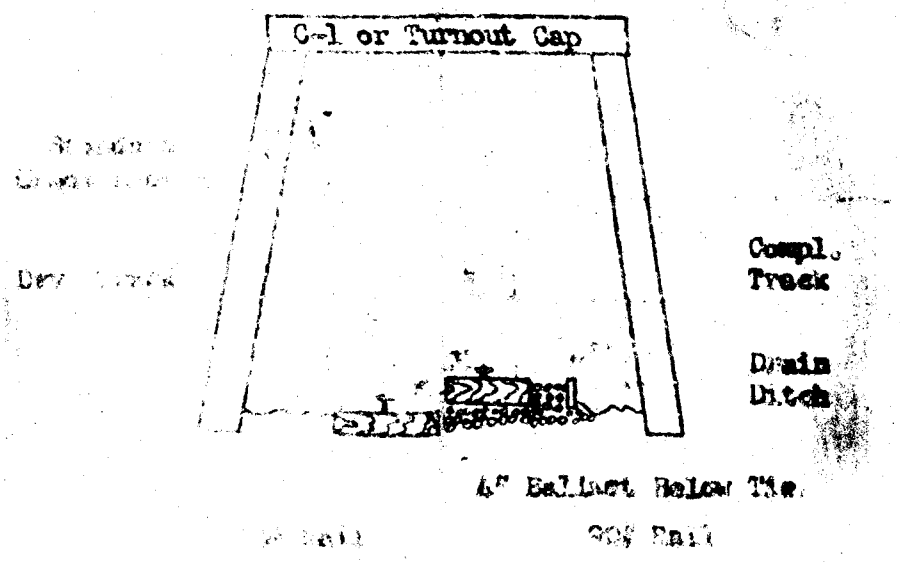
Cages: 2 decks, 50 men per deck.
Inside dimensions: 6'-9½" x 13'-6".

Rated Capacities:
20,000 lbs. supplies per deck.
12,000 lbs. men per deck.
Cage Weight: 20,000 lbs. (Approximate)

Headframe: 109 feet to h sheaves.
Two 14' cast steel sheaves.

Hoist: Nordberg double drum.
15' diameter, 90" face drums.
2¼" hoisting rope.
Maximum hoisting speed: 1,500 f.p.m.
Single reduction drive, two 700-h.p. D.C. motors equipped with M.G. set consisting of one 1750-h.p. A.C. motor and two 600-KW D.C. generators. Hoist-house equipped with 30-ton crane with 5-ton auxiliary.

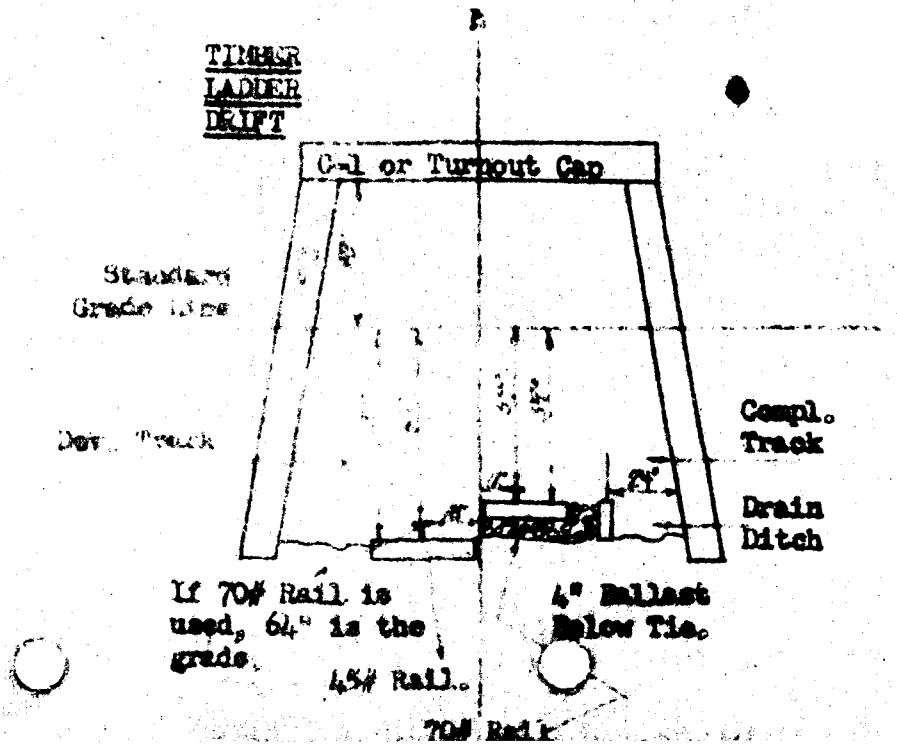
TIMBER HAULAGE DRIFT



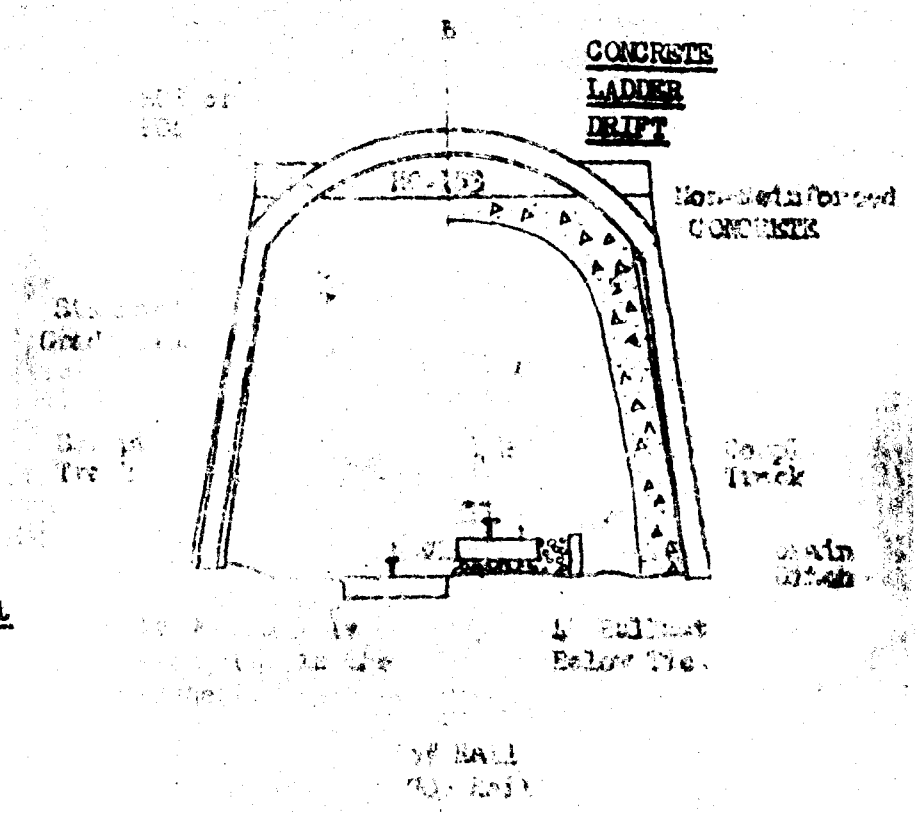
ADVANCE:
0.92 ft. per Man-shift

POSTS: 12"x12"x10'-4"
CAPS: 12"x12"x10'
Sets on 5' Centers
TRACK: 90# Rail, 6x8 Ties on Centers
DITCH: 10" Deep x 24" Wide
EFFICIENCY: Four man crew;
39 holes drilled per set
75 Lbs. Powder used per set

