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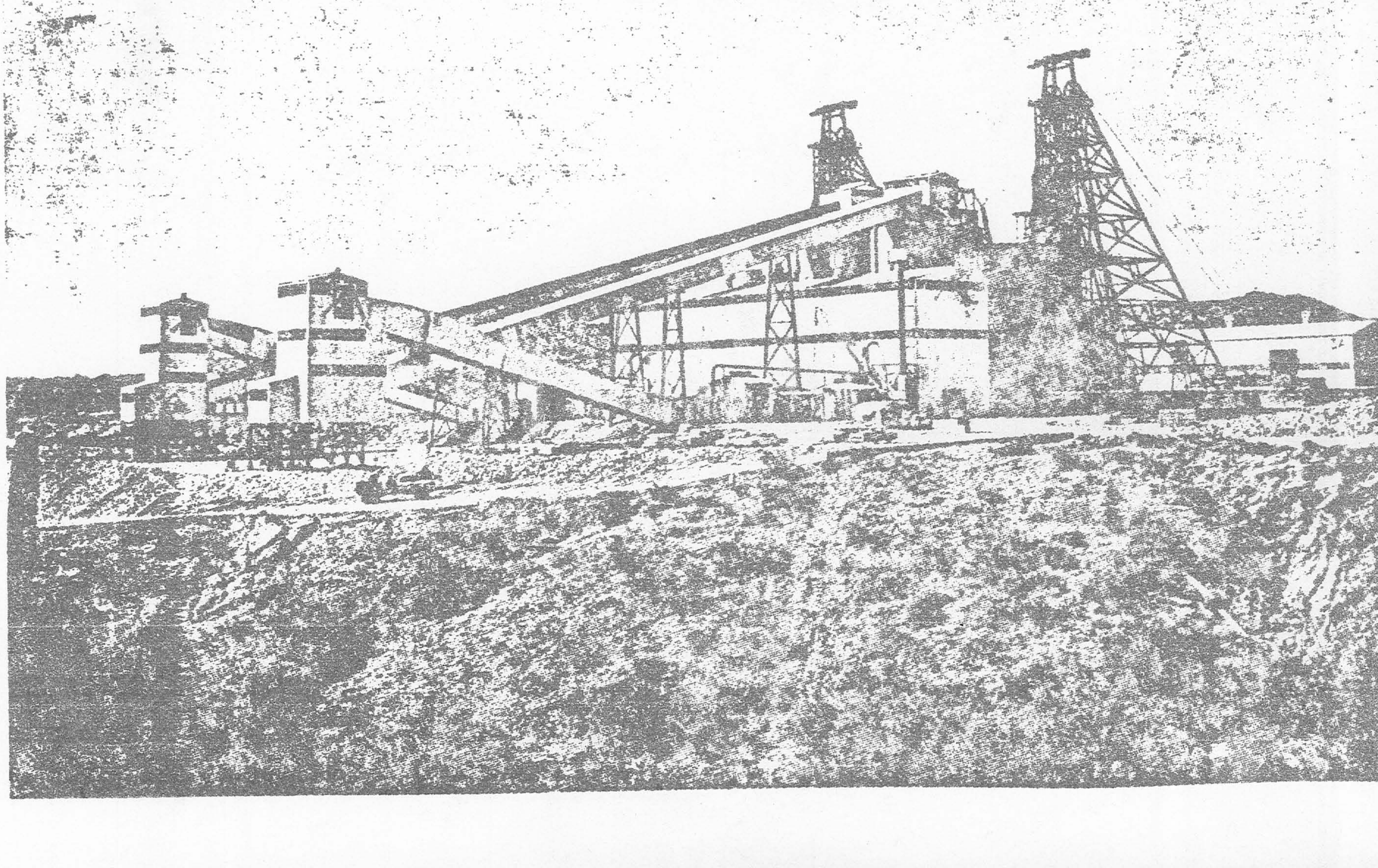
GENERAL INFORMATION BOOKLET -- APRIL, 1968

MAGMA COPPER COMPANY
SAN MANUEL DIVISION



MAGMA COPPER COMPANY
San Manuel Division
San Manuel, Arizona

April, 1968

ORE BODY

Disseminated mineralization in monzonite porphyry and quartz monzonite.

Principal Sulphide Minerals: Chalcopyrite, Chalcocite, Pyrite, and Molybdenite. The grade of the ore is less then 1%.

Overburden: 0 to 1900 feet thick. Average over the Southeast (Main) Ore Body is 670 feet thick, and consists mainly of a very competent rock called Gila Conglomerate.

(The last two pages of this pamphlet show sections of the ore body.)

PRIMARY DEVELOPMENT

NO. 1 SHAFT

Depth: 2,262 feet. (For the Second Lift.)
(Sinking to a depth of 3,170 feet is in progress.)

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 hoist, 5'-0" (Below 1475)

Ventilation Downcast.

Structural Steel Sets and Reinforced Concrete.

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

Skips: 4-ton capacity in counter-balance, 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 Size = 1".
Rope Speed = 545 fpm.

No. 1 Shaft -- cont'd

This shaft is used to hoist waste muck 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 transportation of concrete. This is the development shaft, and it will be sunk to provide initial access to future levels.

NO. 3A-3B SHAFTS

Twin Ore Hoisting Shafts, 195 feet apart.

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

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

Ventilation Exhaust Shafts.

Structural Steel Sets poured 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 service compartment supported every 6'-0".

Headframe: 181' to b 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 steel skips with alloy steel liners, running on solid rubber tires.
Capacity: 22 tons with + 4.5% 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 face drums with 3,700 feet of 2¼" rope capacity in two layers.
Drum Shaft: 27" diameter through drums.
Hoisting Speed: 2,800 fpm.
Two 3,000-hp D.C. motors equipped with M.G. set consisting of one 4,000-hp motor and two 2,500-KW D.C. generators. Steel plate flywheel, 44 tons (approximate) for 80% power peak equalization.

Service hoists are equipped with an 8-passenger cage and 45 cubic feet 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.

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 operation is monitored from control panels at each crusher location.

NO. 4 SHAFT

Depth: 2,158 feet. (For the Second Lift.)

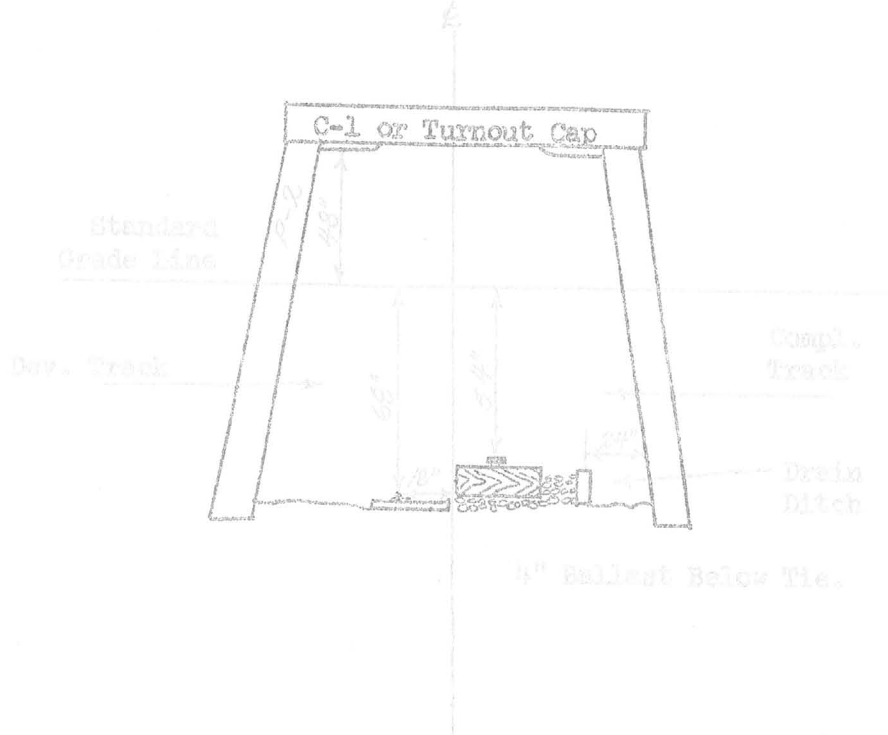
Dimensions: 26'-6" x 14'. Structural steel sets poured in concrete for smooth lining.

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.

No. 4 Shaft -- cont'd

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 feet 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 D.C. motors equipped with M.G. set consisting of one 1750-hp A.C. motor and two 600-KW D.C. generators. Hoisthouse equipped with 30-ton crane with 5-ton auxiliary.



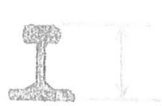
POSTS: 12" x 12" x 10'-4"
CAPS: 12" x 12" x 10'
Sets on 5' Centers.

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

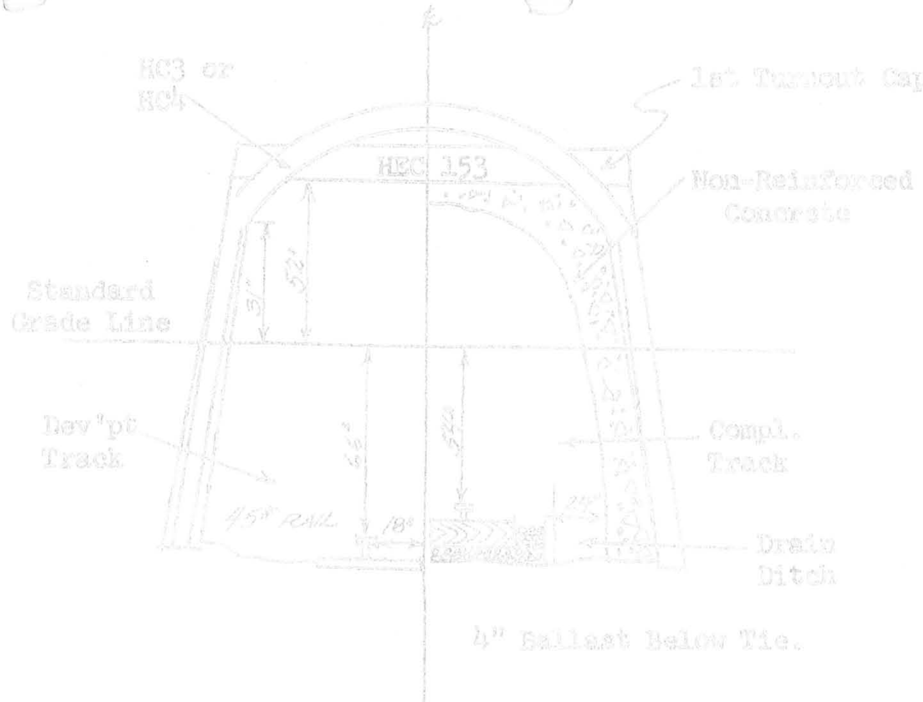
TIMBER HAULAGE DRIFT - 45# Rail for Development
90# Rail Finished Track

TIMBER LADDER DRIFT - If 70# Rail is used, 64" is the grade.
45# Rail for Development.
70# Rail Finished Track.

RAIL MEASUREMENTS



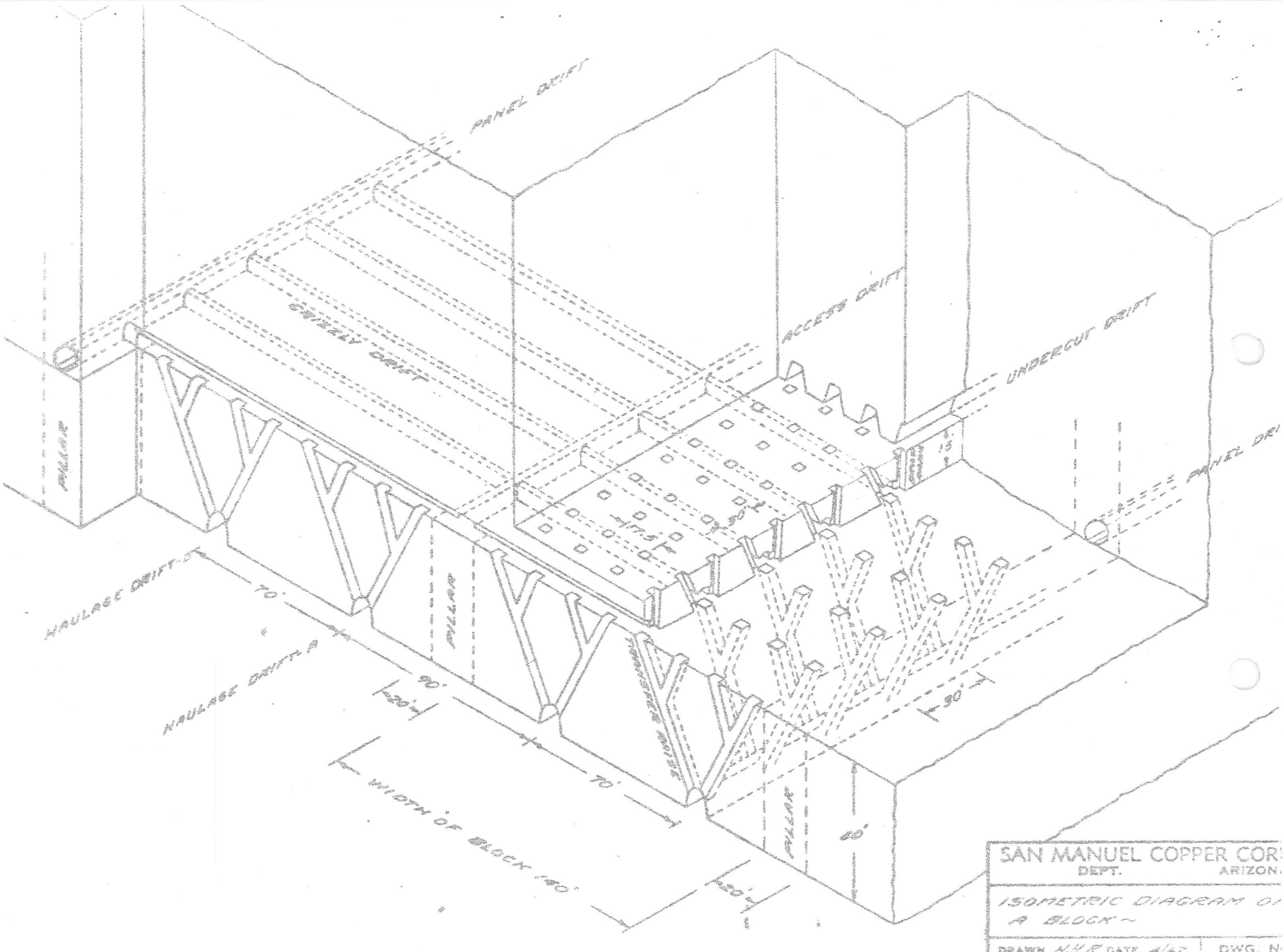
3-3/4" for 45# Rail.
4-5/8" for 70# Rail.
5-5/8" for 90# Rail.



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.



