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Bureau of Mines
Information Circular 7586

MINING AND MILLING METHODS AT THE CASELTON MINE, COMBINED METALS REDUCTION CO., PIOCHE, LINCOLN COUNTY, NEV.

BY GEORGE H. HOLMES, JR.

United States Department of the Interior — November 1950

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UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
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by

George H. Holmes, Jr.[1/]

CONTENTS

1/ Mining engineer, Minerals Division, Region III, Bureau of Mines, U. S. Department of the Interior.

ILLUSTRATIONS

INTRODUCTION AND SUMMARY

This paper is one of a series being prepared by the Minerals Division of the Bureau of Mines on mining and milling methods and practices at various mines in the United States. It describes such methods at the Caselton mine of the Combined Metals Reduction Co.

The Caselton mine and mill are in secs. 28 and 29, T. 1 N., R. 67 E., M. D. B. & M., Lincoln County, Nev., about 10 miles by paved highway southwest of Pioche, Nev. (fig. 1).

This circular summarizes the history of the district and company operations, describes physical features, labor and living conditions, the geology, ore deposits, and the ore. Prospecting and exploration methods are outlined, and shaft sinking, drifting and crosscutting, and raising are covered under development methods. In the section on mining methods, stoping and slushing are discussed, following which are descriptions of underground transportation, hoisting, ventilation, drainage and sampling, and surveying.

The surface and crushing plants are described, and milling practices are presented in detail with explanation of the filter plant and assay office. Safety practices and the company organization are described in the concluding sections of the circular.

ACKNOWLEDGMENTS

Acknowledgment is made to the Combined Metals Reduction Co., 218 Felt Bldg., Salt Lake City, Utah, for permission to publish this report. Special acknowledgment is due S. S. Arentz, general superintendent of Nevada operations; Paul Gemmill, geologist; R. R. Durk, assistant mine superintendent; W. G. Fidler, mill superintendent; H. E. Swanson, metallurgist; E. S. McIntyre, mining engineer; and Stanley Perkes, chemist, for their cooperation in furnishing data on mining and milling methods and practices and their assistance in the preparation of this circular, which was under the direction of A. C. Johnson, chief, Minerals Division, Region III.

HISTORY

High-grade silver ore was discovered during the 1860's, and Pioche became a camp of great activity, which lasted until 1876, when mining ceased owing to exhaustion of the ore bodies and a heavy flow of water at deeper levels. Some activity ensued during the 1890's, but the camp remained more or less dormant until the early 1900's, when the completion of the Union Pacific Railroad to Caliente and construction of a branch line to Pioche provided cheaper transportation for the higher-grade ores to Utah mills and

and smelters. Early mining was on fissure veins in quartzite and on contact deposits along a major dike. The existence of lead-zinc mineralization in the overlying flat limestone beds was known, but the complexity of the ore and the inability to effect a satisfactory separation prevented any extensive mining. Prior to World War I, E. H. Snyder, president of Combined Metals Reduction Co., began metallurgical experiments on these complex ores to find an effective method of lead and zinc separation. This work was under his direct supervision, and in 1924, after many years of extensive research and experimenting in the field of selective flotation, this problem was solved.

During the 1920's, underground development of the mineralized beds was carried out through the No. 1 shaft, and a large area along the west side of the range was explored by churn drilling. Company operations commenced in 1923, and the higher-grade complex ores were shipped by rail to the company's mill at Bauer, Utah. The Caselton shaft was sunk to a depth of 1,470 feet during the early 1930's, and the 69,000-volt transmission line from Hoover Dam to the Pioche district was completed in 1937. The advent of cheap power made for lower operating costs and was chiefly responsible for the construction of the Caselton mill, which was started during late 1940 and completed in 1941. Originally designed to handle 500 tons daily, its capacity was increased to 1,000 tons in 1943. Construction of the Caselton mill by the Combined Metals Co. gave impetus to the mining industry in the Pioche and adjoining districts, because lower-grade ores could be mined and milled at a profit, as the company was willing to accept custom ores from other properties.

Production from the Combined Metals mine has been continuous since 1923, and the mill has a record of uninterrupted operation since 1941. It is estimated that 1,925,000 tons of ore has been mined since operations began, of which 900,000 tons was treated in the Caselton mill. In addition, an estimated 700,000 tons of custom ore has been milled.

PHYSICAL FEATURES, COMMUNICATIONS, AND UTILITIES

The Caselton plant is on the southwest side of the Ely range of mountains, a northwest trending range that attains an altitude of 7,300 feet. Altitude at the mine is about 6,000 feet. A paved road connects the property with U. S. Highway 93, about 6 miles to the northeast, and a spur from the Caliente-Pioche branch of the Union Pacific Railroad extends from Pioche to the mine.