TIMBER LADDER DRIFT

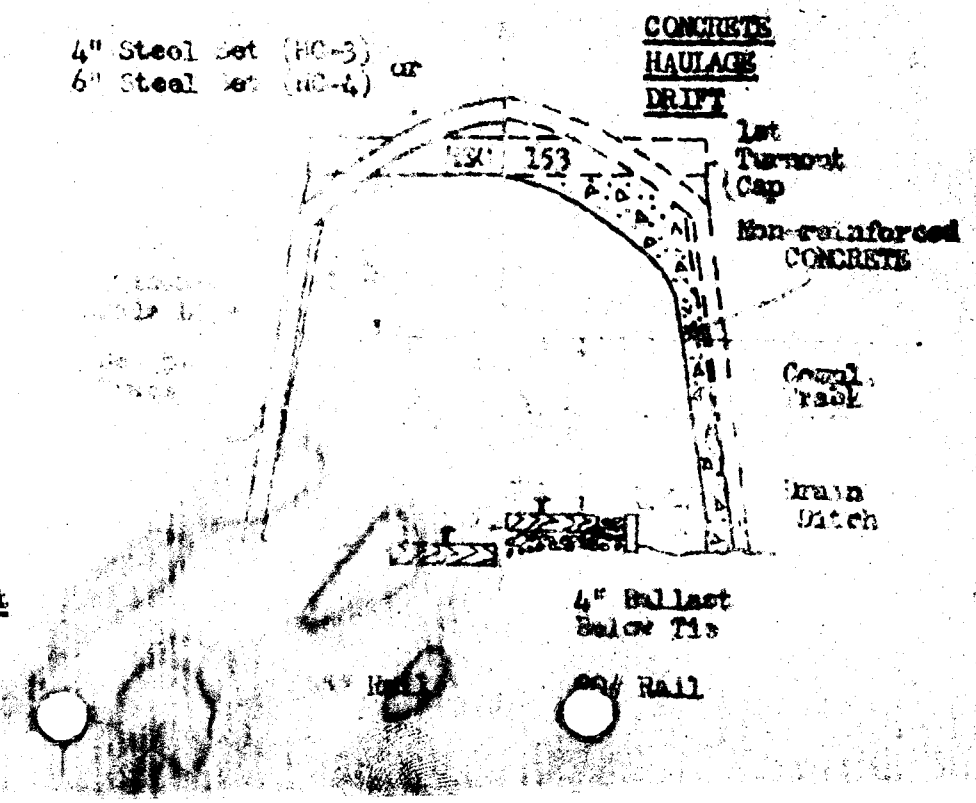


ADVANCE:
0.92 ft. per Man-shift

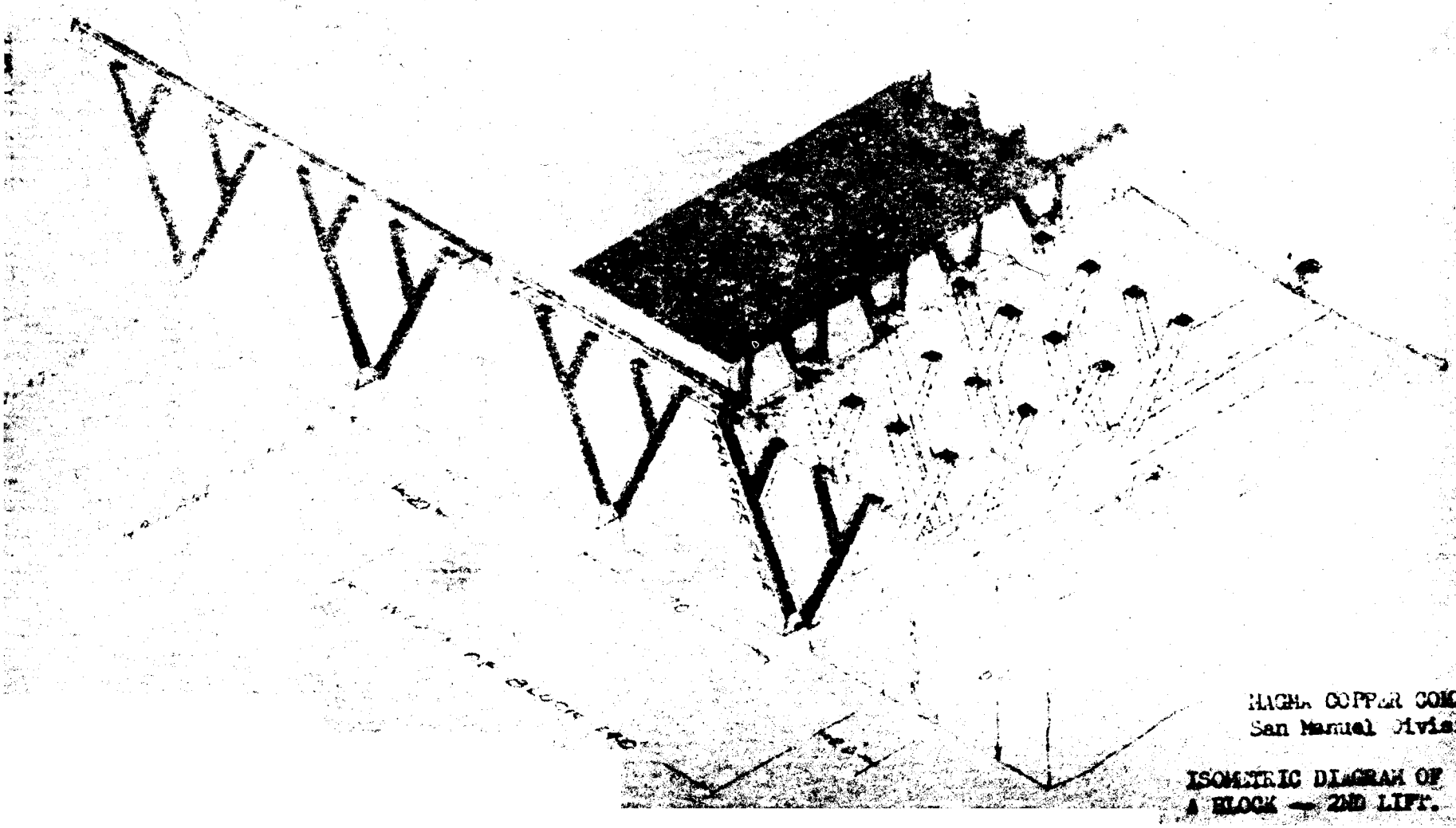


ADVANCE:
0.81 ft. per man shift

4" or 6" H.F.
POSTS: 9'-6"
Arch Caps
Sets on 5' Centers
Trench ditch and
efficiency same as when
using timber.



ADVANCE:
0.86 ft. per man shift



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San Manuel Division

ISOMETRIC DIAGRAM OF
A BLOCK — 2ND LIFT.

BLOCK DEVELOPMENT

GRAVITY FLOW TRANSFER RAISE

2075

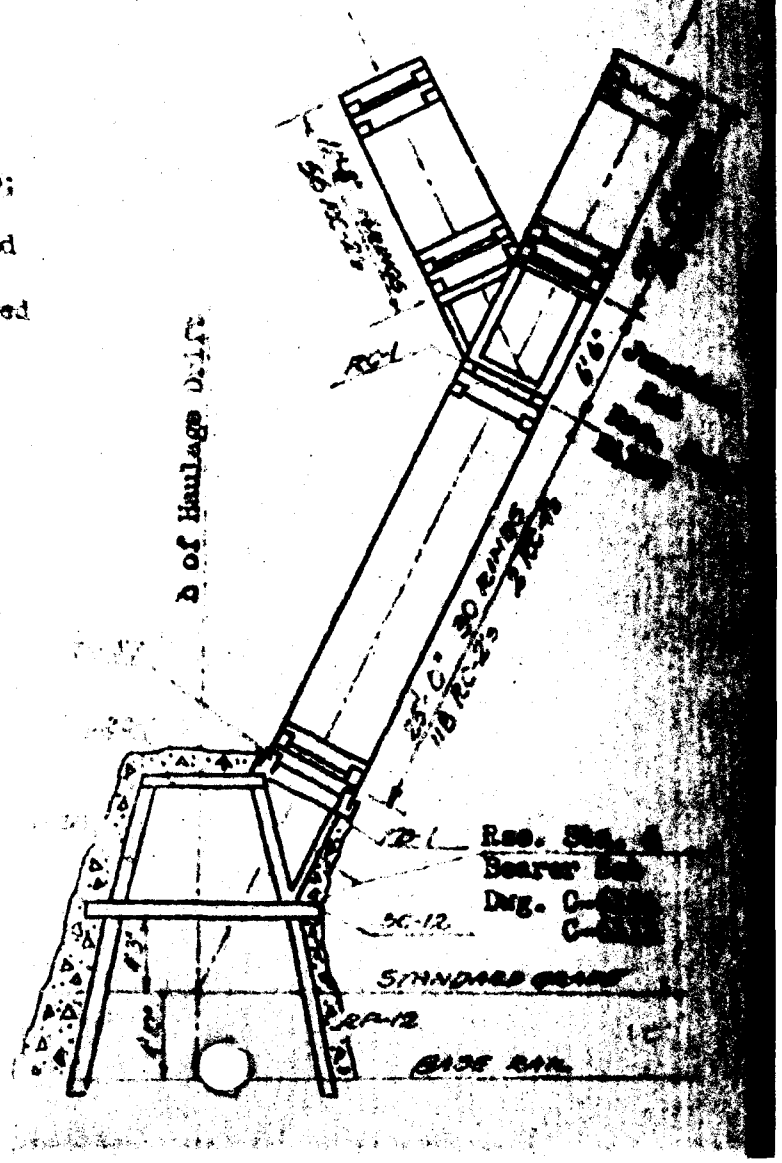
18'-9" to ℄ of Panel Drift

Base Rail

4' 8"

4' x 4' inside.
LINING: 6" x 8" cribbing, armored with 3" x 4" x 1/4" steel angles.
INCLINATION: 63°
LENGTH: 48'
EFFICIENCY: 2-man crews advance two raises at once; 14 holes drilled 5' deep; 30 lbs. 45% [illegible] powder used per round, detonated with electricity only; Ventilated with compressed air.
ADVANCE: 5' per man-shift.