SAN MANUEL COPPER COR DEPT. ARIZON		
ISOMETRIC DIAGRAM O A BLOCK ~		
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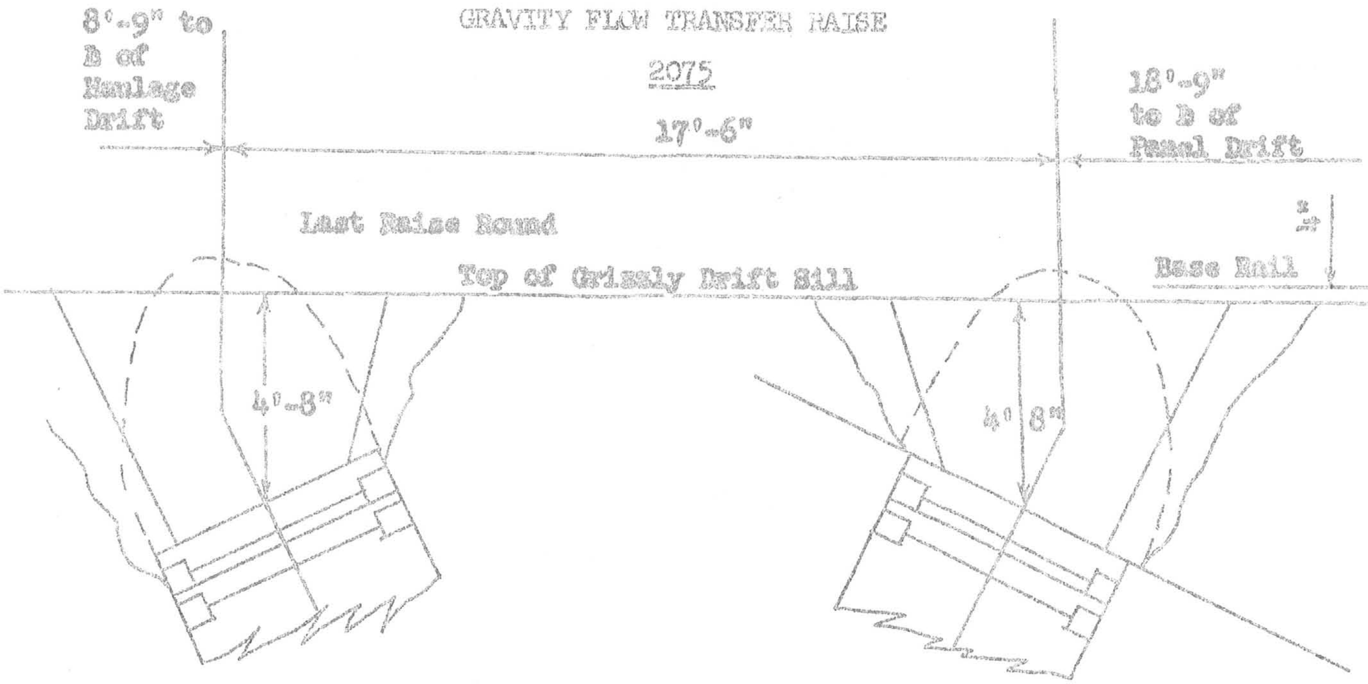
APPD.	SCALE 1"=50'	ACCT.

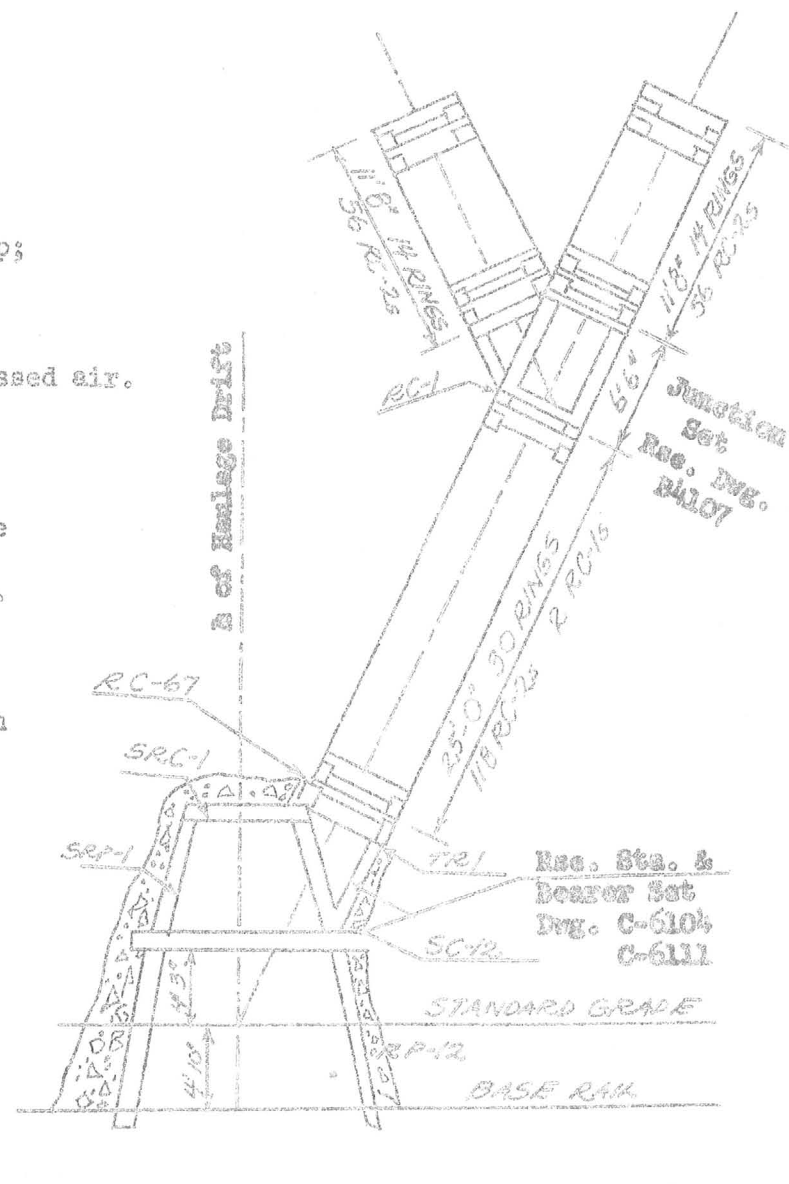
GRAVITY FLOW TRANSFER RAISE

2075



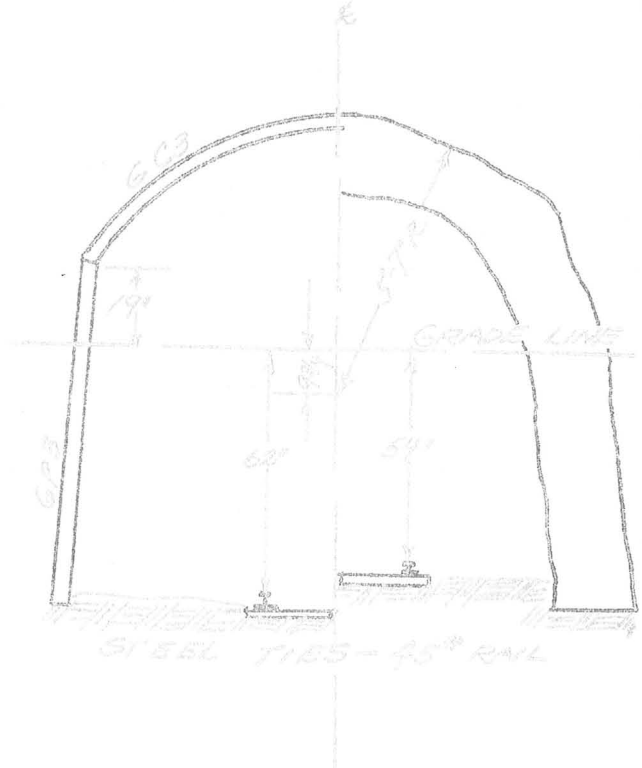
4' x 4' inside.
LINING: 6" x 8" cribbing, armored with 3" x 4" x 1/4" steel angles and "T"-irons.
INCLINATION: 63°
LENGTH: 48'
CREWS: 2-man crews advance two raises at once, using 3" stopers. 14 holes drilled 5' deep; 35 lbs. 60% Amogel used per round, detonated with electric caps. Ventilation with compressed 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.



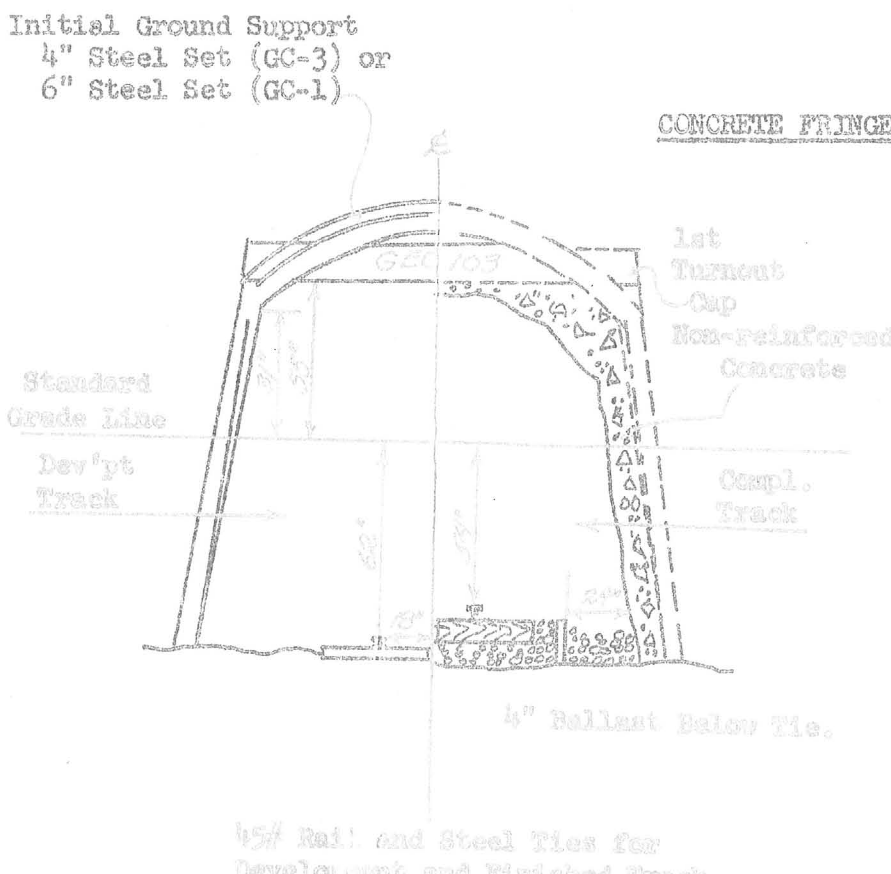
Excavation only:
Rock Bolts and Steel Straps
GC-3, GP-3
are used as pre-concrete support.
SIZE: 10'-3" x 9'-1"
Each round marked on face by boss.

Two-man crews or 3 men in two headings.
29 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.

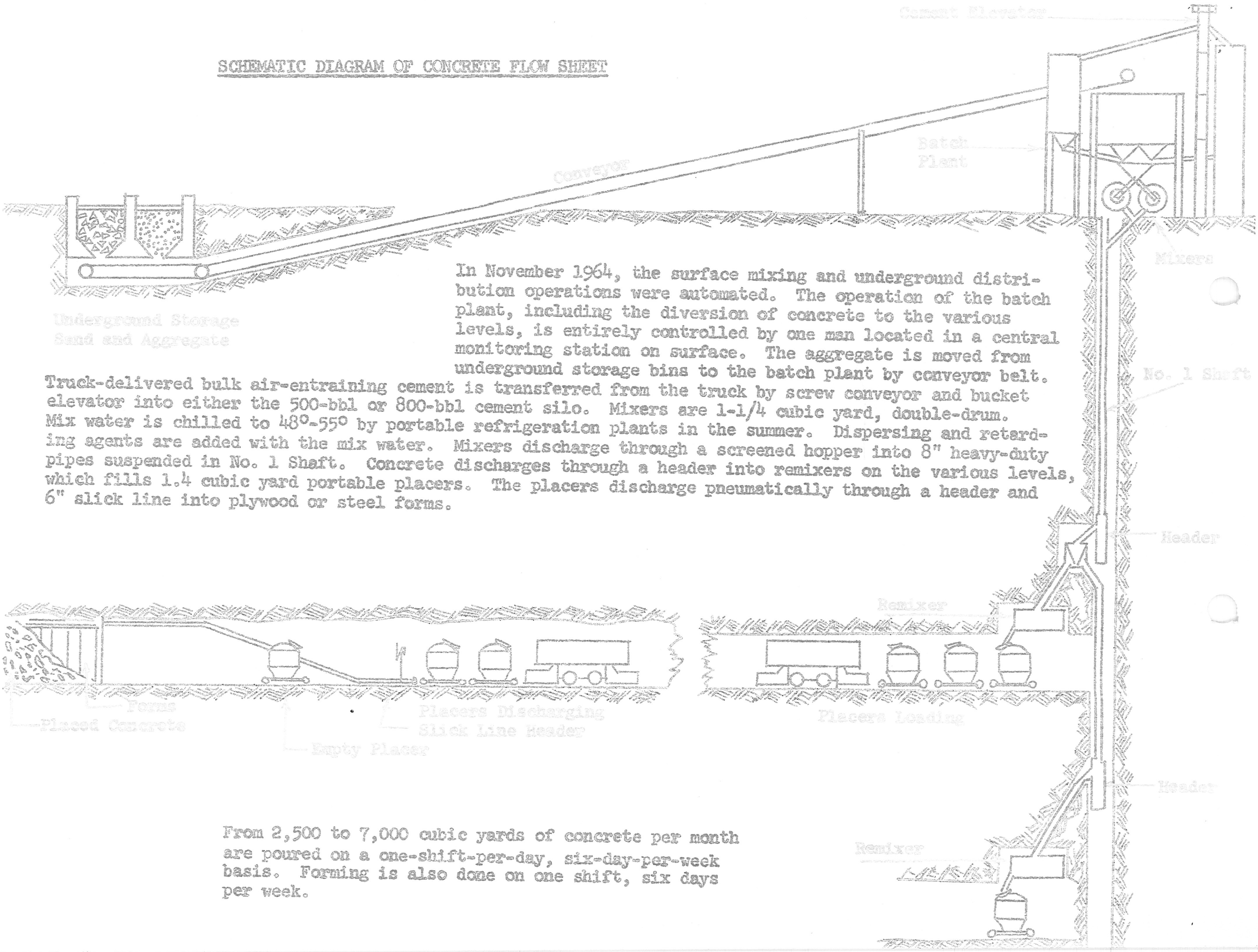


CONCRETE PANEL DRIFT

CONCRETE FRINGE DRIFT

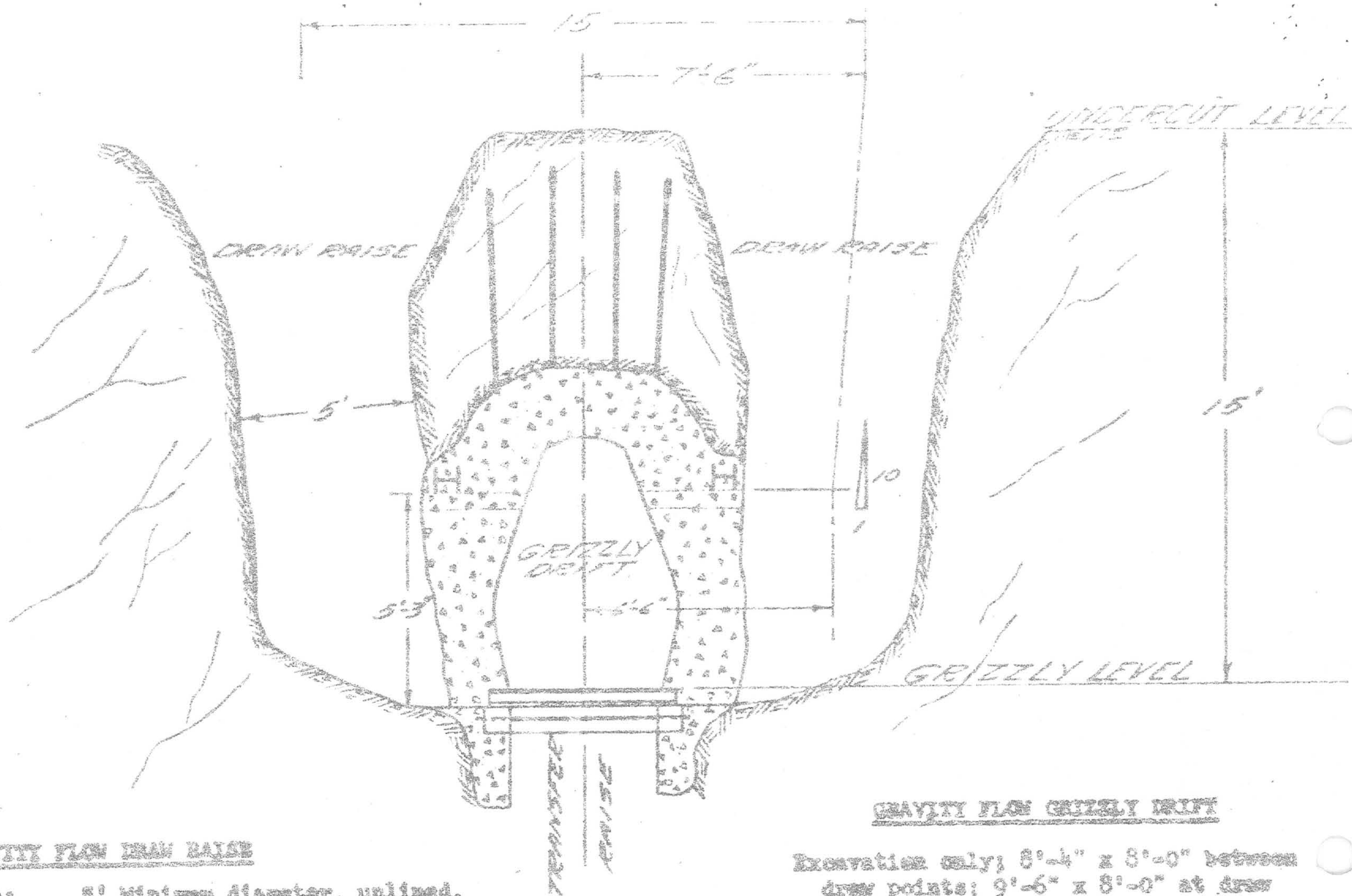


SCHEMATIC DIAGRAM OF CONCRETE FLOW SHEET



In November 1964, the surface mixing and underground distribution operations were automated. The operation of the batch plant, including the diversion of 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 screw conveyor and bucket elevator into either the 500-bbl or 800-bbl cement silo. Mixers are 1-1/4 cubic yard, double-drum. 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 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 fills 1.4 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 one-shift-per-day, six-day-per-week basis. Forming is also done on one shift, six 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 a stick of 60% Amogel. Electrically blasted.