The town of Pioche, county seat of Lincoln County, is on the northeast slope of the Ely range about 2-1/2 airline miles from the Caselton plant, and is situated on U. S. Highway 93, 108 miles south of Ely and 193 miles north of Las Vegas, Nev. The Pioche branch of the Union Pacific Railroad connects with the main line at Caliente, 25 miles to the south. Lead concentrates are transported over this rail system to the International Smelting & Refining Co.'s smelter at Tooele, Utah; zinc concentrates are shipped by rail to the Anaconda Copper Mining Co.'s reduction works at Great Falls, Mont.

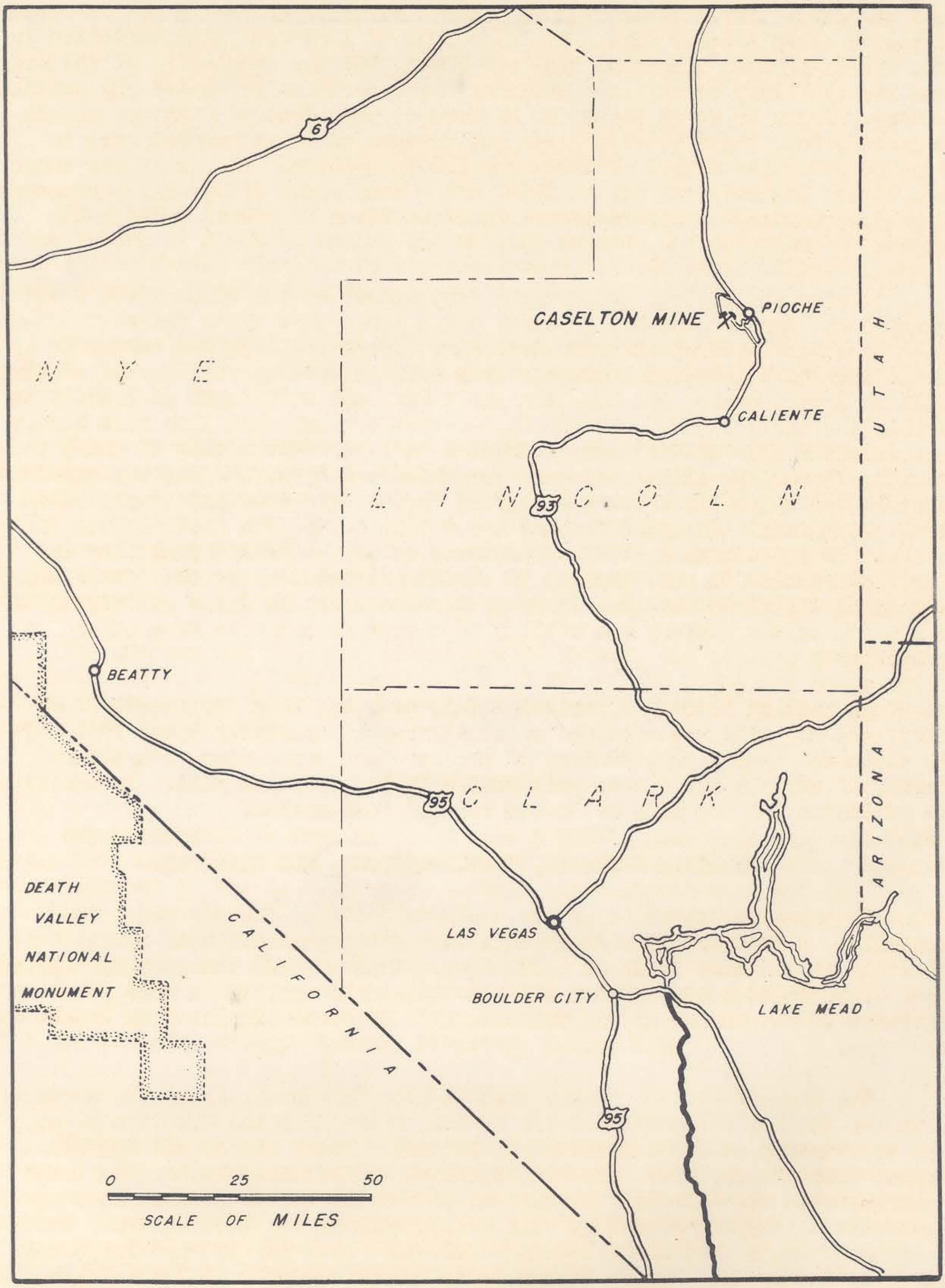


Figure I. - Location map.