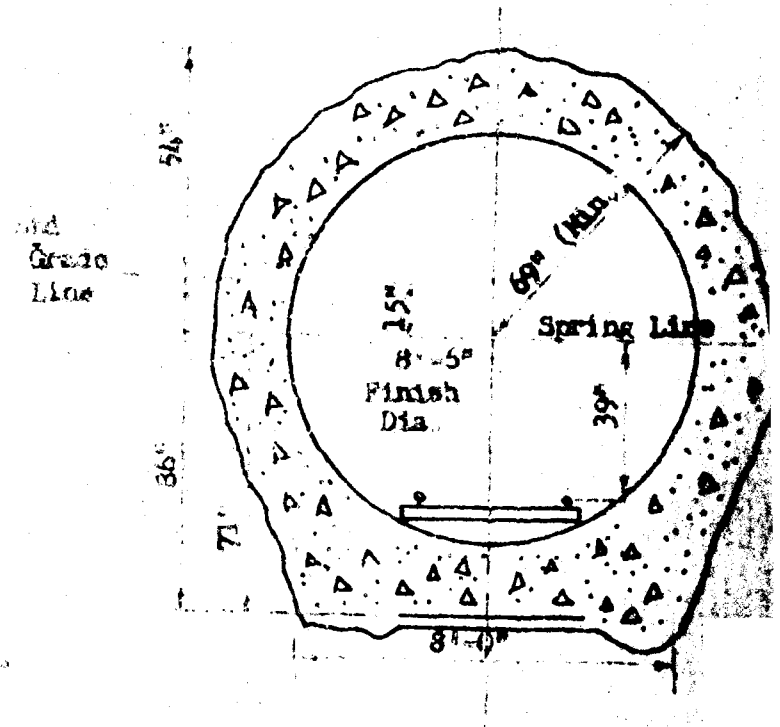
Transfer Raise Stations are cut by the regular drift crew using the same equipment they use to drive the drift. They are cut as the drift heading is advanced.
Raise stations are steel pony sets on top of special drift sets. Lined with non-reinforced concrete.



Excavation only:
Rock Bolts and steel straps used as pre-concrete support.
SIZE: 11'-6" x 11'-6".
Each round marked on face by boss.
Two man crews.
29 holes drilled 6' deep.
60 lbs. E.G. powder used per round; drilling done with two 3" drifters on hydraulic boom arms; ventilation with fans and tubing.

ADVANCE: 1.45 feet per Man-shift.

Finished drift 8'-6" in diameter with non-reinforced concrete lining.



1415 or 2015 Panel Drift

CONCRETE

Cement, sand, and aggregate are dry batched at a 300-ton surface batch plant.

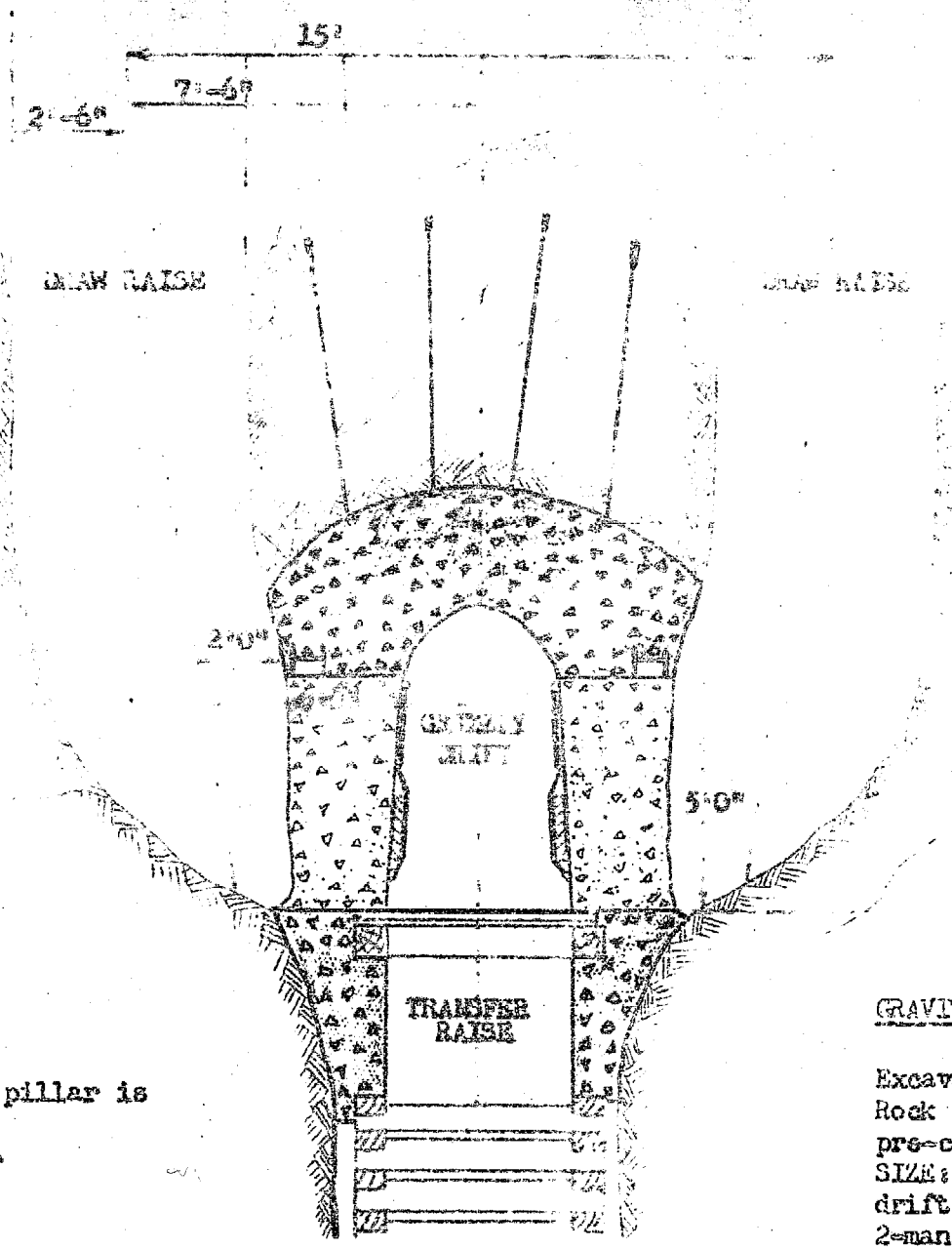
Concrete dry batch is hauled in four 1¼-cubic yard batches per truck to the mixers.

Mixers are 1¼-cubic yard double drum, track mounted, paving type.

Mix water is chilled to 38-40° by portable refrigeration plants.

Air entraining, dispersing, and retarding agents are added with the mix water. Mixer discharges through a screened hopper into two 8" heavy-duty pipes suspended in No. 1 Shaft. Concrete discharges through a discharge header into a remixer on the Grizzly Level, which fills 1¼-cubic yard Flocrete portable placers. Placers discharge pneumatically through a Flocrete header and 6" slick line into plywood or steel forms.

From 3,000 to 4,500 cubic yards of concrete per month are poured on a one shift per day, six day week basis. Forming is done on two shifts, six days per week.