GRAVITY FLOW GRIZZLY DRIFT

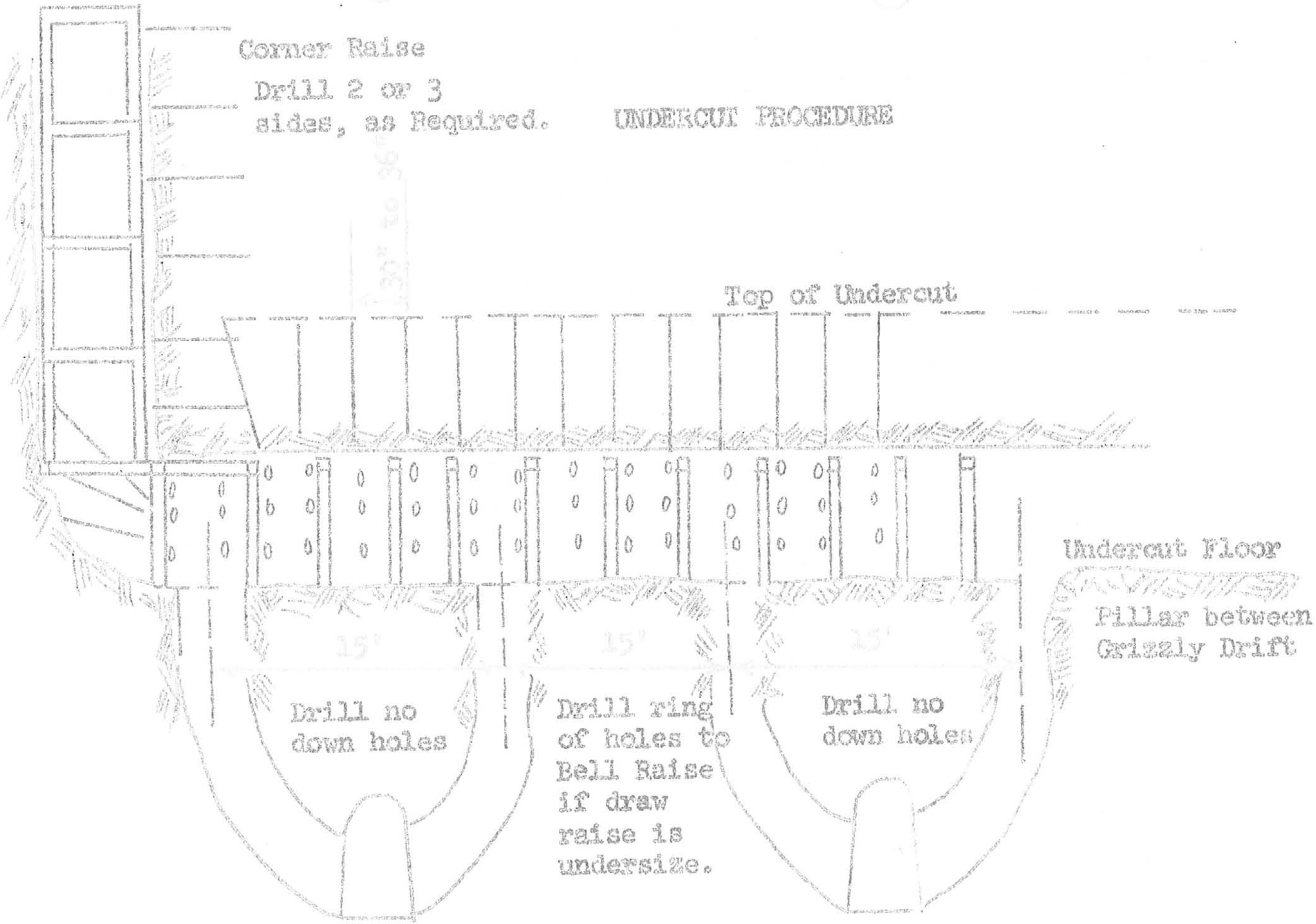
Excavation only; 8'-4" x 8'-0" between draw points; 9'-6" x 8'-0" at draw points.

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

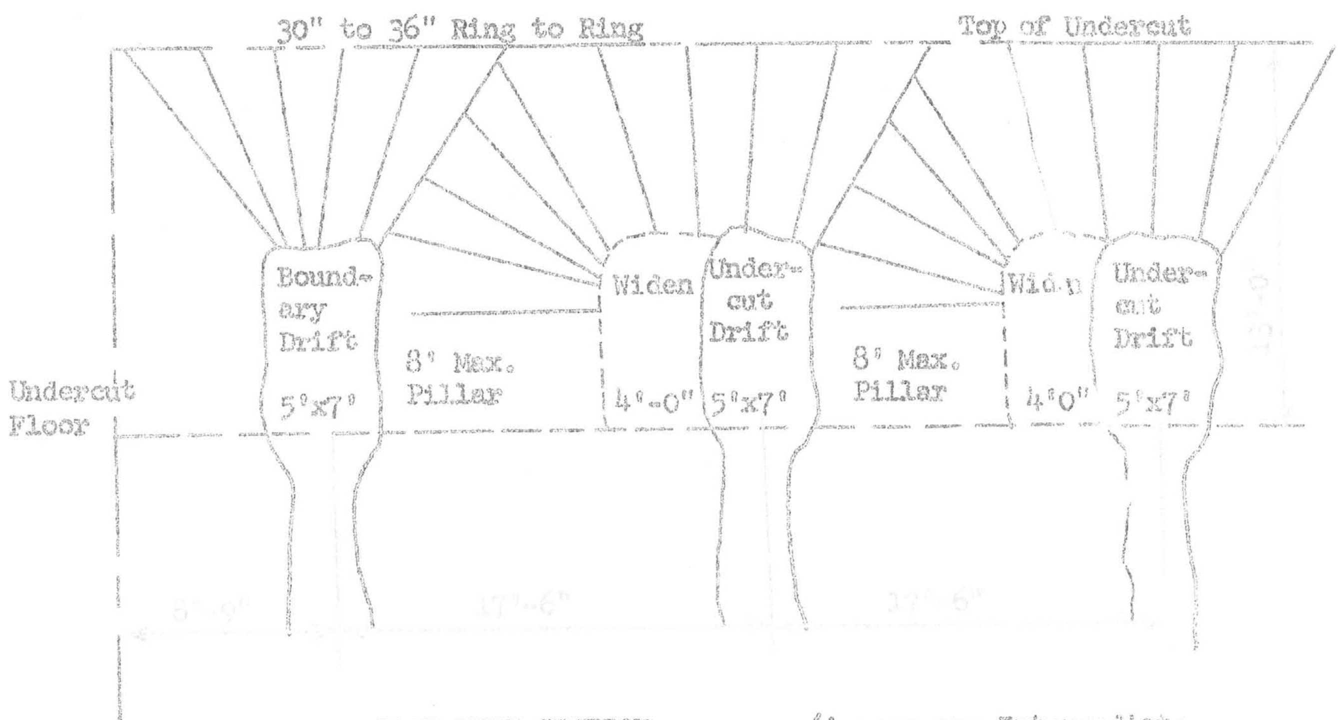
Size: 5' wide, 8-3/4' high finished drift with concrete reinforced at the draw points only.

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 Raise)

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 feet above the grizzly drift floor. They are driven 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 tops of 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 is started 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 feet and timbered if necessary. The remaining pillar, about eight feet thick, is drilled through, and the back of the widened drift is then drilled out to a height of 13 feet 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-foot 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.

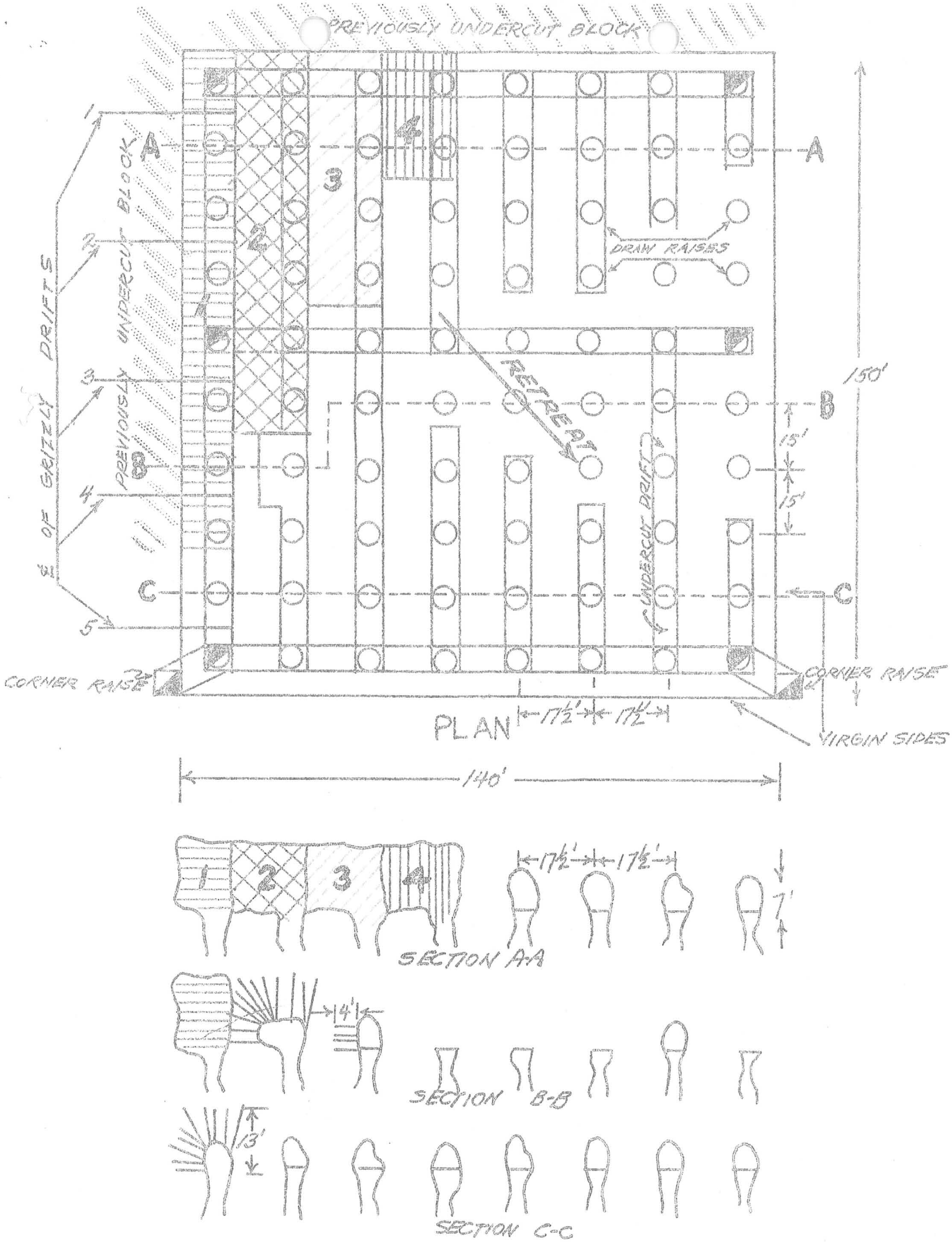
TIMBER:

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, depending on draw raise spacing and ground condition.

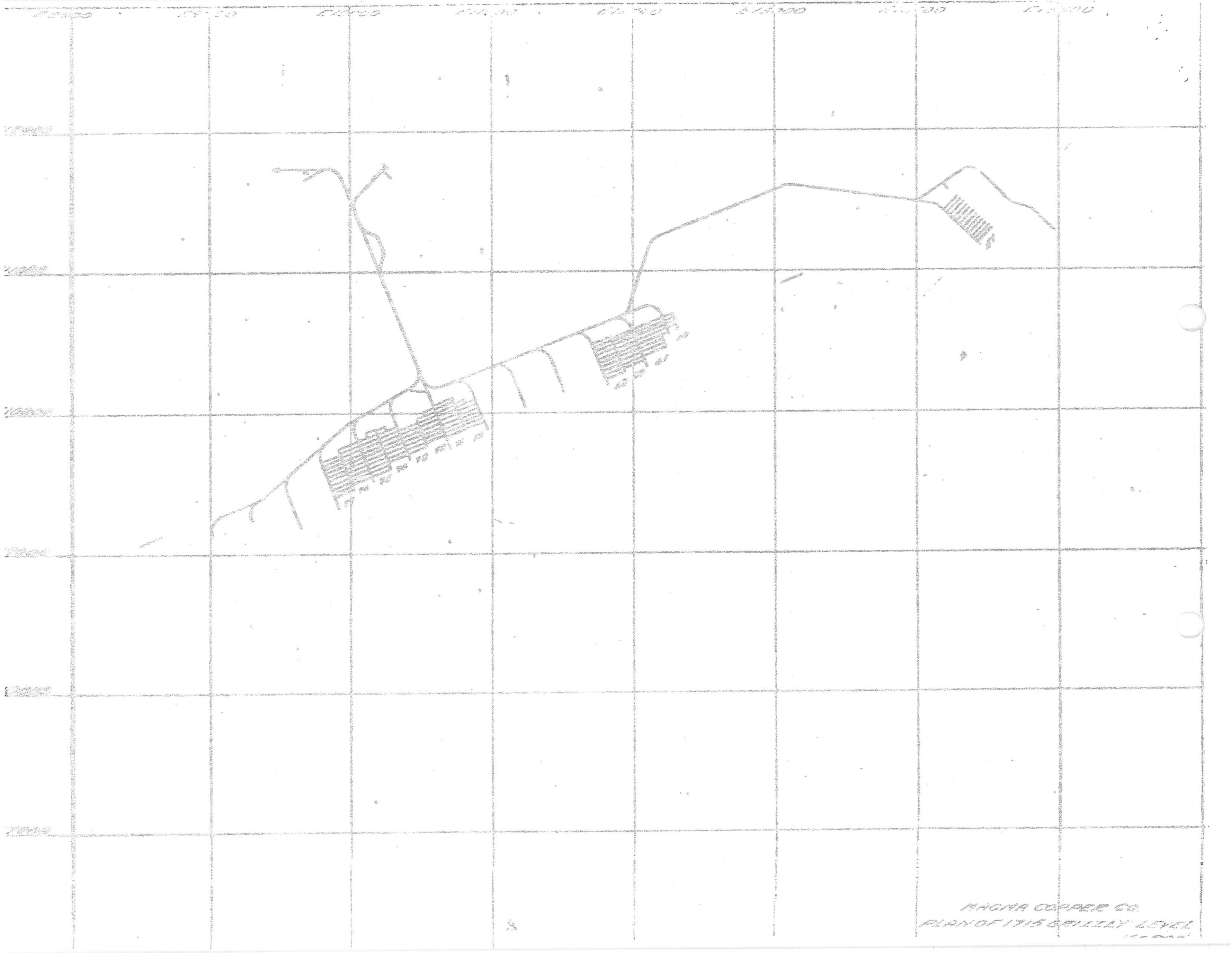
45% N.G. powder or ammonium nitrate primed with a stick of 60% Amogel is used with Millisecond electric blasting.

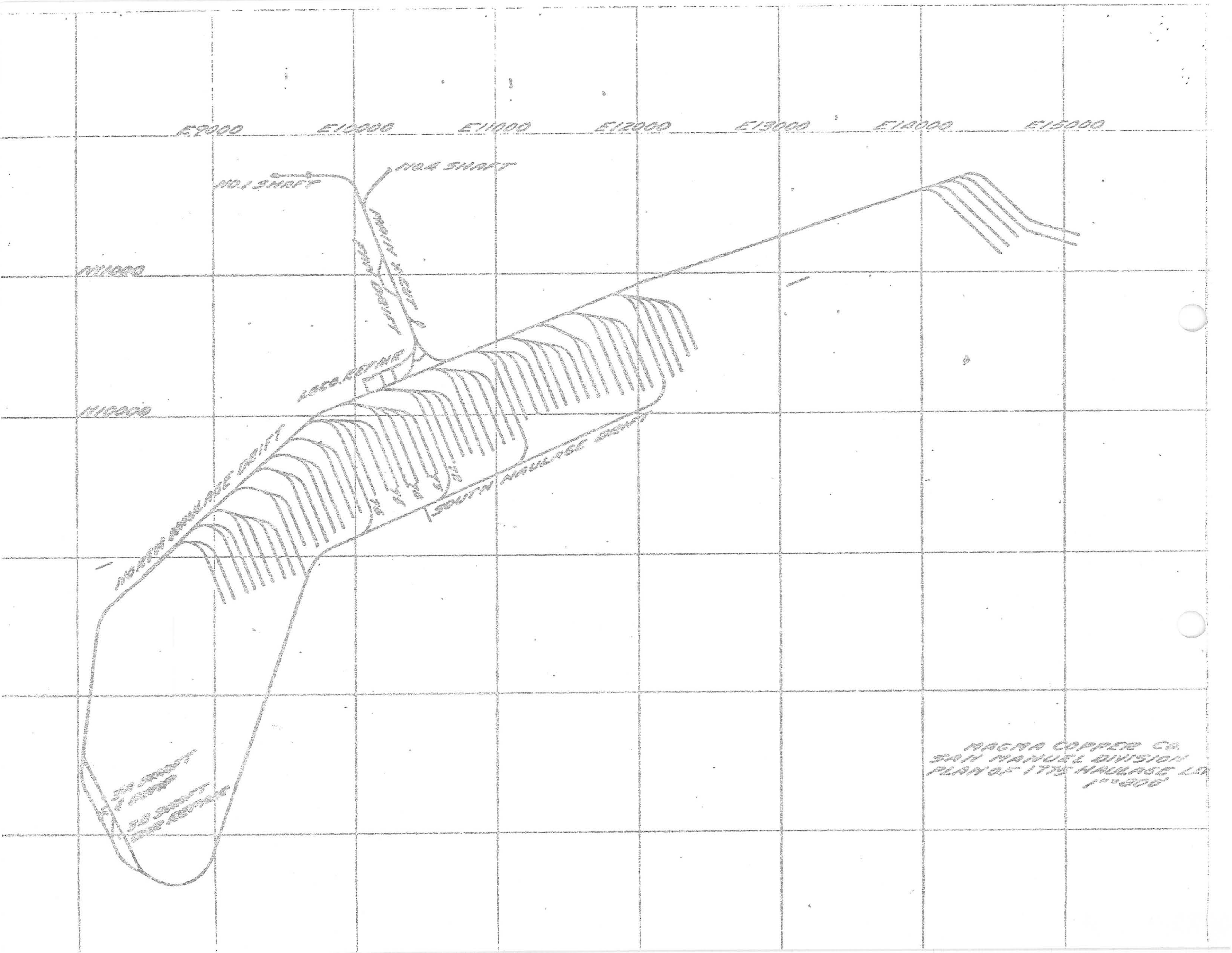


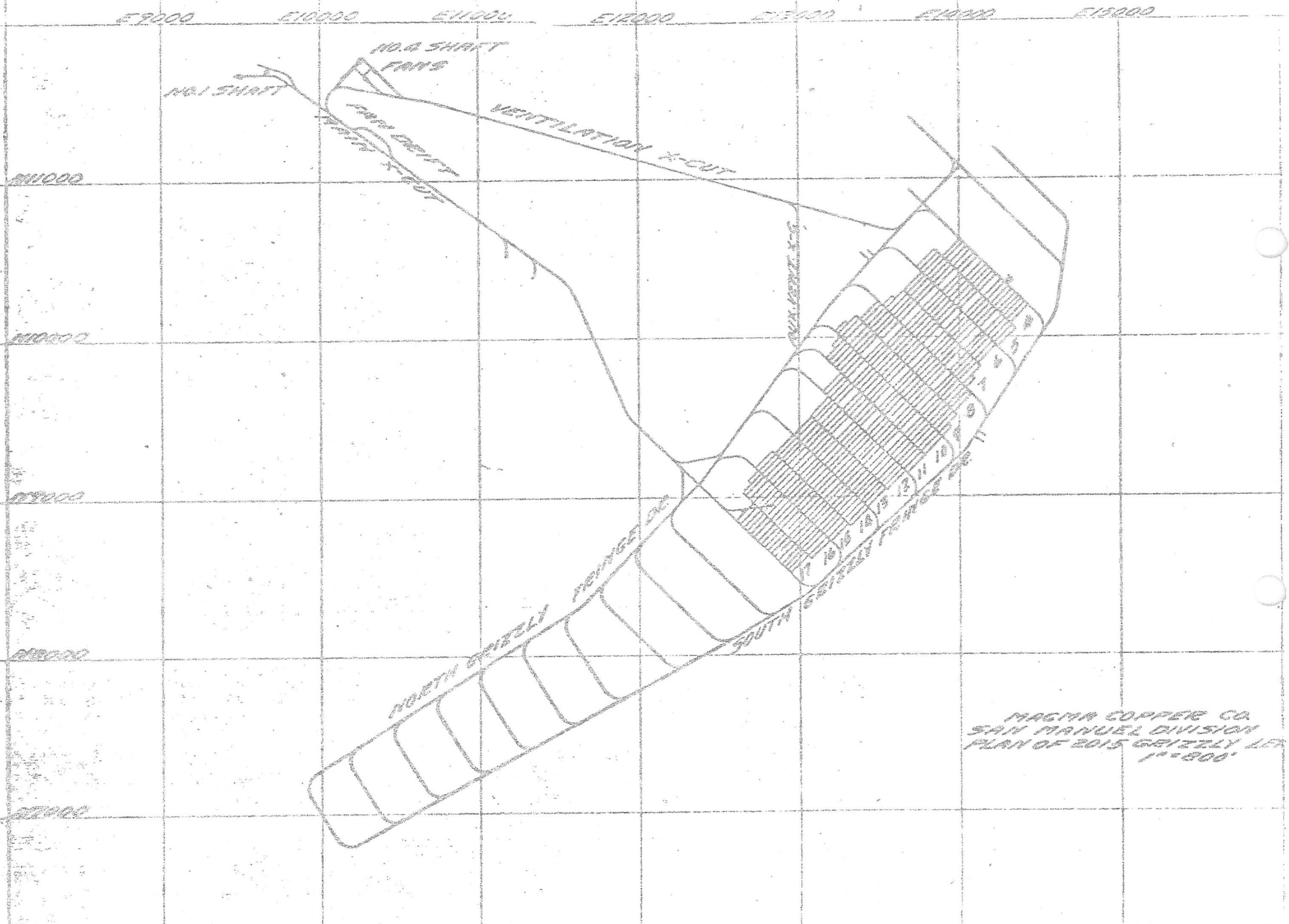
SECTIONS

PROGRESSION OF UNDERCUTTING

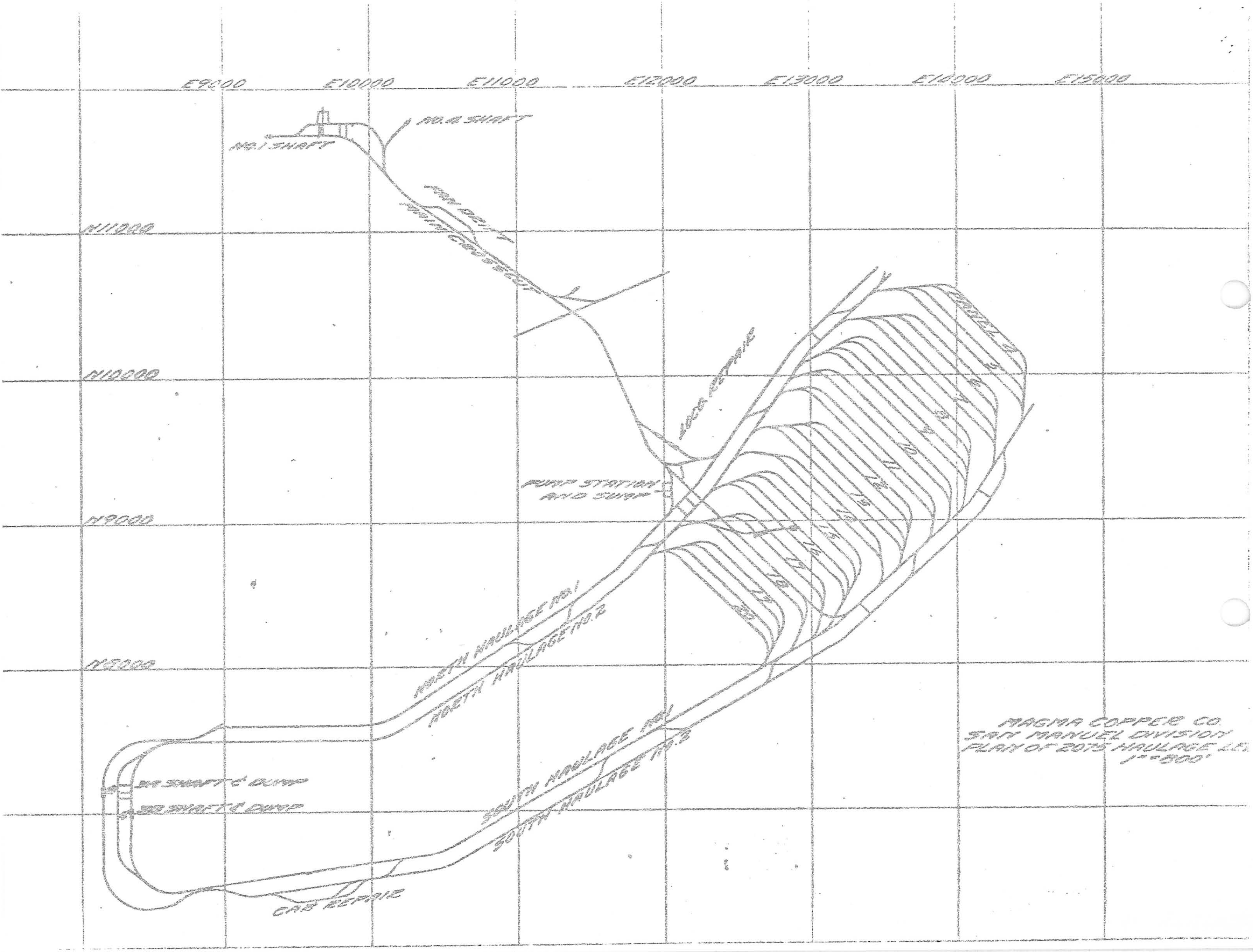
TYPICAL BLOCK


MAGMA COPPER CO.
PLAN OF 1715 GRIZZLY LEVEL


E9000
E10000
E11000
E12000
E13000
E14000
E15000
N11000
N10000
NO. 1 SHAFT
NO. 2 SHAFT
SOUTH HAULAGE DRIFT
NORTH HAULAGE DRIFT
MAGMA COPPER CO.
SAN MANUEL DIVISION
PLAN OF 1775 HAULAGE LEV
1"=800'



E9000
E10000
E11000
E12000
E13000
E14000
E15000
N11000
N10000
NO.4 SHAFT
FANS
NO.1 SHAFT
FAN DRIFT
VENTILATION X-CUT
AUX. VENT. X-C.
NORTH GRIZZLY FRINGE DR.
SOUTH GRIZZLY FRINGE DR.
MAGMA COPPER CO.
SAN MANUEL DIVISION
PLAN OF 2015 GRIZZLY LE.
1" = 800'


E9000
E10000
E11000
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E14000
E15000
N11000
N10000
N9000
N8000
NO.1 SHAFT
NO.4 SHAFT
FAN DRIFT
MAIN CROSSCUT
LOCO REPAIR
PUMP STATION
AND SUMP
PANEL 2
NORTH HAULAGE NO.1
NORTH HAULAGE NO.2
SOUTH HAULAGE NO.1
SOUTH HAULAGE NO.3
3A SHAFT "C" DUMP
3B SHAFT "A" DUMP
CAR REPAIR
MAGMA COPPER CO.
SAN MANUEL DIVISION
PLAN OF 2075 HAULAGE LEV.
1"=800'

GENERAL MINE OPERATING DATA

Operating Shifts per Day	3
Operating Days per Week	7
Operating Days per Year (7 Holidays)	358
Production per Day, Tons	40,000
Production per Year, Tons	14,320,000
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	150' - 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	1,250
High-Pack	50
Held for Repair	80
Held for Grade	20
Total Draw Points	1,400

Rate of Draw, Inches per Day	18

Types of Explosives Used:

Secondary Blasting - 45% (No. 3) Amogel in 1-1/8" x 6" sticks or 60% (No. 1) Amogel in 3/4-lb. and 1-2/3 lb. bags. Initiation is with zero delay electric blasting caps. These are tied into a trunk line to a central underground location where the 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' 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 four 8'-booms and four 3½" drifters with 6' screw 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 feed-leg 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 D.C. motors. They haul fifteen 12- to 13-ton capacity cars.

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".
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 without uncoupling. Car-stops rise and lock the train in position. The Motorman activates the dumper which rotates 180° and returns to the upright position. The car-stops then retract and the Motorman advances three car lengths to the next dump 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

479,000 cfm goes down #4 and #1 Shafts from the surface.
20,900 cfm Miscellaneous intakes, in addition to shafts.

24,000 cfm - 1st Lift (1415-1475 Levels)
160,000 cfm - SubLevel (1715-1775 Levels)
315,000 cfm - 2nd Lift (2015-2075 Levels)

1st Lift - One hi-speed Axivane mine fan, 60-hp, 1750 rpm, 5' diameter on the 1415 Main Crosscut.

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 - Three 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.

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 or air movers with tubing.

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.

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.

DRAINAGE -- cont'd

No. 1 Shaft is pumping 2,800 gpm, principally from the 2nd Lift;
900 gpm, from 3B Shaft Bottom;
Present pumping is 3,700 gpm Total.

Mine water is pumped approximately 8 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, 1600-hp, diesel-electric.
Trackage:	132-lb. rail, 7-mile haul to receiving bin at reduction plant, level track.

CHANGE ROOM

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.

COMPRESSOR HOUSE:

Five 3,500 cfm compressors, delivering at 100-lb. 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.

NO. 1 AND NO. 4 YARDS:

Surface installations in this area include a Machine Shop (including Car Repairs), Electric Shop, Drill Repair Shop, 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 addative storage tanks), Stand-By Power Plant, Compressor House, No. 1 and No. 4 Hoisthouses, Potable Water Treating Plant, and Change Rooms.