GRAVITY FLOW DRAW RAISE

SIZE: 4' Minimum width.
Top widened to 8' when pillar is blasted.

LENGTH: 15'-0" above grizzly.

No lining is used.

EFFICIENCY: 2-man crew drives several raises at once. 9 to 13 holes drilled 6' deep. 20 lbs. N.G. powder used per round.

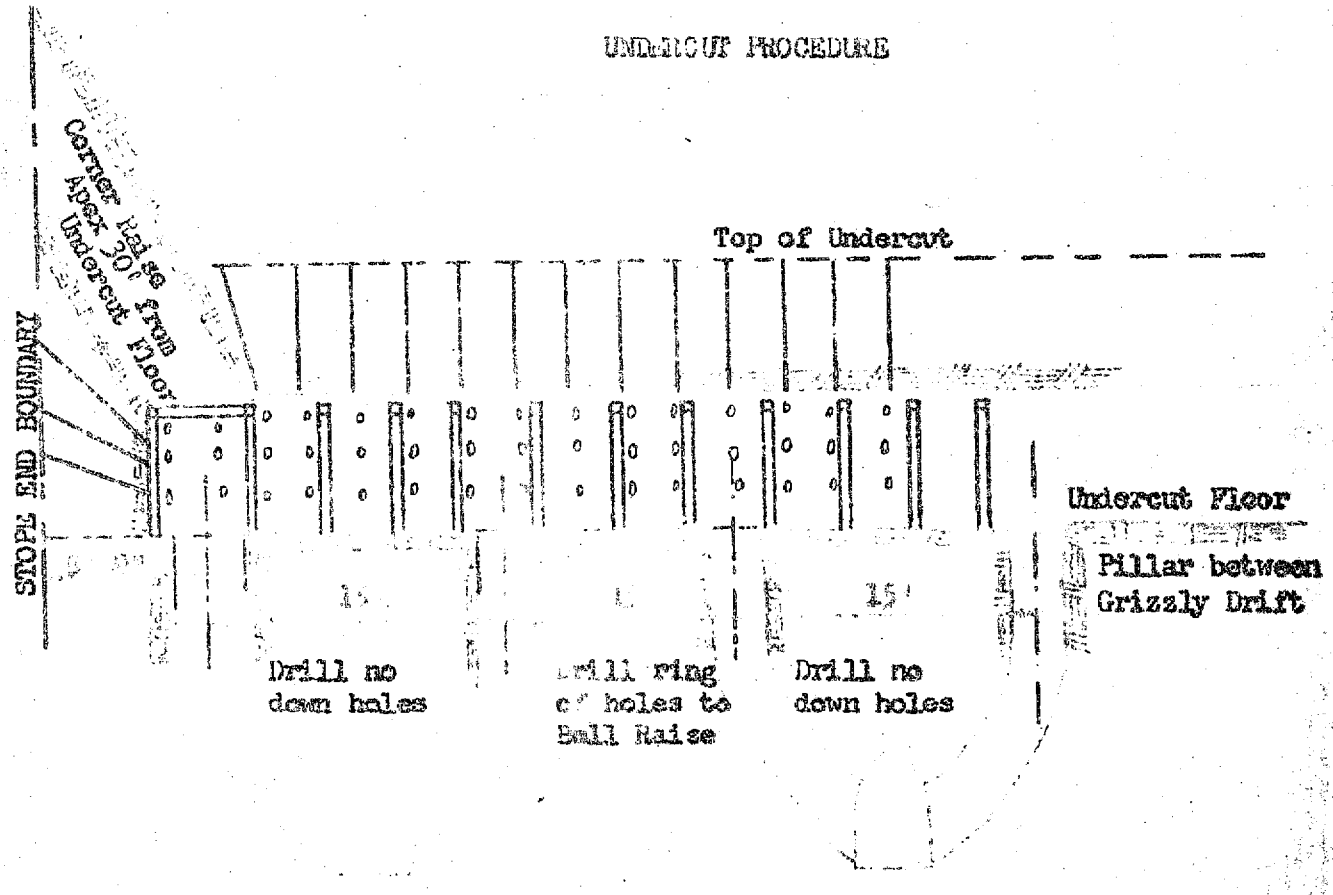
ADVANCE: 11' per Man-shift.

GRAVITY FLOW GRIZZLY DRIFT

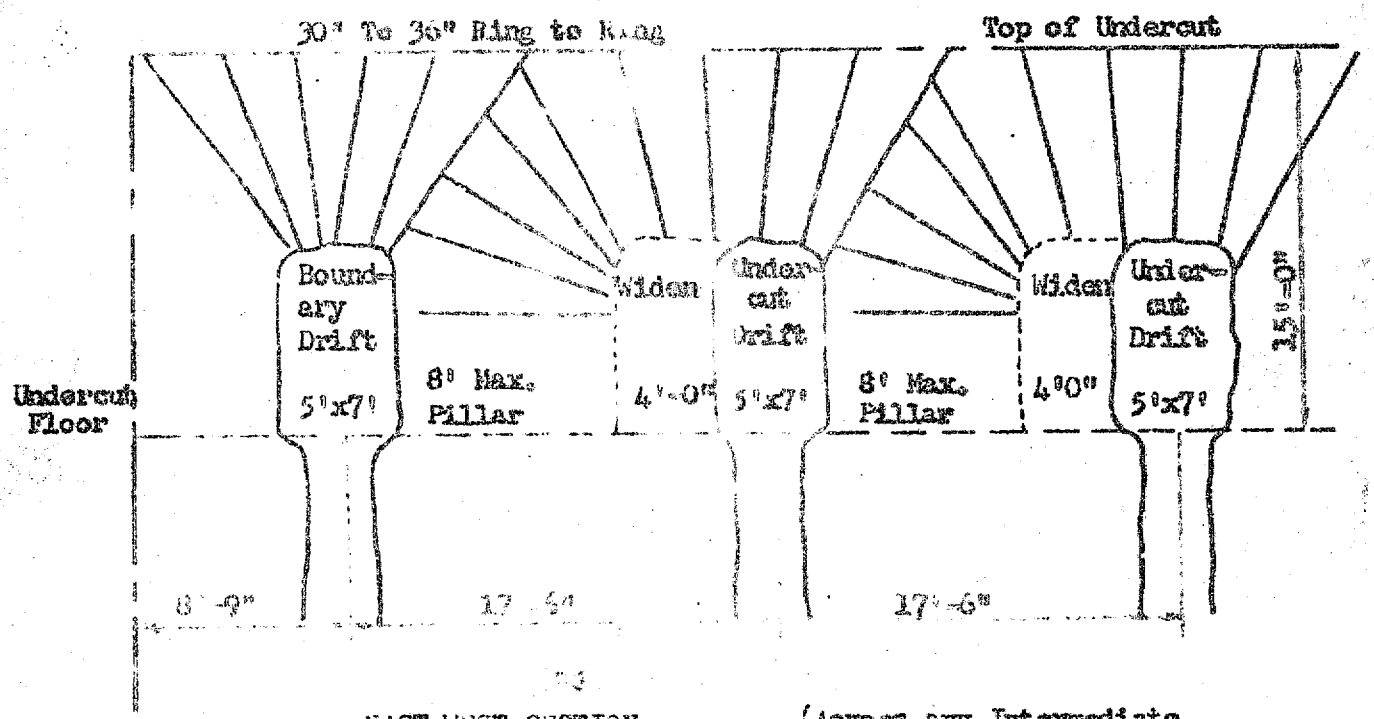
Excavation only; 8' x 8'.
Rock bolts and wire mesh used for pre-concrete support.
SIZE: 4' wide, 6½' high. Finished drift with non-reinforced concrete.
2-man crews used. 13 to 21 holes drilled 6' deep. 30 to 40 lbs. N.G. powder used per round; drilling is done with jackleg. Ventilation with air mover and tubing.

ADVANCE: 2.52 ft. per Man-shift.

UNDERCUT PROCEDURE



NORTH-SOUTH SECTION (Alongside Boundary)



EAST-WEST SECTION (Across any Intermediate Line of Draw Raise)

UNDERCUT PROCEDURE

Undercut drifts are driven 5 x 7' and are timbered only as necessary with unframed 6-inch round posts and 6" x 8" caps or pole stulls. The initial drifting is along the tops of the outer row of draw raises, completely circling the block. In the final stage of undercut drifting, parallel drifts are driven on 17½' centers, conforming with the draw raise spacing, across the tops of the draw raises. The undercut crew bells the top of each draw raise to a diameter of 8 feet as it is crossed.

Undercut pillar crews start the cave by drilling and blasting out a pillar between drifts or at a boundary of the block. The pillar crews retreat away from this initial cave, breaking the ground into the caved area. Before each pillar is blasted, the drift is widened on one side about four feet and timbered if necessary. The remaining pillar, about 8 feet wide, and the back of the widened drift, are then drilled out to a height of 15 feet and shot. The timber is drilled with wood augers and shot with the undercut round. Generally, a 15-foot section along the drift length is taken with each blast. Care is taken to insure that the pillar is completely broken by drawing off sufficient broken muck to observe the effect of the blast before the next adjoining pillar is shot. Millisecond delay electric caps are used in pillar blasting, and are wired in series-parallel with not more than 25 primers in any one series. Circuits are tested with a galvanometer before being connected to the power source. All blasting lines go through an interrupter switch and from this switch to the main pillar blasting switch which is a completely independent circuit.

TIMBER:

Round posts and 6" x 8" caps with 6" x 8" stringers or sills over raise tops.

2" x 12" side and back lagging.

Raise tops temporarily covered with 2" lagging.

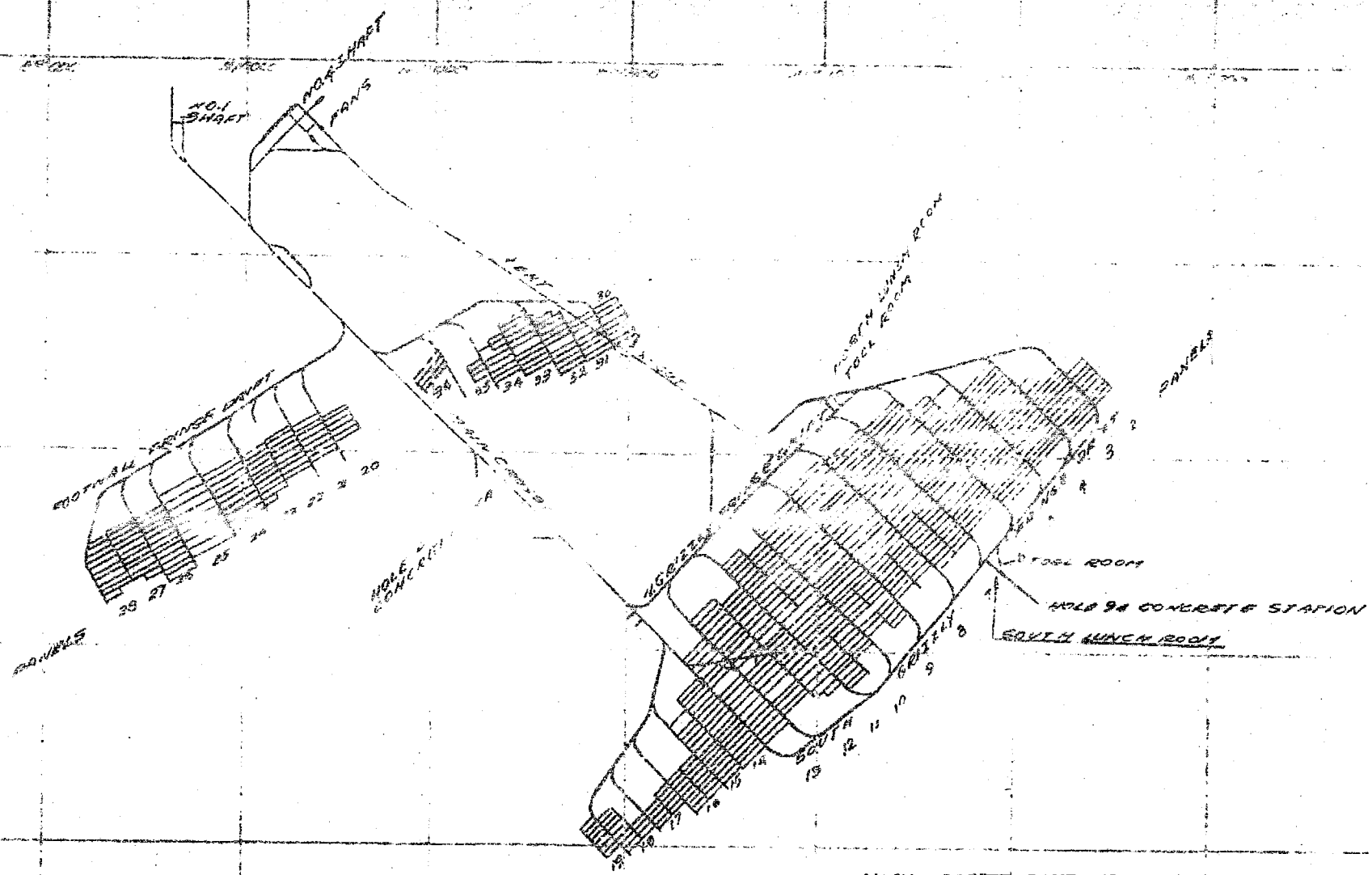
EFFICIENCY:

2-man crews drill 10 to 18 jackleg holes and 20 to 30 stoper holes, depending on draw raise spacing and ground condition.

100 to 175 lbs. 45% N.G. powder is used per pillar.

ADVANCE:

104.96 square feet per man-shift.