NO. 1 AND NO. 4 YARDS -- cont'd

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.

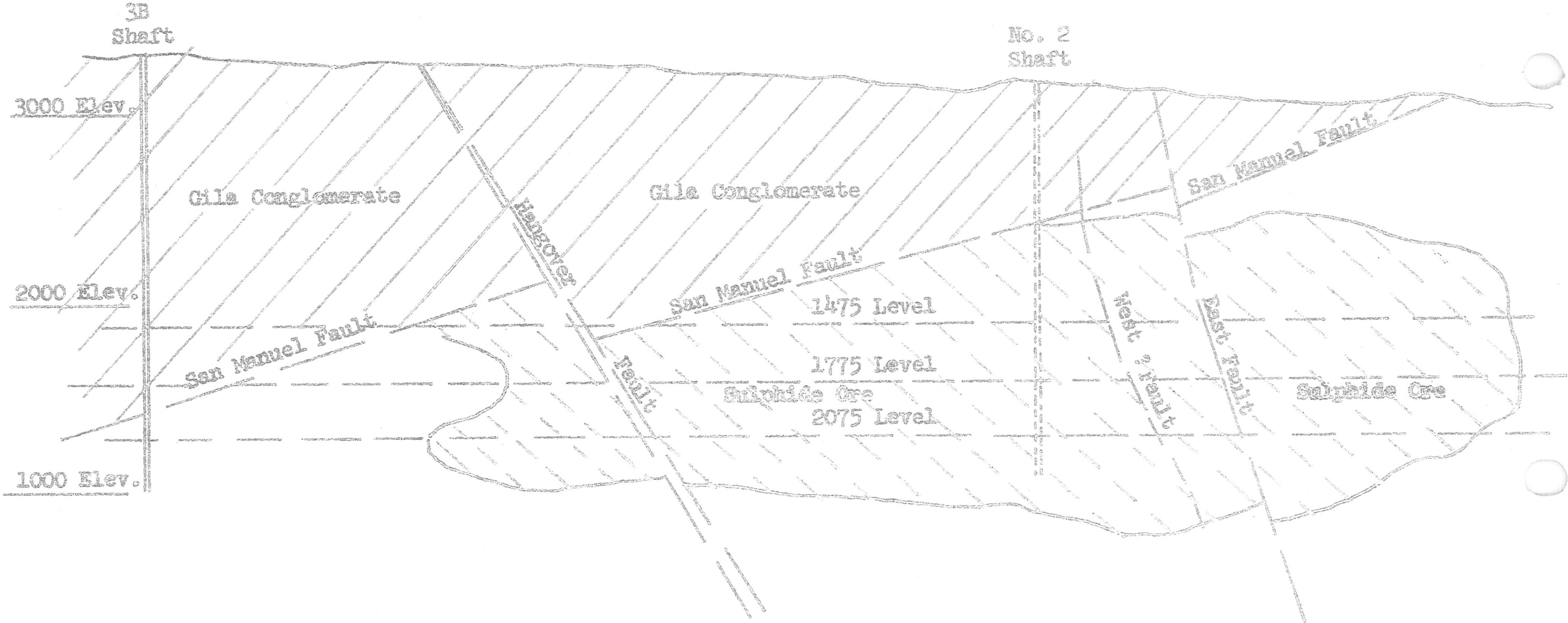
Timber: 12" x 12" drift timber.
2" and 3" lagging, various lengths.
6" and 8" cribbing, pre-framed.
Pole posts - Texas pine for undercut timber.

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.

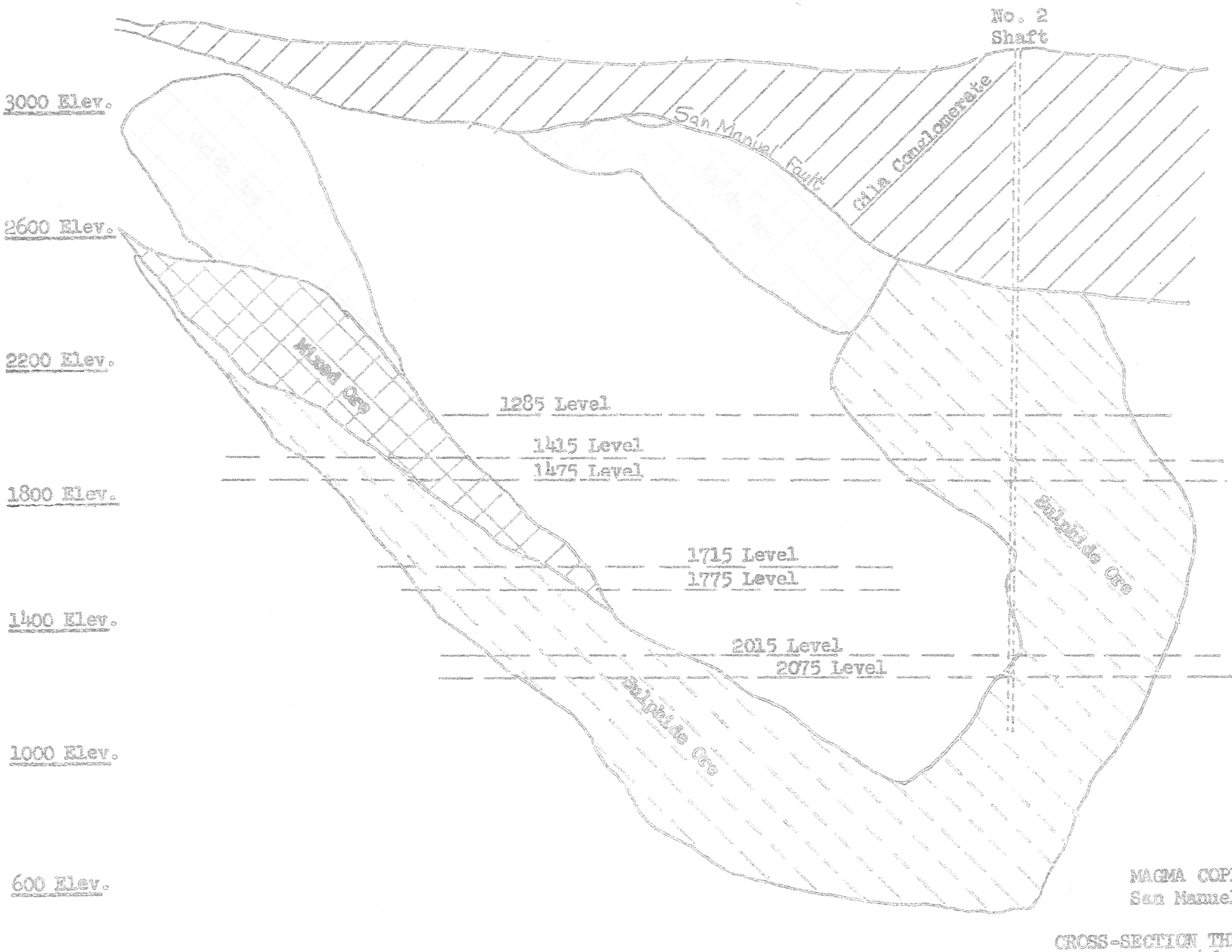
METAL PRODUCTION SAN MANUEL ONLY for 1966

Average Daily Mine Production -- Dry Tons	41,500
Pounds Copper recovered per Ton of Ore Mined	13.9
Copper, pounds	202,779,403
Molybdenum Sulphide, pounds	7,088,366
Gold, ounces	22,396
Silver, ounces	311,699



MAGMA COPPER COMPANY
San Manuel Division

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



MAGMA COPPER COMPANY
San Manuel Division

CROSS-SECTION THROUGH
OREBODY N46 W
LOOKING NORTHEAST

OUTLINE FOR SAFETY TRAINING OF SUPERVISORS

SAFETY ENGINEER

ASSISTANT SAFETY ENGINEER

DISPENSARY

- Personnel
- Records

ADMINISTRATIVE

- Safety Procedure
- Accident Investigation & Reports
- Employee Safety Committees
- Supervisor Safety Meetings
- Monthly Reports

SUPERVISOR SAFETY TRAINING

SAFETY INSPECTOR

NEW-HIRE ORIENTATION

- Company Policy:
  - Insurance
  - Accident & Sick Releases
  - Absenteeism
  - Brass System
  - Check-out System U.G.
  - Workmens Compensation Law
- Check out equipment
- General Rules
- Fire Prevention
- Explosive Display

ORIENTATION TOUR

Surface

- Dispensary
- Lamp Rooms
- Shafts
- Fire-Stench

Underground

- Loading Cage & Man-Trains
- Ventilation
- Explain Evacuation Routes, How marked.
- Active Block (Explain hazards)
- Explosive Magazines
- Trolley System
- Passing Trains

INSPECTION

- Shafts
- Drifts & Cross Cuts
- Stope Preparation
- Production
- Repair
- Haulage & Hoisting
- Construction
- Electrical Department
- Mechanical Department
- Warehousing
- Water Analysis
- Accident Investigation
- Accident Analysis

SAFETY MEETINGS

- Safe Practice
- Accident Investigation
- Accident Analysis
- Supervisors Duties
- Attitude
- Job Instruction
- First Aid
- Emergency Fire Procedure
- Safety Devices
- Motion Pictures

EMPLOYEE TRAINING

- Safety Meetings (Monthly)
- Safe Practice
- Accident Analysis
- Safety Devices
- Motion Pictures
- First Aid
- Job Instruction
- Employee Responsibility and Obligation.

FIRE MARSHAL

Surface Fire Installations

- Fire Hydrants & Hoses
- Hi-Pressure Water
- Fire Trucks
- Fire Extinguishers

Surface Crew Training

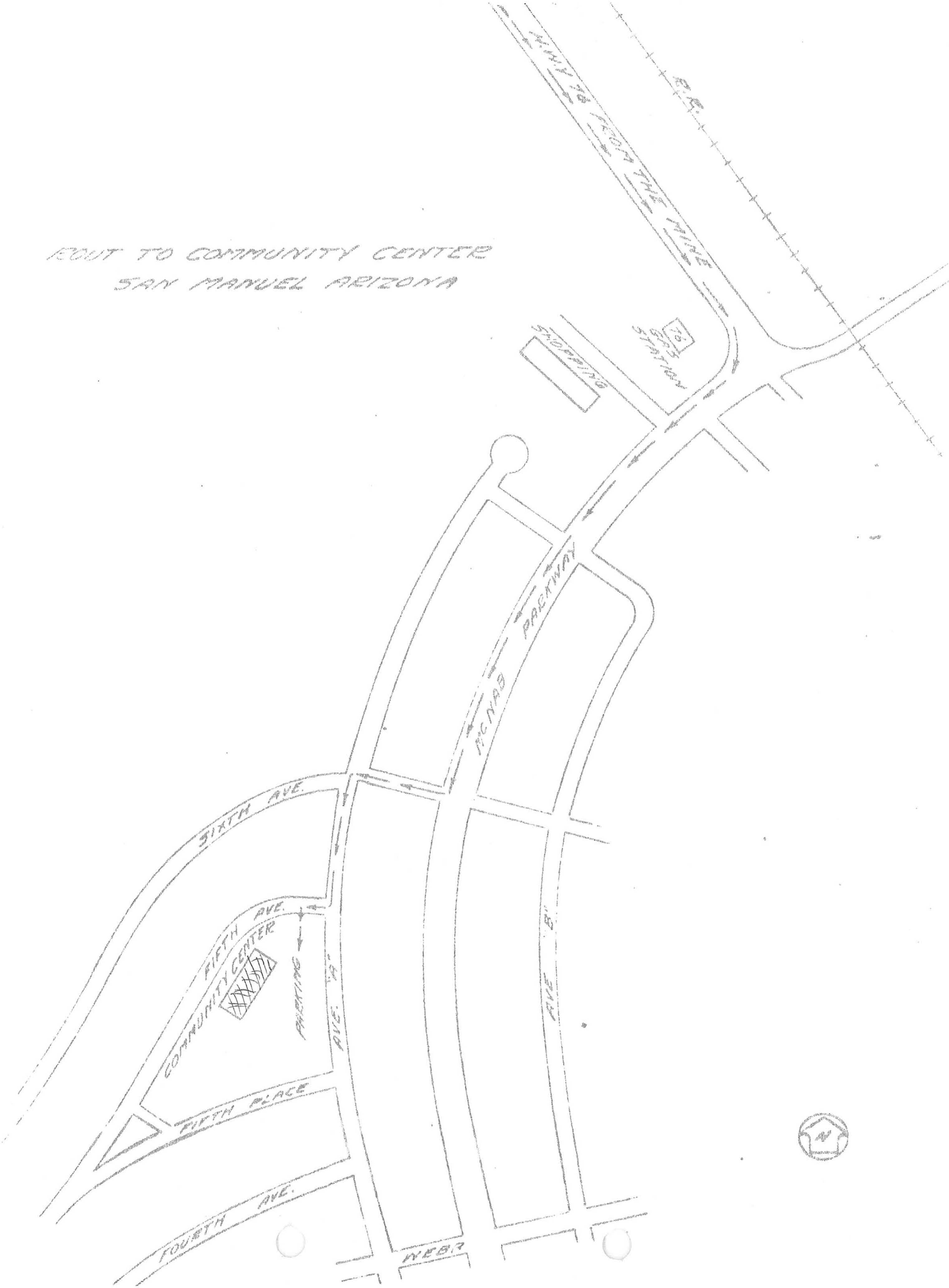
- Physical Check Installations
- Hi and Low Pressure Systems
- Fire Hoses & Hydrants

Underground Fire Installations

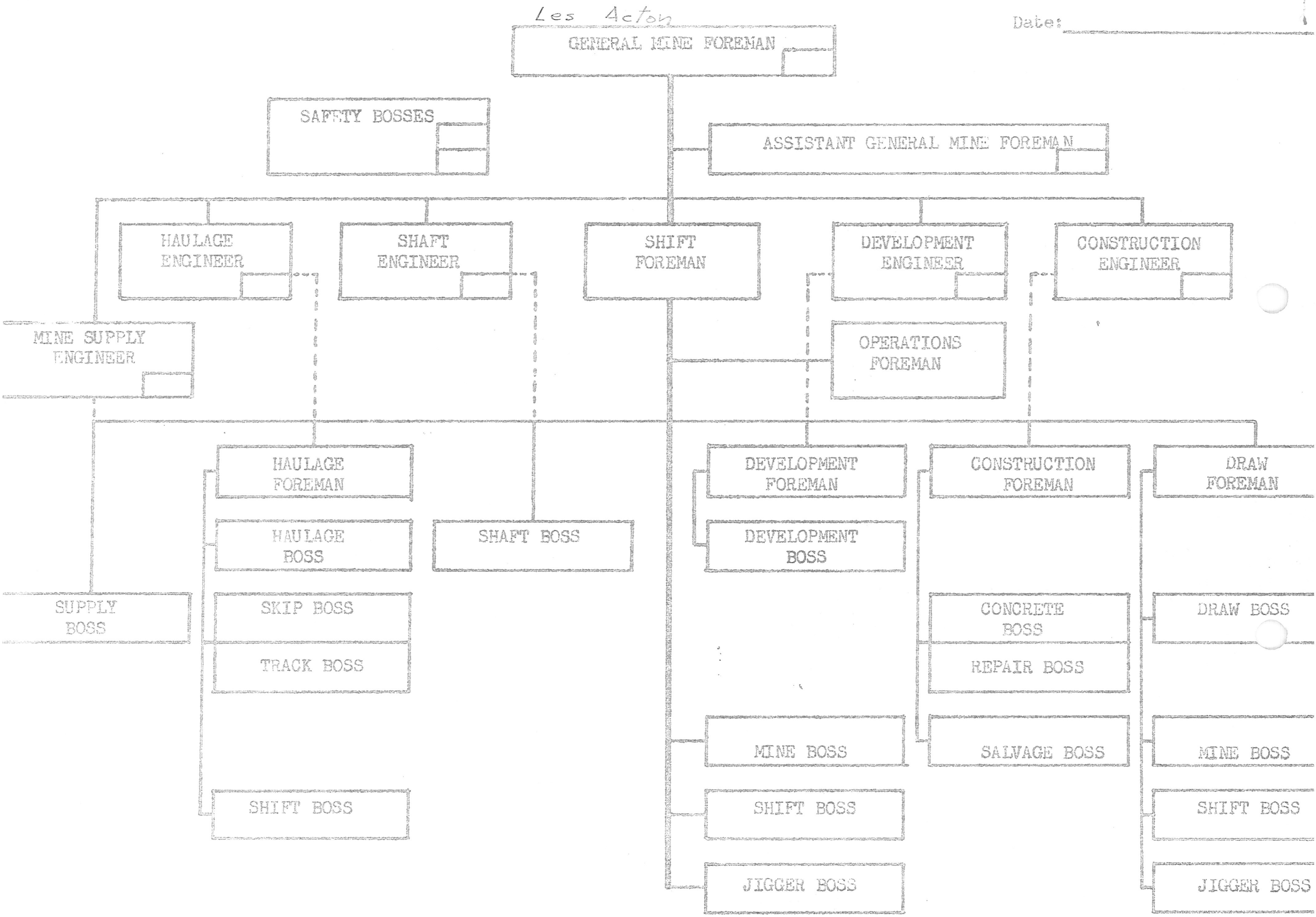
- Foam Machines
- Fire Drops & Hose Installation
- Fire Trucks
- Self-Rescuers
- Chemox Stations
- Mine Rescue Trucks
- Fire Doors