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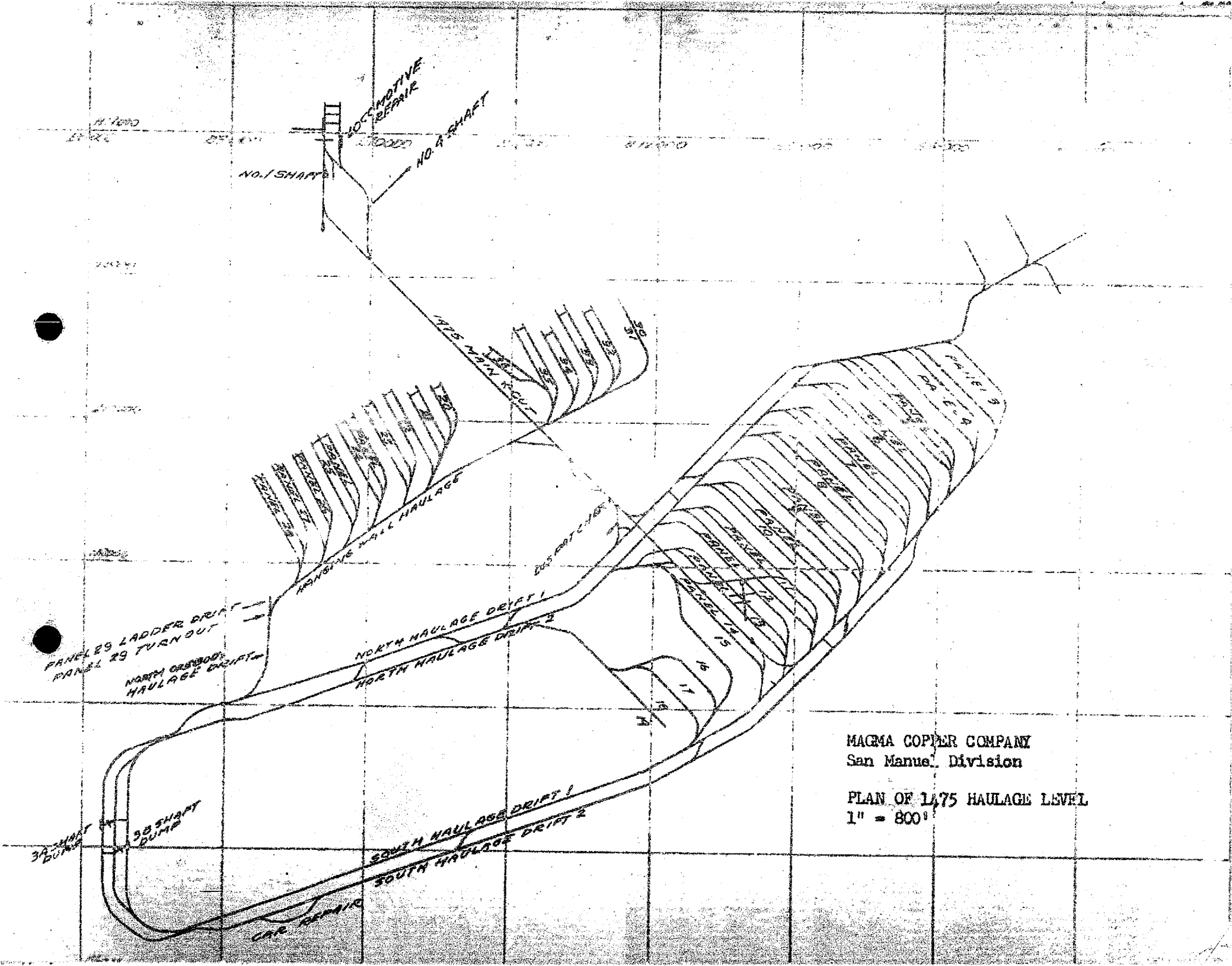
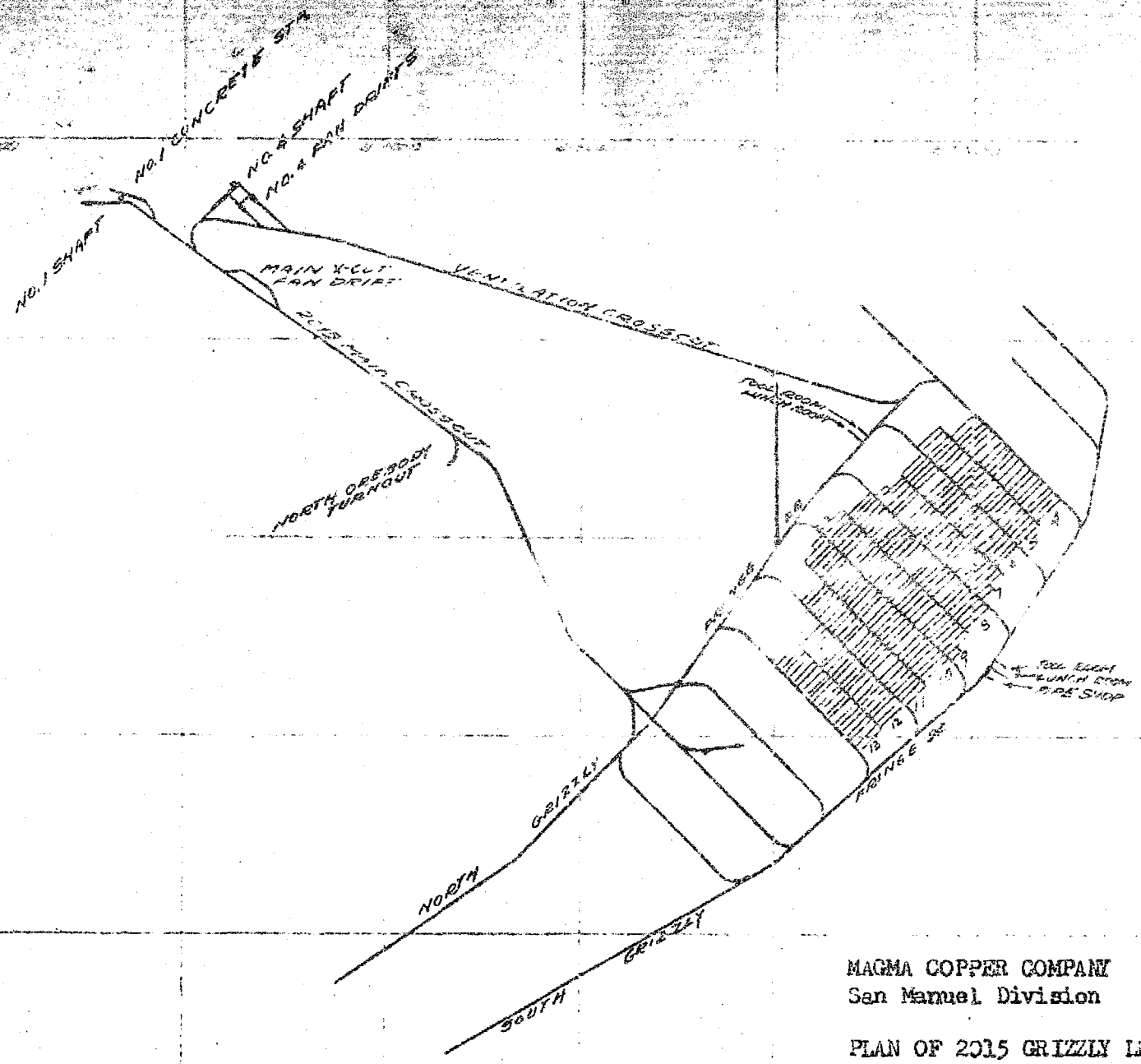
San Manuel Division

PLAN OF 1,415 GRIZZLY LEVEL
1" = 600'



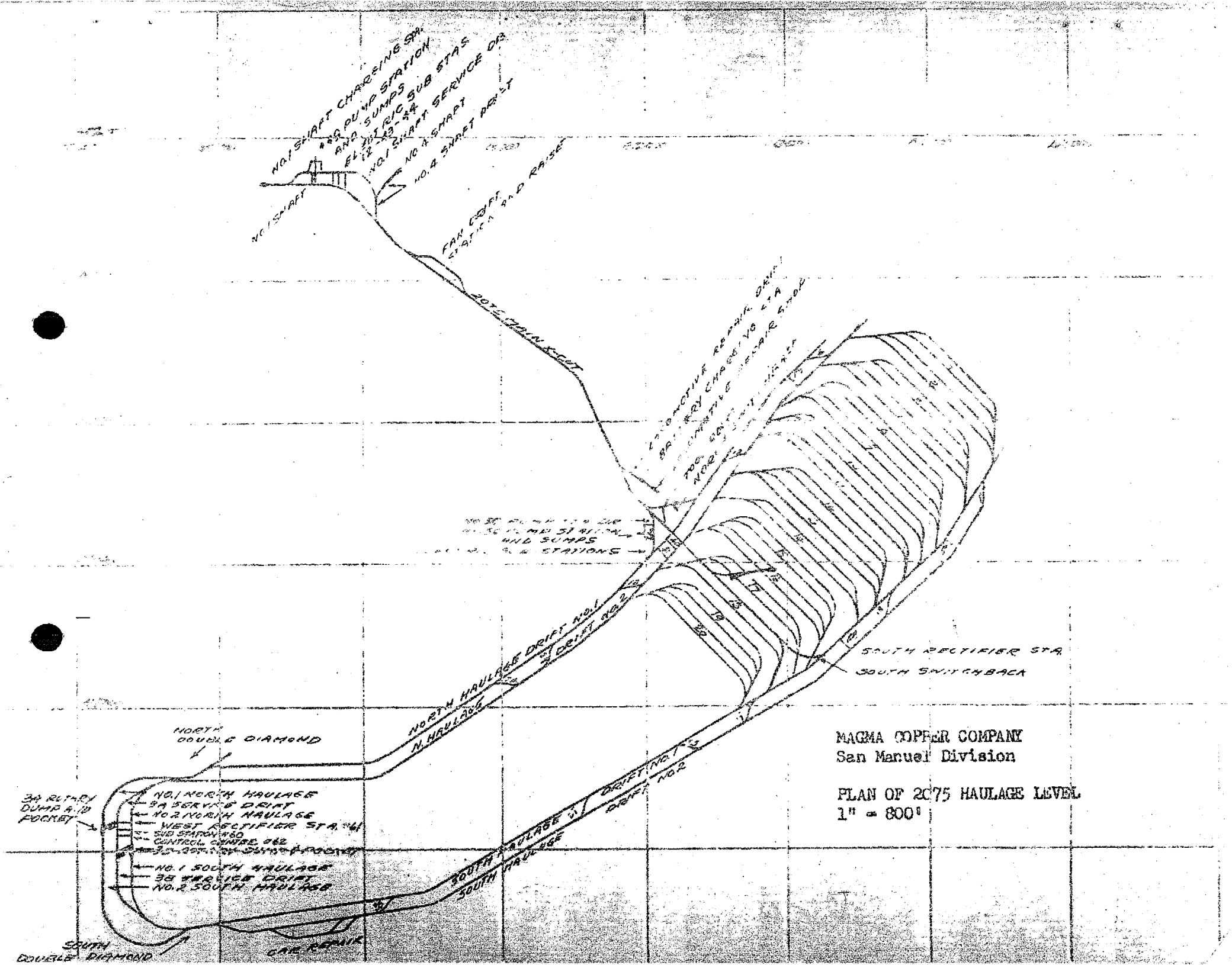
MAGMA COPPER COMPANY
San Manuel Division

PLAN OF 1475 HAULAGE LEVEL
1" = 800'



MAGMA COPPER COMPANY
San Manuel Division

PLAN OF 2015 GRIZZLY LEVEL
1' = 800'


NO.1 SHAFT CHARGING STA.
NO.2 PUMP STATION
AND SUMPS
ELEC. SUB STA.
NO.1 SHAFT SERVICE DRIFT
NO.4 SHAFT
NO.4 SHAFT REST
NO.1 SHAFT
FAN DRIFT
STATION AND RAISE
2075 MAIN DRIFT
LOCOMOTIVE REPAIR DRIFT
BATTERY CHARGING STA
LOCOMOTIVE REPAIR SHOP
TOP OF NO.1 SHAFT
NO.2 SHAFT
NO.2 PUMP STATION
AND SUMPS
STATIONS
NORTH HAULAGE DRIFT NO.1
DRIFT NO.2
N. HAULAGE
SOUTH RECTIFIER STA.
SOUTH SWITCHBACK
NORTH DOUBLE DIAMOND
3A RETURN DUMP & LIP POCKET
NO.1 NORTH HAULAGE
3A SERVICE DRIFT
NO.2 NORTH HAULAGE
WEST RECTIFIER STA. #61
SUB STATION #60
CONTROL CENTRE #62
NO.1 SOUTH HAULAGE
3B SERVICE DRIFT
NO.2 SOUTH HAULAGE
SOUTH HAULAGE
DRIFT NO.1
DRIFT NO.2
SOUTH DOUBLE DIAMOND
CAR REPAIR
MAGMA COPPER COMPANY
San Manuel Division
PLAN OF 2075 HAULAGE LEVEL
1" = 800'

GENERAL OPERATING DATA

Operating Shifts per Day	3
Operating Days per Week	7
Operating Days per Year	358
Production per Day, tons	35,000
Production per Year, tons	12,530,000
Active Undercut Area, sq. ft.	343,088
Undercut Reserves, tons	7,273,000
Draw Point Spacing	17.5' East-West x 15' North-South
Draw Points (Average per Month):	
Active	1,175
High-Pack	41
Held for Repair	81
Held for Grade	10
Total Draw Points	1,307
Rate of Draw, Inches per Day	15
Tons of Ore per Pound of Powder	10

Type of Explosive Used:
45% Amogel in dry areas; 40% Gelatin in wet areas.

Blasting for Block Development and secondary blasting is done electrically from one central location. Generally, large drift headings, when dry, are primed with regular blasting caps and safety fuse. All blasting is done at the middle and end of each shift.

Metal Production for 1962:

Pounds of Copper Recovered per Ton of Ore Mined	13.4
Copper, pounds	168,416,024
Molybdenum Sulphide, pounds	4,157,021
Gold, ounces	15,025
Silver, ounces	302,953

BLOCK DIMENSIONAL DATA

Block Width	140' - 300'
Block Length	150' - 240'
Present Average Block	140' x 180'
Ore Height above Undercut Floor	125' - 600'
Distance Undercut Floor to Grizzly Level Floor	15'
Distance Floor Haulage to Floor Grizzly Level	60'
Grizzly Bar Spacing	14"
Grizzly Bar Material	45# Rail

MANPOWER

Mine Working Force Efficiency Rates

Man-shifts per Day
Tons per Man-shift

Based on 35,000 tons of ore production per day.		M.S. per Day	Tons per M.S.	M.S. per Day	Tons per M.S.	M.S. per Day	Tons per M.S.
PRODUCTION:	Drawing Ore	120	292				
	Hauling Ore	126	278				
	Hoisting Ore	18	1944				
	Total Production			264	132		
DEVELOPMENT:	Block	62	566				
	Primary	46	755				
	Total Development			108	324		
GEN'L UNDERGROUND:	Repair	48	733				
	Salvage	10	3423				
	Construction	7	5010				
	Track	15	2394				
	Supply-Service & Misc.	95	372				
	Total Gen'l U'ground			175	201		
MINE ELECTRICAL		84	415				
MINE MECHANICAL		126	278				
MINE SURFACE		76	461				
	Total Elec., Mech., Sfc.			286	122		
	TOTAL MINE					833	42

The above working force is directed by 120 supervisors and an engineering staff of 45 personnel.

UNDERGROUND HAULAGE DATA

Haulage locomotives are 23-ton, 4-wheel trolley type. They haul fifteen 12-ton cars. 250-h.p., 275 volt D.C.

Ore cars are 15-ton box-type with one stationary coupling and one rotating coupling.

Length center to center of coupling: 17'-6"
Width, overall: 6'-0"
Height above track: 5'-6"
Truck: National Malleable Mine Car Truck; 14" cast iron wheels.
Couplers: National Malleable Willison rotary and non-rotary couplers.
Rubber draft gear for coupling shock absorption.

Track gauge = 36".

Dump: Rotary Tipple - dumps three cars at a time.

COMMUNICATIONS

Haulage trains and supply trains are moved on direct orders from a Dispatcher by the use of a radio phone system. In addition, radio phones are installed in repair shops and at vantage points for use by supervision.

Draw and haulage operations are coordinated through the Dispatcher by an audio paging system.

A standard telephone system consisting of seven circuits aids in coordinating hoisting, maintenance, and service facilities between the surface and the mine underground.

VENTILATION

490,000 c.f.m. goes down #4 and #1 Shafts: From Surface.
57,900 c.f.m. - Miscellaneous Intakes in addition to Shafts.
200,000 c.f.m. - 1st Lift (1415 and 1475 Levels)
290,000 c.f.m. - 2nd Lift (2015 and 2075 Levels)

1ST LEVEL - Two Joy Hi-speed Axivane mine fans, 200-h.p., 1160 rpm, 5' diameter. One on the 1415 Vent Crosscut and one on the 1415 Main Crosscut.

2ND LEVEL - Three Joy Hi-speed Axivane mine fans:
One - Main Crosscut, 2075, 200-hp, 1160 rpm, 5' diam.
One - Vent Crosscut, 2015, 450-hp, 1160 rpm, 6' diam.
One - Main Crosscut, 2015, 200-hp, 1160 rpm, 5' diam.

Auxiliary ventilation air is directed through operating blocks by means of ventilation doors and Joy Axivane 20-h.p. large volume, low pressure lo-speed mine fans. Individual working places are ventilated by 20-h.p. hi pressure, hi-speed fans or air movers with tubing.

DRAINAGE

Newly opened areas show an appreciable flow of water which drains quickly. Mine underground was planned so that water drains either to No. 1 Shaft or to 3A and 3B Shafts.

No. 1 Shaft is pumping 2,100 g.p.m., principally from the 2nd Level;
3B Shaft is pumping 900 g.p.m. from 3B Shaft Bottom;
Present pumping is 3,000 g.p.m. Total.

To prevent surface drainage from entering the mine, surface washes leading to the cave area are either diverted or dammed up to hold the water for evaporation.

SURFACE ORE TRANSPORTATION

Cars:	100 tons capacity, 35 to 40 per train.
Locomotive:	125-ton, 1,600 h.p. diesel-electric.
Trackage:	132-lb. rail, 7 mile haul to receiving bin at reduction plant, level track.

COMPRESSOR HOUSE:

Five Chicago-Pneumatic 3,500 c.f.m. compressors, delivering at 100-lb. air pressure, each equipped with 600-h.p., synchronous motor.
One Chicago-Pneumatic 1936 c.f.m. - 350-h.p. synchronous motor.
One Chicago-Pneumatic 1596 c.f.m. - 300-h.p. synchronous motor.
Total = 21,032 c.f.m., delivering at 100 lbs. air pressure.

CHANGE ROOM

Accommodates 1,900 men with lockers, showers, and toilet facilities. Heated with gas space heaters.
In the same building is the Foreman's Office, Time Office, Safety Engineer's Office, Dispensary, and Lamp Room.