Underground Crew Training

- Use of McCaa & Chemox Apparatus
- Foam Machine Operation
- Brattice & Construction
- Rescue & Recovery
- Auxiliary Rescue Equipment
- First Aid


ROUT TO COMMUNITY CENTER
SAN MANUEL ARIZONA
HWY 76 FROM THE MINE
R.R.
GAS STATION
SHOPPING
McNAB PARKWAY
SIXTH AVE.
FIFTH AVE.
COMMUNITY CENTER
PARKING
AVE. "A"
AVE. "B"
FIFTH PLACE
FOURTH AVE.
WEBB

Date: ____________


Les Acton
GENERAL MINE FOREMAN
SAFETY BOSSES
ASSISTANT GENERAL MINE FOREMAN
HAULAGE ENGINEER
SHAFT ENGINEER
SHIFT FOREMAN
DEVELOPMENT ENGINEER
CONSTRUCTION ENGINEER
MINE SUPPLY ENGINEER
OPERATIONS FOREMAN
HAULAGE FOREMAN
DEVELOPMENT FOREMAN
CONSTRUCTION FOREMAN
DRAW FOREMAN
HAULAGE BOSS
SHAFT BOSS
DEVELOPMENT BOSS
SUPPLY BOSS
SKIP BOSS
CONCRETE BOSS
DRAW BOSS
TRACK BOSS
REPAIR BOSS
MINE BOSS
SALVAGE BOSS
MINE BOSS
SHIFT BOSS
SHIFT BOSS
SHIFT BOSS
JIGGER BOSS
JIGGER BOSS

SCHEDULED MAINTENANCE TIME FOR ALL SHAFTS

Elec. Dept. | Mech. Dept. | Mach. Dept. | Mine Dept.

Revised 4/15/68

Day — 8:00 A.M. to 4:00 P.M. (8:30, 9:30, 10:30, 11:30, 12:30, 1:30, 2:30, 3:30)

Sunday

Monday
- 3B Main Signals
- 4 Shaft Signals
- 1 Aux Sig.
- 3A Aux Skips
- 3A Aux. Hoist & Signal
- 3B Main Skips
- 3B Aux Skips
- 4 Shaft / 1 Aux Hoist, Cages and Chairs

Tuesday
- 3A Main Shaft Hoist Maintenance
- 3A Shaft Ropes & Skips
- 4 Shaft Guide Inspection
- 3A Shaft Guide Maintenance

Wednesday
- Do not tie up #1 Aux Hoist
- 1 Aux. / 4 Shaft Hoist Maintenance
- 3A and/or 3B Aux. Pumpmen Service Pumps in Bottom
- 3A Aux. / 3B Aux. Guide Inspection

Thursday
- 3B Main Shaft Hoist Maintenance
- 3B Shaft Ropes & Skips
- 1 Aux. Guides
- 3B Shaft Guide Maintenance

Friday
- 3A Main Signals
- 3A Aux / 3B Aux Ropes & Skips
- 3B Aux. Hst & Signals
- 3A Main Skips
- 4 Shaft / 1 Aux Hoist, Cage and Chairs

Saturday
- 1 Main Shaft Hoist & Signals
- 1 Main Ropes
- 1 Main Hoist & Skips
- 4 Shaft / 1 Aux Ropes & Skips
- 3A or 3B Shaft Manway Maintenance on Alternate Weeks
- No. 1 Shaft Guide Maintenance on "C" Shift

$$P_1 = \frac{T_1}{t_1}$$

WHERE P_1 = TONS HOISTED PER MINUTE OF HOISTING TIME

T_1 = TONS HOISTED PER 24 HOURS

t_1 = MINUTES ACTUAL HOISTING TIME PER 24 HOURS

$$P_2 = \frac{T_2}{t_2}$$

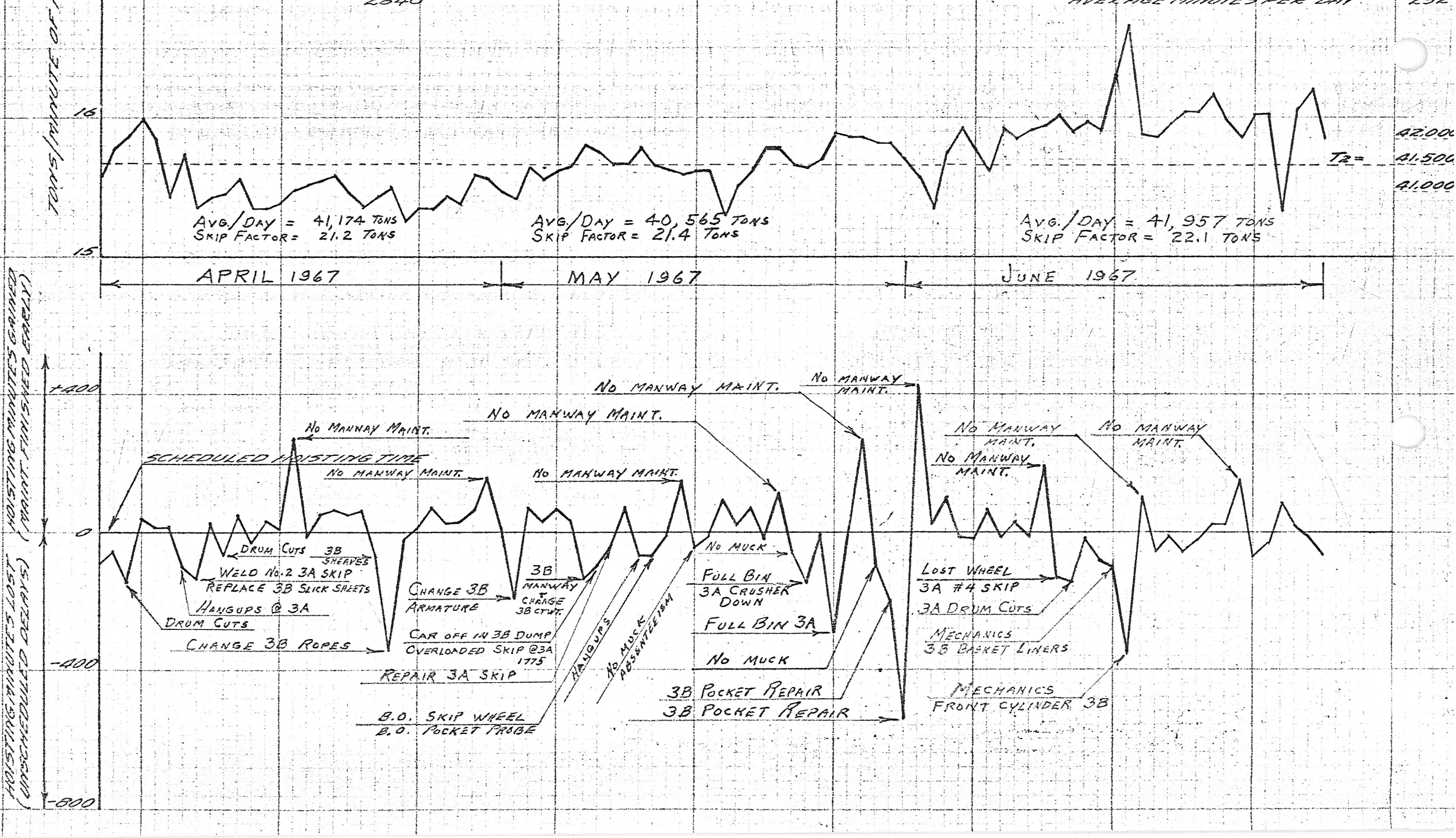
WHERE P_2 = TONS REQUIRED PER MINUTE OF SCHEDULED HOIST TIME

T_2 = TONS REQUIRED PER 24 HOURS

t_2 = MINUTES HOISTING TIME SCHEDULED PER 24 HOURS

$$P_2 = \frac{41.500}{2648} = 15.67 \text{ TONS}$$

MAINTENANCE TIME PER WEEK	(MINUTES)
HOIST MAINTENANCE ELECTRICAL	570
ROPES AND SKIPS	240
GUIDES	90
SIGNALS AND SKIPS	120
DRUM CUTS (100 MINUTES/60 DAYS)	12
ROPE CHANGES (600 MINUTES/300 DAYS)	14
SKIP CHANGES (150 MINUTES/30 DAYS)	35
MANWAY MAINTENANCE	120
MISC. DELAYS (10 MINUTES/SHIFT/SHAFT	420
TOTAL MINUTES PER WEEK:	1621
AVERAGE MINUTES PER DAY:	232



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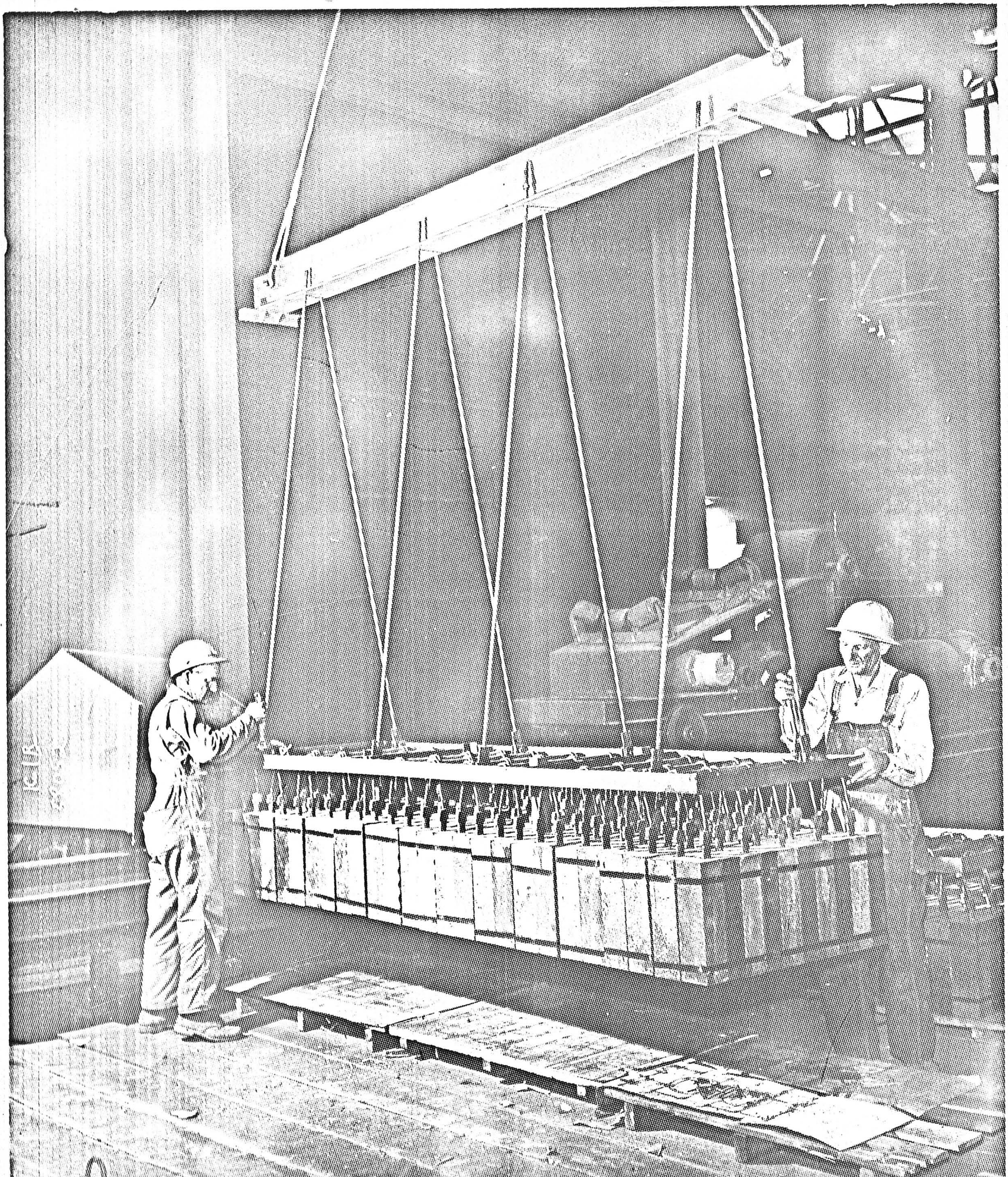
REFRACTORY REPLACEMENT OF PANEL TYPE ROOFS AT THE SAN MANUEL SMELTER

by

Edward J. Caldwell
Assistant Smelter Supt.
Magma Copper Company
San Manuel Division
San Manuel, Arizona

Smelting Division
Arizona Section, A.I.M.E.
Tucson, Arizona
December 4, 1967



The San Manuel Division smelter of the Magma Copper Company is located at San Manuel, Pinal County, Arizona in the San Pedro Valley and is approximately 45 miles northeast of Tucson.

The smelter has two reverberatory furnaces. The No. 1, which is not currently used and is in standby condition, is 32-feet wide and 102-feet long inside the brick-work. The No. 2 reverb is identical to the No. 1 except that its width is 34-feet inside the brickwork.

The roof of both reverbs rises in the first ten feet from the burners to where the bottom of the roof is 11-feet above the hearth line. This elevation is maintained for an additional twenty-six feet and then dropped in the next ten feet to 10-feet above the hearth line. This elevation is then maintained back to the uptake.

The entire roof of both reverbs as well as the uptake is of suspended, chemically-bonded, basic brick of magnesite-chrome composition. The sidewalls of the uptake are also suspended.

Starting at a point about ten feet from the burners, the flat section of the roof is composed of five rows of panels with eight panels to the row across the furnace. The panels are 10-feet long by 3-feet wide. Each panel is made up of an angle iron rectangle; this rectangle is carried by eight hanger rods from an I-beam resting freely across the main beams of the reverb super structure.

The brick, originally 15-inches thick, are banded two to the hanger. These hangers in turn are hung from pipes placed across the horizontal legs of the angle iron rectangle. A complete panel, when new, weighs about 9,000 pounds including the steelwork, and there are 260 brick to the panel. Half the brick are plated and half are unplated; through the use of a "checker" installation, a steel plate around every brick is achieved.

This panel construction was applied to the No. 1 reverb when it was rebuilt. The only difference in construction is that No. 1 has only seven panels to the row as the furnace is two feet narrower than No. 2.

These five rows of panels cover all of the roof length that is accessible for service by the 5-ton overhead crane.

The brick in the balance of the roof --- from the last row of panels to and including the uptake, are suspended from pipes that pass through the vertical legs of heavy angle irons that are laid parallel to the furnace length. These angle irons in turn are carried by hangers attached to permanently-mounted I-beams overhead.