NO. 1 AND NO. 4 YARDS

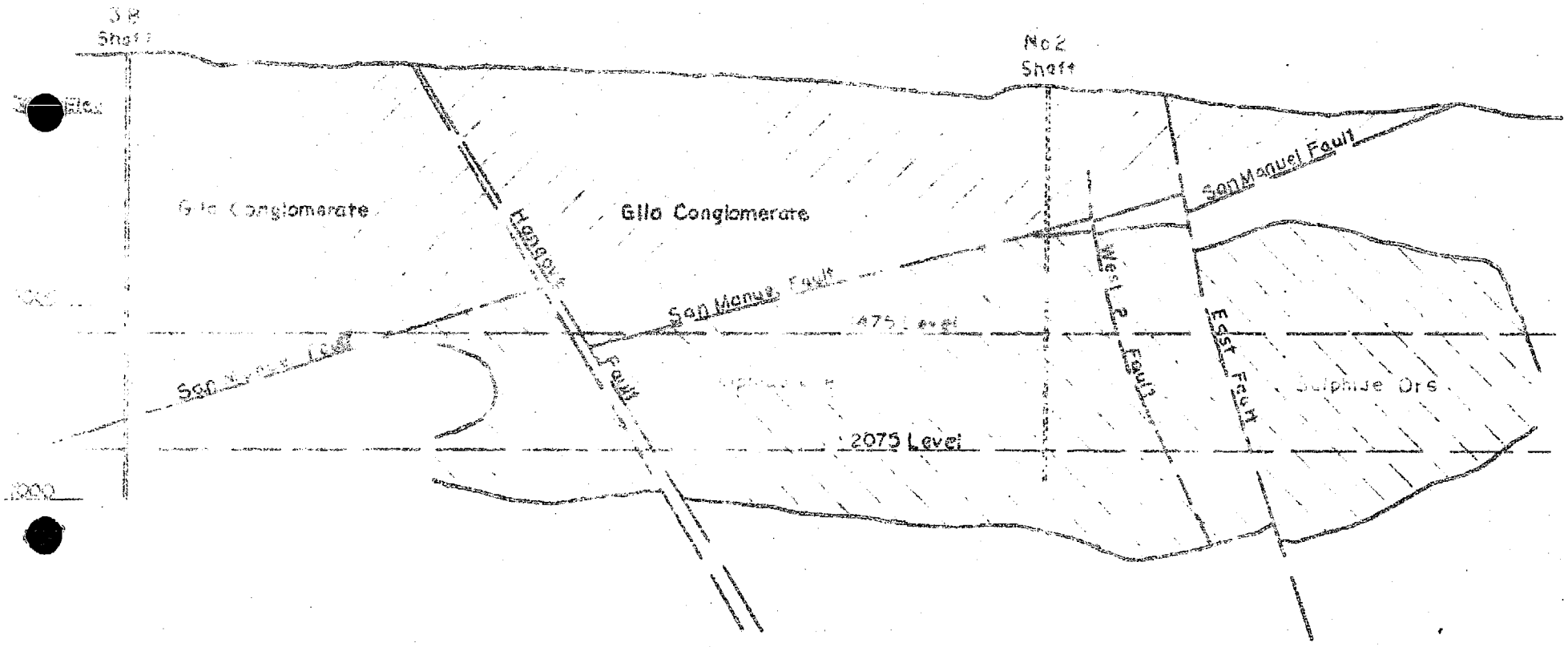
Surface installations in this area include a Machine Shop, Electric Shop, Drill Repair Shop, Blacksmith Shop, Truck Maintenance Shop, Framing Shed, Carpenter Shop, Warehouse facilities, Timber Treating Plant, Salvage area, Pipe Shop, Car Repair Shed, Sand-Blast Shed, Paint Shed, Fire Marshal Shed, Mine Rescue Training Center, and Batch Plant.

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

Steel:	Variety of structural shapes for shop fabrication jobs and mine ground support.
Timber:	12" x 12" drift timber. 2" and 3" lagging, various lengths. 6" x 8" cribbing, preframed. Pole Posts - Texas pine for undercut timber.

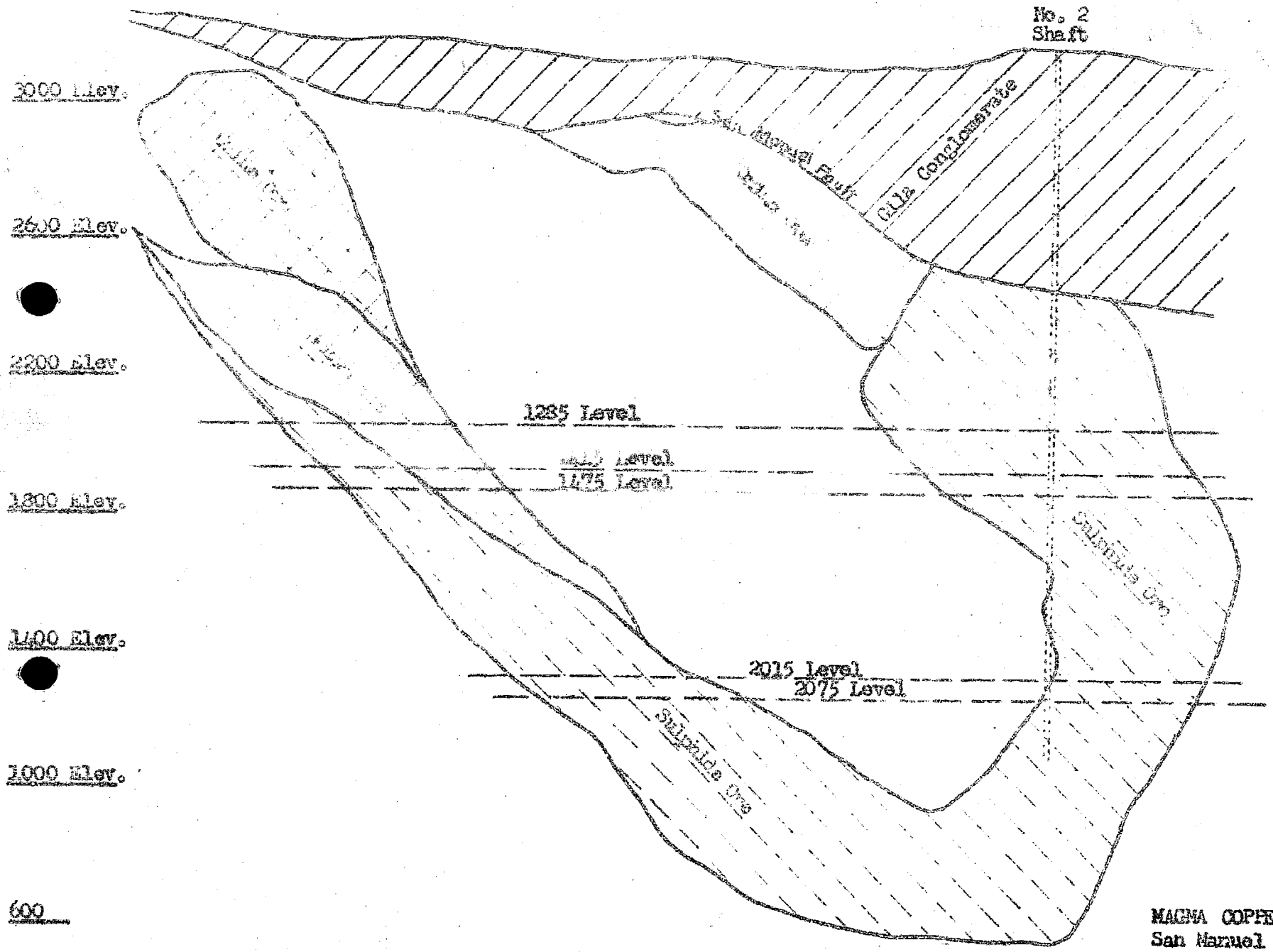
A large explosives magazine is maintained to supply the mining operation.

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



MAGMA COPPER COMPANY
San Manuel Division

LONGITUDINAL SECTION THROUGH NO. 2
AND 3B SHAFTS, LOOKING NORTHWEST.



MAGNA COPPER COMPANY
San Manuel Division

CROSS-SECTION THROUGH
OREBODY N46°W
LOOKING NORTHEAST