The firing rate on the No. 2 reverb is dependent upon concentrate inventories and will vary from 175,000 to 225,000 cfh of natural gas. During the year 1966, this reverb smelted a daily total of over 1,100 dry tons of solid charge of which 960 dry tons was concentrate carrying 7 to 8% moisture.

The replacement panels are constructed only when the need for them is anticipated, and the number required is either known or estimated; no completed panels are intentionally carried on hand.

These replacement panels are assembled in a clean, well-ventilated area on the reverb working floor. This area is not only accessible for service by trucks and fork trucks, but also to the 5-ton uptake crane so that materials handling is no problem.

The steel boxes that enclose the finished panels are obtained from the machine shop (Slide 1). These are made from a 6-foot by 10-foot sheet of 18-gauge, cold-rolled steel (Slide 2). This sheet is placed in a break and formed to produce an open-end box that is three feet wide across the bottom with sides fifteen-inches high. The remaining three-inches at the top of each side is bent at ninety-degrees so that it will fit over the top of the completed panel. The end enclosures for this box are made in two separate pieces, and a complete box is thus formed with three pieces.

The bottom of this box is lined with three thicknesses of 32-pound, asbestos paper before brickwork commences (Slide 3) (Slide 4). The first end piece section of the box (Slide 5) is placed in position; this end-piece and the sides then have one thickness of asbestos paper placed thereon (Slide 6).

Installation of the brick then begins (Slide 7) (Slide 8). Since the entire panel will be enclosed, the pairs of brick are not banded (Slide 9); the use of a "checker" system that alternates the plated and unplated brick assures a steel plate around every brick (Slide 11).

Following the installation of every fourth course of brick, an expansion joint made of corrugated steel is provided (Slide 12) (Slide 13). When the panel is completed, the second end-piece section is installed in the same manner as was the first one with the bottom of the end-piece secured under the last row of brick.

The angle iron frame is then placed on top of the completed panel (Slide 14). The pipes for the brick hangers are installed, and the hangers are hooked over them. This angle iron frame has adjustable, vertical spacers mounted on it so that proper distance may be maintained in order to keep the hangers from becoming disengaged (Slide 15).

The I-beam with its eight hanger rods is then attached to the completed panel, and the assembly is then raised off of the floor (Slide 16). The unit is then banded twice horizontally (Slides 17 to 24).

The completed panels are then transported singly to the front end of the reverb by the uptake crane. A monorail affects the transfer of the panels from the uptake crane to the reverb crane. They are then placed on the reverb super structure for preheating by the radiant heat from the reverb roof. This preheating may progress for as long as three weeks before the panels are installed.

Seven panels in the first row were changed out on Easter Sunday, March 26, 1967 after nineteen months of service. The crew assigned to this work consisted of four brickmasons, four helpers, a repairman and a crane operator.

The 1st panel to be removed was loosened from the adjacent panel and the shoulder brickwork with a bar. The crane then lifted the panel out easily and set it on the feed deck overlooking the converter aisle. The repairman cut the bolts off of the eight hanger rods where they attach to the panel, and the four helpers started stripping the brick hangers and pipe and throwing the old brick into a ladle in the converter aisle below. In the meantime, a second panel was being withdrawn, and it was handled in the same fashion. As soon as the eight bolts were cut off of this second panel, the crane spotted the I-beam with its eight, loose hanger rods over the first replacement panel; the hanger rods were attached thereto with new bolts. This panel was then lowered into place.

The same sequence was then followed -- with one panel in and one panel out -- until all seven panels had been changed. The total time involved was three hours, and 210 square feet of roof was replaced with new brick of the same thickness as the original. The men involved were neither "burned up" nor exhausted as is usually the case with roof repairs; thus, we feel the panel construction is well-substantiated and proven.

On July 4, 1967, four panels in the center of the second row were similarly replaced following twenty-three months of service.

One item that presented a minor problem was the rapid linear expansion of the steel box as soon as it contacted the furnace atmosphere. Since the ends were not free to move because of the banding, the sides buckled outward from zero inches at both ends to about three-inches at the center of the panel. This presented some difficulty in placing the new panels snugly together with the result that insufficient clearance was provided for the last panel when it was ready to be placed. This was overcome by forcing the panels together laterally with a chain hoist until clearance was provided for the last panel to be lowered into place.

We believe that this expansion of the steel can be taken care of in the future by either making the box in two sections or possibly three instead of one continuous piece. In this manner, the individual sections will be cut long enough to overlap each other by some two-inches, and no buckling should occur as the individual sections will then have freedom of movement.

As mentioned previously in this report, the roof is composed in the main of chemically-bonded, magnesite-chrome brick. In the original construction of the No. 2 reverb, we test panels were installed in the first row that were entirely made up of direct-bonded, high-fired, basic brick. When this row was changed out on Easter Sunday, it was found that these two test panels were in remarkably good condition. The first and thinner of these two panels ranged in thickness from seven to twelve-inches. The second panel was twelve-inches minimum. The first was removed not only for curiosity but also on- desire to inspect it rather than the fact that it had seven-inches minimum. It could not be returned to service, of course, as it was damaged upon contact with the cooler atmosphere. The second panel was left in place and is still in servi e

Based upon this experience, it was decided to make up two more test panels of this direct-bonded brick and have them ready for service before the next replacement was due.

Although refractory suppliers do not generally recommend this type of basic brick for hot-patching, we felt that we could do it successfully and eliminate spalling by employing the installation proceedures just described.

It was with this thought in mind that two of the four panels installed on July 4, 1967 were composed entirely of this direct-bonded, high-fired refractory. The panels were successfully installed with no apparent spalling whatsoever. These were in service only ten days when the work stoppage occurred, and the reverb has been on a holding fire since that time.

Based upon this limited but rewarding experience, we feel that the high-fired, direct-bonded type of basic brick represents a refractory superior to other basic types in roof applications if proper precautions can be taken in their installation on a hot furnace. The panel type construction has proven to us to lend itself readily to such precautionary measures, so that choice of refractories for hot-patching appears to be optional with the panel type roof.

(To be followed by an 8mm. movie film showing construction and replacement of panels).

PREPRINT NO. 65AU323

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of AIME
345 EAST 47TH STREET, NEW YORK 17, N.Y.

CONCRETING AT THE SAN MANUEL MINE, SAN MANUEL, ARIZONA

H. W. Seaney
Concrete Foreman

R. L. Tobie
Chief Mine Engineer

Magma Copper Company
San Manuel Division
San Manuel, Arizona

This paper is to be presented at the SME Fall Meeting - Rocky Mountain Minerals Conference, Phoenix, Arizona, October 7 to 9, 1965

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PREPRINT NO. 65B10

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345 EAST 47TH STREET, NEW YORK 17, N.Y.

SAN MANUEL'S NEW PROCESS
FOR THE RECOVERY OF MOLYBDENITE

Harry K. Burke
Mill Superintendent
San Manuel Division
Magma Copper Company
San Manuel, Arizona

Joseph F. Shirley
Graduate Student
of the University of Arizona
Tucson, Arizona

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

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GENERAL GEOLOGY AND ORE DEPOSITION

OF THE REPLACEMENT DEPOSIT

Magma Mine - Superior, Arizona

by

James D. Sell, Geologist

Spring Meeting
Arizona Section - AIME
Underground Mining Division
Superior, Arizona
June 4, 1960

(Not for publication)

INTRODUCTION

The replacement type ore body in limestone, which presently accounts for fifty per cent of the Magma mine production, is located in the eastern part of the Magma system. The general area is named the East Division.

The central part of this division is located about four thousand feet east of No. 2 and No. 3 Shafts which are located north and slightly east of the general offices. In relation to the surface the East Division is located below the tunnel on the Superior-Miami highway.

Active stoping in the replacement deposit has been carried on for the past ten years. From a small "interesting" occurrence of copper-iron mineralization, the replacement bed ore body has been developed into a sizeable part of the production and reserves of Magma Copper Company.

This paper is an introduction to some of the geologic features of the replacement deposit. The major features to be discussed include the fault structures, the relationship of the vein to the beds, the barren embayments within the deposit, and the types of mineralization fringes bounding the ore deposit.

GEOLOGY

Rock Types

Within the Superior mining district a variety of rock units exist. (Plate IA, Generalized geologic column of the Magma mine area.) The oldest rock encountered in the metamorphic Pinal schist of older precambrian age, with the younger precambrian sedimentary Apache group unconformably on the schist. The Apache group includes the Scanlan conglomerate, Pioneer shale, Barnes conglomerate, Dripping Spring quartzite, Mescal limestone, and the Apache basalt. Overlying this group is the Cambrian Troy quartzite followed by the Devonian Martin limestone, Mississippian Escabrosa limestone and the Pennsylvanian Naco limestone. Intruded into this metamorphic-sedimentary sequence is a very thick section of diabase, probably Pre-devonian in age, and quartz monzonite porphyry dikes which are early Tertiary in age.

All of the above types have been locally covered by the Whitetail conglomerate and dacite. Quaternary basalt dikes cut through the Naco limestone within the mine area, but undoubtably penetrate the dacite outside the area. Very late sands, gravels, and erosional debris now partially cover the topographic surface.

In the East Division proper, the rock types encountered include the diabase, Troy quartzite, Martin limestone, and the porphyry dikes.

Underground the formations dip thirty degrees eastward, just as they do where exposed at the surface. (Plate IB, Rock sequence near the replacement deposit.) In the East Division the Troy quartzite is about 100 feet thick, while the Martin limestone is about 340 feet thick. The term footwall limestone is used to designate the portion of the Martin limestone which underlies the mineralized beds. The thickness of the footwall unit ranges from 12 to 20 feet. The replacement ore horizon occupies a zone of limestone some 12 to 30 feet thick. The hanging wall limestone is the limestone beds above the top of the ore horizon.

Vein Structures

Only one major vein structure is associated with the replacement deposit. It has been given several designations but the present correlation is with the South Branch of the Magma Vein. Complicated fault structures between the central and east portions of the Magma mine system precludes a definite correlation. Minor mineralized shear zones and small vein structures are abundant in the diabase and especially in the quartzite underlying the replacement horizon, but few penetrate up into the Martin limestone.

Fault Structures

Major through-going fault structures are minor in number in the East Division. However, these major faults may be classified into several systems--east-west, north-south, northwest and northeast. (Plate II, Major fault structures in the replacement deposit.) The east-west system is well exemplified by the major vein structure as noted above. The vein fault is a normal fault with the south side down relative to the north side. It has been followed in the quartzite-limestone replacement areas from the 2250 level down to the 3400 level, or covering about 2400 feet horizontally.

The largest fault, in the north-south system, has been designated as the NS 5 W fault. This structure has a horizontal component of movement of about 400 feet (east side north) and a vertical component of 90 feet (east side up). Faults having a larger horizontal component of movement than vertical component may be referred to as strike-slip faults.

Two more strike-slip faults have been encountered. The first is located about 575 feet west of the NS 5 W fault. This fault has around 50 feet of horizontal movement and less than two feet of apparent vertical movement. Its trace in the beds is N 15° E.

The second fault lies 250 feet farther west and appears to be of limited extent. However, it does offset a mineralization fringe some 30 feet with no appreciable vertical offset. The trace of this fault is N 25° E.

A third fault, which may be a strike-slip type, has been encountered in the main level drifts as they were driven from No. 2 Shaft to the East Division. Its effect on the beds is unknown at the present time but it apprently offsets the Magma vein some 80 feet.

All of these strike-slip faults have the same direction of movement--the eastern block has moved north relative to the western block.

A number of east-west trending faults, other than the vein system, have been found which generally complicates the exploration and development of the replacement deposit. Usually they begin to form east of a strike-slip and first appear as a "roll" in the mineralized horizon. As they are followed eastward, the roll becomes more sharply developed until at some point the actual fault forms with a faulted displacement between the two sides. Structures of this type are known as hinge faults. Generally the displacement increases eastward and on one of these faults has attained a maximum of some thirty feet. These faults generally terminate near the next strike-slip fault east of where they originated. These are normal fault structures in that the side which is down dropped lies in the direction of the dip of the structure.

The northwest system is not well developed by throughgoing structures, but they are found throughout the deposit.

A flat-dipping (30-40 degrees) northeast trending group has only recently been encountered. The structures formed by this system apparently are bounded on the east by the first strike-slip fault west of NS 5 W fault. The effect of these faults within the ore horizon die out rapidly to the west. This group of faults probably does not extend much farther west than the second strike-slip fault.

Minor faulting throughout the replacement deposit generally had the same trend as the major structures, that is, east-west, north-south, northwest and northeast. The major fault, the NS 5 W fault, has been used as a dividing line for naming the position of the working places east and west. The workings east of the fault are called east bed workings and those to the west are called west bed workings.

Relation of the Vein to the Beds

The east-west trending South Branch of the Magma Vein is also used for naming positions within the East Division. The replacement beds located north of the vein are called the north beds, while those to the south are called the south beds. (Plate III, Vertical section showing the relation of the vein to the beds.) In a vertical section it is noted that the south beds are displaced about 30 feet downward in relation to the north beds. It is well to point out at this time several interesting points regarding the vein. 1. Deep in the diabase the vein is little more than a poorly mineralized fracture zone containing hematite and sphalerite with little copper. 2. As the quartzite contact is approached the vein widens and the copper values become of commercial interest. 3. The width and grade increases to a maximum in the quartzite and little hematite or sphalerite is found. 4. As the footwall of the south beds is intercepted the vein structure begins to break up although quartz, pyrite, chalcopyrite and bornite are abundant. 5. The vein is not esaily traced within the south-bed--north-bed replacement zone but generally a quartz structure helps to identify it. The hematite content is usually quite low. 6. The structure is usually lost as the north beds are encountered. 7. Where followed up into the hanging wall above the north beds, only a fracture zone is found with minor hematite and zinc.

North and South Beds

The north beds have a much shorter lateral extent than do the south beds. The limit is generally less than 150 feet to the north of the vein. The average thickness of the north beds may exceed that of the south beds but averages under thirty feet. Thicknesses of sixty feet have been mined but in these areas the horizon contained poorly mineralized limestone beds between heavily mineralized limestone beds.

The south beds seem to have been much more favorable for mineralization than the north beds. The mineralization, on the average, extends over 500 feet south and in some places extends

800 feet south of the vein structure. The average thickness is probably around 15-20 feet but may reach 30 feet.

Barren Embayments in the Replacement Beds

The entire lateral distance, between the mineralization fringes to the north and south of the vein, is not completely replaced. Barren zones exist which occupy the entire vertical interval of the replacement bed horizon. These bodies trend east-west in plan and are generally devoid of mineralization and structure except for scattered pyrite and a few minor vertical breaks. They have the same appearance as the limestone outside the limits of the ore body. (Plate IV, Barren embayments in the replacement beds.) Two have been found within the ore limits of the east beds. Both start at the NS 5 W fault and extend eastward. The first one has a north-south width of 40 feet and extends about 100 feet eastward. Surprisingly enough this mass of barren limestone occurs next to the vein. The other is also about 40 feet wide but extends some 200 feet eastward.

Two additional ones have been found in the west beds and the westward extent of these have not yet been ascertained. The smallest one projects some 150 feet eastward into the replaced zone. The larger one splits the horizontal north-south extent of the ore body and projects some 500 feet eastward into the ore body. In both of these, prongs of mineralized replacement beds have extended westward on both sides of the barren blocks.

Configuration of the Replacement Horizon.

The present configuration of the replacement horizon is dominated by the initial eastward dip of the limestone beds. (Plate V, East-west section through the replacement horizon.) In an east-west vertical section, the dominant fault structure is the NS 5 W fault which was discussed earlier. Throughout the west beds the replacement horizon dips eastward at its normal thirty degrees. There is little flattening of the beds as the NS 5 W fault is approached. However, on the east side of the fault the beds are much flattened and actually reverse dip in the vicinity of the fault. The change in dip of the beds on the east side has been attributed to vertical fault movement on the NS 5 W fault but undoubtably compressive forces have helped by bowing and folding the beds either before or during the period of faulting.

In north-south sections the main features noted are the barren embayments within the ore horizon and the displacements on the steep-dipping east-west hinge fault system. (Plate VI, North-south vertical sections across the east beds.) In the east beds, a central high is noted with down dropped trough-like areas on both sides. In the west beds (Plate VII, North-south vertical sections across the west beds) the central high is missing but the trough zone is well developed on the south side of the ore body. The complications caused by the hinge faults are well shown.

ORE DEPOSITION

Hypogene Minerals

The relative importance, volume-wise, of the minerals in the East Division is as follows: Specular variety of hematite, pyrite, red hematite, chalcopyrite, bornite and chalcocite. Other minerals also occur and include quartz, ankerite (?), magnetite, barite, galena, sphalerite, calcite and rhodochrosite. Minor amounts of gold and silver are noted in the assays but the specific minerals have not been identified.

The minerals of commercial interest include chalcopyrite, bornite and chalcocite.

Within the vein system, quartz, pyrite, chalcopyrite, bornite and ankerite (?) are the common minerals with minor specularite, sphalerite and barite.

The replacement bed horizon contains all the minerals named above, but specularite and pyrite are the two most noted.

Mineralization Fringes

The mineralized limestone-altered limestone fringes or cut-offs are of special interest.

Three minerals cut-off types are known. (Plate VIII, Types of mineralization fringes.) The first is the fault cut-off where a pre-mineral fault is the control. The displacement across this fault is generally very small, being less than two feet. The second is the "barren-wall" cut-off where the mineralization suddenly changes from a completely replaced section into barren fringe limestone. The replaced section is generally thicker than 12 feet on this type, and changes to barren limestone is less than two feet of lateral distance. The third type is a combination of the first two. In this a fault partially controls the mineralization and the top side of the mineralization zone will gradually begin to drop toward the footwall. When the mineralized thickness decreases to 4-8 feet the mineral then ends on the barren-wall type cut-off.

All three of these types can be exhibited in less than twenty-five feet of one another. A fault on the fringe extends out into the ore body and the other two types become dominant.

In general high-grade ore is found on the south fringe of the ore body but the other mineralization fringes are not particularly noted for their association with high-grade ore.

Sequence of Mineral Deposition

Mineral deposition appears to follow the normal sequence found in other hypogene deposits. Magnetite, hematite, and pyrite with minor quartz flooded the replacement horizon by extensive replacement of the limestone, with some copper being introduced at this time. The quartz and pyrite are early minerals and continued to be deposited throughout the mineralizing period. Following the extensive pyritization and hematitization of the ore horizon some of the faults were reactivated. This stage was followed by the major influx of copper mineralization which formed the economic ore body as it is known today.

Controls on the Mineral Deposition

The primary control on the mineral deposition is the host rock itself with the physical-chemical favorability of this particular horizon. Why this specific horizon is most favorable is unknown. However, it is well to note that this same stratigraphic unit is very favorable in other areas. The lower Devonian beds at Bisbee, Morenci, Christmas and Globe contain replacement ore bodies similar to that which is found here.

The faults in many places show a very strong control on the copper mineralization but at this time the structural history of the area is not well enough known to limit the major direction. It is suggestive, however, that the east-west trend is highly favorable as a control but there are exceptions to this.

Within the beds the copper mineralization rarely if ever occurs outside of the hematite-pyrite areas. It would thus seem that the pre-preparation of the host rock by the earlier iron mineralization was also essential.

SUMMARY

In summary, the replacement deposit located in the Devonian limestone constitutes a unique type of ore deposit for Magma.

Some of the features can be easily traced throughout this deposit. Such things as the faulting, the warping of the beds, the types of minerals present, and the barren embayments of limestone. All of these features, and others, are currently being examined and recorded. Much progress has been made in the last ten years in the exploration, development, and mining of this deposit.

The progress made in the integrating of geologic information is very encouraging. Projects presently underway are numerous. They include a detailed paragenetic study, a study of the stages of mineralization and faulting with their interrelationship, and a study of the minor mineralized fracture-vein zones. Many of the points discussed today are early tentative concepts based on these studies.

Through the integration of data an understanding emerges, not only for this deposit, but for others as well. Understanding this deposit will aid in the exploration for additional ore bodies within this specific horizon and other favorable replacement horizons within the Magma area.

SAFE HAULAGE OPERATION

at the

SAN MANUEL COPPER CORPORATION

By

W. R. Collier

Acting Mine Safety Engineer

For Presentation

STATE MINE INSPECTORS' MEETING

Phoenix, Arizona

March 22, 1960

SAFE HAULAGE OPERATION

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SAN MANUEL COPPER CORPORATION

By W. R. Collier

Perhaps in no other phase of the underground operation at San Manuel has safety played such a vital part as in the ore haulage level operations. Size of the equipment, tonnage requirements, electric power used, and overall size of the level presented a unique type of proolem to the engineers who laid out and brought this large underground mining operation into production.

Full use of radio communications, intercom type phone circuits, block signal systems, and full safety features on the haulage equipment, i.e., deadman type controls, three separate braking systems, air horns, dual sealed beam headlights, overspeed circuit breakers, and all other modern safety devices available at the time were used.

Safety engineering of particular problems is a normal part of operations. However, one major factor must now be considered. Due to the delicate balance and smooth operation of the mine haulage operation, any major change must be completely analyzed as to how it will effect the entire mining operation before it is used. "Trial and error" methods have no place in a haulage system that has become, in a very short time, one of the largest of its kind in the world.

During the initial period of training of ore haulage personnel, manpower was in short supply and it was not always possible to employ men of the caliber desired. Experienced underground haulage men were not available and had to be trained by Company supervisors. All of our haulage level supervisors had the benefit of experience in high tonnage underground haulage operations prior to coming to San Manuel.

Since the first undercut pillar was blasted on November 24, 1955, over 37 million tons of ore have been hauled and hoisted. The present monthly quota of approximately one million tons was reached in early 1958.

Heavy ground weight in some sections of the main haulage lines adjacent to active stope areas requires major timber repair. Development work being done, as well as normal electrical and mechanical maintenance, presents a congestion problem that is eased by a "Draw by shifts of different blocks". This, in turn, has presented a safety problem of housekeeping, material storage, and elimination of electrical hazards.

Timber repair crews must leave haulage lines in safe operational condition for the oncoming shift. Electricians and mechanics can do only that work that they can complete or leave in a safe condition without interfering with normal operations or creating a hazard.

Development of new haulage lines in new panels, driving of transfer raises, and concreting operations are serviced and supplied from main haulage lines, and although ore haulage equipment does have priority of movement, traffic control is a haulage responsibility administered by a dispatcher in radio contact with all locomotives on the level.

Tests made by the Safety Department show that a communications circuit (radio, audio intercom, or telephone) is opened to the dispatcher on an average of twelve times a minute. Incoming calls are handled in sequence of importance as relative to ore train movement.

Any error by the dispatcher giving non-haulage equipment access to the main haulage lines or any unauthorized use of main lines could result in a very serious accident.

A complete description of the communications system is outlined in a paper, "Mine Communications System at San Manuel," written by Mr. C. L. Pillar, Mine Superintendent, for presentation to the A. I. M. E. in San Francisco during their meeting in February, 1959.

For those present who are interested in the technical details of the haulage operation and equipment, an excellent article by Mr. C. F. Cigliana, Mine Foreman, was published in the May, 1958, issue of Mining Engineering.

Strict enforcement of safety rules, seeing that other departments working on the haulage level comply with haulage regulations, screening of haulage employees within limits of existing union labor contracts, and a planned system of training are the foundations on which the haulage supervisors conduct the program of accident prevention.

An experienced, safety-conscious group of haulage supervisors expedite the program, under the guidance of Mr. G. Massey, Haulage Foreman, who is present at this meeting.

POLICY

Responsibility that a well coordinated safety program is conducted by the supervisory staff rests with the Safety Department. The responsibility for the safety of the men on duty rests with the supervisory staff one hundred percent.

The foreman or first-line supervisor is the key man in accident prevention, particularly with regard to unsafe acts. Because these supervisors are so integral a part of the safety program, their training, sincere cooperation, and contribution towards improvement of methods is a primary factor in considering future policy.

GENERAL OVERALL PROGRAM

Supervisory safety training is done in three different methods.

1. A two-month tour of duty in the Safety Department is given each mine shift boss. He is selected for this tour of duty by the Mine Foreman from a list compiled in the Foreman's office. During his term with the Safety Department he receives concentrated safety information and acts as a Safety Inspector. Two mine shift bosses are assigned to the Safety Department every two-month period.
2. Bosses' Safety Meetings: Twice weekly a 30-minute meeting is held in the Safety Office. This meeting, held after shift, is attended by all day shift mine supervisors and all shift work supervisors who are currently on the day shift. Meetings are planned and prepared well in advance as to subject matter to be presented to the bosses.

3. Informal approach: As briefly outlined in Safety Department Relative to Haulage Operation, Safety Engineers and Inspectors work through the immediate boss by calling attention to unsafe conditions or unsafe work practices, make recommendations and suggestions to assist the bosses in correcting the unsafe condition or practice.

Fire protection engineering, inspection, and maintenance are all Safety Department responsibilities, as is the maintenance of stations of emergency equipment, first aid supplies, and rescue apparatus.

As of January, 1959, safety meetings for employees were set up with the thought of allowing the employees to take a more active part in the safety program. Meetings are engineered as to topics, time, and location. Employees are encouraged to offer practical suggestions at these meetings. Suggestions are forwarded to the Safety Department for consideration and processing if found to be practical. Written answers to these suggestions, and suggestions turned in from suggestion boxes, are returned to the employee through his boss.

Introduction of new safe practice procedures and equipment, issuing or revising of rules are a Safety Department function. This is done by consultation and concurrence with the department heads affected by the change.

Investigation of all serious injuries, compiling monthly reports, the use of pictures and films, maintenance of bulletin boards, signs, and the many other usual functions of a Safety Department are a part of the general safety program.

SAFETY STAFF

The Mine Safety Staff consists of a Mine Safety Engineer and two Assistant Safety Engineers, two mine shift bosses as Inspectors, and a Fire Marshal. Safety Department personnel carry no line authority except the authority to stop any obviously unsafe operation until a foreman can be contacted.

MINE SAFETY PROGRAM RELATIVE TO THE HAULAGE OPERATION.

In addition to the "General Safety Rules and Instructions", an "Operation of Trains and Motors" pamphlet was revised and re-issued in January, 1959. This procedure covers four main sections of ore haulage:

1. General Rules: Motor operation, Handling equipment, Working near haulage equipment.
2. Ore Haulage Levels: Ore Train Operation.
3. Loading of Ore Trains: Car loader safety, use of loading lights, tools.
4. Supply and Development on Haulage Levels: Operation of service crew motors, Car transfers, Changing batteries.

The procedure was read and explained to the workmen during safety meetings held during January and February, with special emphasis given parts of the procedure governing work done by the men under the supervisor conducting the meeting.

Safety Inspectors use "Check Sheets" daily in haulage level inspection tours. These notebook size forms facilitate checking of:

1. Motor and Motorman: Gloves, respirator, safety glasses, rerailers, fire extinguishers, horn, brakes, etc.
2. Pony Sets: Trolley guard, loading lights, ladders, tools, sprays, housekeeping, control boards, timber condition, etc.

Carbon copies of the Check Sheets are processed through the shift bosses with a follow-up inspection at a later date.

In addition to a round-the-clock safety program carried out by the supervisors, "B" (afternoon) and "C" (graveyard) spot check inspections of haulage level operations are made by the Safety Staff on an irregular schedule.

Blasters and battery motormen "Safety Job Instruction" forms are provided for the haulage bosses to assist in qualifying and instructing employees.

Haulage bosses report daily on a "Haulage Operational" report any defects not corrected during their shift.

Accident experience, while not comparable with a surface haulage operation, does compare favorably with other departments in the mine in frequency. Actual statistics are:

1959 - 8 Months

Lost Time Accidents	14
Days Lost (Including 3,000 days charge permanent partial)	3,067
Frequency	39.63
Severity	8,682.

1960 - To March 1st

Lost Time Accidents	2
Days Lost	6
Frequency	23.80
Severity	71

SUPPLEMENTARY INFORMATION SHEET FOR MEN RATED AS BLASTERS

BLASTERS 1475 LEVEL

In blasting hung raises, the blaster should first find out, if possible, what caused the hang-up, and place the blast where it would do the most good.

As an example--If because of a thick bank in the raise, the raise has narrowed at one point and rough muck caused the hang-up, it is much better to undercut the bank to bring the raise in than just to free the boulders in the hang-up, because rough muck behind the hang-up will hang the raise again and more blasts will have to be put up.

Small shots against "key" rocks in a hang-up do much better than large bombs not placed properly.

"Concussion" shots should be used only for fine or wet muck. They should be limited to two sticks of powder, placed three or four feet away from the muck.

Each blaster is responsiole for all explosives in his line. Sacks should be separated when not in use, and a bench or box should be provided for storage while trains are being loaded.

Clearance to blast is to be obtained <u>FROM THE DISPATCHER ONLY</u>. Clearance should be obtained as soon as the shot or shots are loaded. As soon as the blasts have gone, notify the dispatcher because workmen on the 1415 Level are being held up.

A good blaster is not known for the number of blasts he puts up, but for how well he keeps the raises free of hang-ups in his line. As the senior workman, housekeeping both in the pony set and in the drift is his responsibility, as is the reporting to his boss of anything that is in need of attention in his line that is not his normal work to take care of.

W.R.C. 12-10-59

No. ____________

Name ____________________________

BLASTER, 1475 LEVEL

TO QUALIFY AS A BLASTER ON THE 1475 LEVEL, A MAN MUST BE ABLE TO ANSWER THE LISTED 8 QUESTIONS.

1. How many sticks of powder are you permitted to use in a bomb, without first getting the boss's okay to use more? ____________________

2. Why are NO electric caps used in active transfer raises?

____

3. How much are you allowed to cut off of an 8-foot fuse? ____________

4. Explain how you get a clearance to blast? ____________________

____

5. Allowing for manways to the 1415 Level, how is a blast guarded?

____

6. After you get caps, primacord and powder from the main magazines, how do you take care of them in the working area? ____________________

____

7. Where are the bombs made up? ____________________

8. Show how you make up a bomb, using primacord; show how you tie a bomb on a blasting stick.

____

Supervisor checking procedure

W.R.C. 12-10-59

MOTOR INSPECTION

Date:________________ Shift:________

Inspector:____________________________

	Motor	Man's Number	Gloves	Respirator	Glasses	Re-railer	Tail-Light	Fire Ext.	REMARKS

PONY SET INSPECTION

Date:________________ Shift:________

Inspector:____________________________

Panel:________________ Drift:________

	Chute Number	Trolley Guard	Manways	Control Boards	Baffle Plate	Screens	Tools	Spray	Clean	Remarks

CHECK LIST FOR BATTERY MOTORMEN AND SWAMPERS

#________________ #________________
Motorman Swamper

____
Inspector

1. When do you need a swamper?
2. How close can you follow:
   a. A muck train?
   b. A supply train?
   c. Another motor?
3. How many motors are allowed to be in an airlock at one time?
4. How many men are allowed to ride:
   a. A 4-ton motor?
   b. An 8-ton motor?
5. When is it safe to get on or off a moving motor?
6. When does the swamper walk behind a string of flats being pushed?
7. How far ahead of cars or trucks being pushed should a swamper walk?

   ____ 15 ft. ____ 50 ft. ____ 150 ft. ____ 200 ft.
8. Is a whistle required while swamping?
   Does the motorman have to answer the swamper's signals with his whistle?
9. Where do you get safety glasses?
   Demonstrate use of haulage block lights.
   Demonstrate leaving motor for short time.
   Demonstrate changing batteries.
   Demonstrate spotting trucks or cars.
10. What should a motorman do when approaching men working or walking in haulage drifts?

11. What are the hazards in coupling cars?
    a. Can moving cars or trucks be uncoupled?
    b. In lining up couplers should the car or trucks be stopped first?
12. Where do you stand:
    a. While re-railing cars or trucks?
    b. While train or motor is passing you?
    c. While coupling or uncoupling cars?

REMARKS:________________________________

W.R.C. 3-20-60