The prevailing climate is semi-arid, with an average rainfall of about 12 inches more or less uniformly distributed throughout the year. Sagebrush and scattered junipers comprise the vegetation along the valleys and low hills, pinon pines and other evergreens occurring at higher elevations.

Telegraphic facilities are available at the Union Pacific depot at Pioche. The plant is connected through the Pioche exchange with long distance telephone lines and a company system of 21 telephones links the mine, mill and surface plant.

Power is supplied from the 69,000 volt line extending from Hoover Dam generators to the Lincoln County Power District No. 1 substation adjacent to the Combined Metals property. Lines carrying 22,000 volts lead from this substation to transformers at the mine and mill, where it is stepped down to 2,300 volts. Power is further stepped down by surface and underground transformers to 110 volts for domestic use and 440 volts for electrically operated mine and milling machinery. The average monthly power consumption is 1,740,000 kilowatt-hours.

Water for mine and mill use is pumped at a 2,500 gallon-per-minute rate from mine sumps to surface storage tanks; a 100,000 gallon storage tank supplies the mill. A unique system, used to provide water for domestic use and to augment the Pioche water supply, utilizes a drift driven to the northwest on the 1,200 level of the Caselton mine and terminating in quartzite in an area segregated by numerous faults. Water flows from these faults at a 200 gallon per minute rate and is impounded in the drift by a concrete dam. It flows by gravity through a 10-inch pipe line to a sump at the 1,200 station and is pumped to surface storage tanks by a 350-horsepower multistage centrifugal pump. The water is then pumped by two 30-horsepower centrifugal pumps to tanks serving the plant, company houses, Caselton housing units, and to supplementary Pioche water storage. Take-off lines from the shaft column provide drinking water in the mine.

LABOR AND LIVING CONDITIONS

The Caselton plant operates on a 6-day-week basis, the mine operating two shifts, the crushing plant one shift, and the mill three shifts daily. Necessary shaft and equipment repairs are made on the seventh day. Workmen alternate shifts every 2 weeks. Mining is on contract, based on linear footage advance in drifts, crosscuts, and raises and on cubic-foot excavations in stopes.

On October 1, 1949, there were 291 employees at the Caselton mine and mill. The supervisory and labor force were grouped in the following categories:

Mine, supervisory, technical, clerical........	16
Mine, labor......................................	204
Surface, supervisory, technical, clerical.....	16
Surface, labor...................................	55

The surface labor force distribution was:

Mill....................................	17
Construction............................	13
Assaying................................	5
Mechanical, carpentry...................	20

The 32 staff personnel include 15 technical and clerical employees.

Employees live in the nearby towns of Pioche, Panaca, and Caliente, or in the F.H.A. housing units that were constructed in 1942 and 1944 at Pioche and adjacent to the Caselton mine. The Pioche housing authority comprises 120 family units; the Caselton group consists of 40 family units, a dormitory with accommodations for 70 single men, a community building, and boarding house. Construction of these units greatly alleviated a critical housing shortage.

Eleven company-owned homes, a guest house, and a staff house accommodate key supervisory personnel. Four additional dwellings are under construction.

School is held at Caselton for children in the first three grades, after which they are transported by bus from Caselton to a grade school at Pioche or to the Lincoln County high school at Panaca.

GEOLOGY

The Caselton area, along the southwest side of the Ely range, consists of flat-bedded Paleozoic sedimentary rocks that have been greatly disturbed by widespread faulting. Nearly all of the faults are premineral with major to minor displacement. Normal faulting predominates, but some thrust faulting is evident. The formations are consistently uniform and persistent with but little folding or tilting. Major east-west trending and steeply dipping fissures cross the formations and are considered to be the source of mineralization in the flat-lying Combined Metals limestone beds.

The columnar section shown in figure 2 and the following description of the stratigraphy are based on University of Nevada Bulletin 34, Geology and Mining Series.2/

The lowest formation is the Prospect Mountain quartzite, a red to buff and white, generally massive quartzite containing some narrow silver-lead fissure veins in the mine area. The Pioche shale, lying conformably over the quartzite formation, is a yellow to brown, micaceous, arenaceous shale and sandstone with numerous intercalated limestone beds. Economically, this formation is most important, as replacement mineralization has taken place in numerous limestone beds in areas cut by fissures. The Combined Metals beds occur in this formation.

2/ Revisions in the Camrian Stratigraphy of the Pioche District, Nevada, by Harry E. Wheeler.

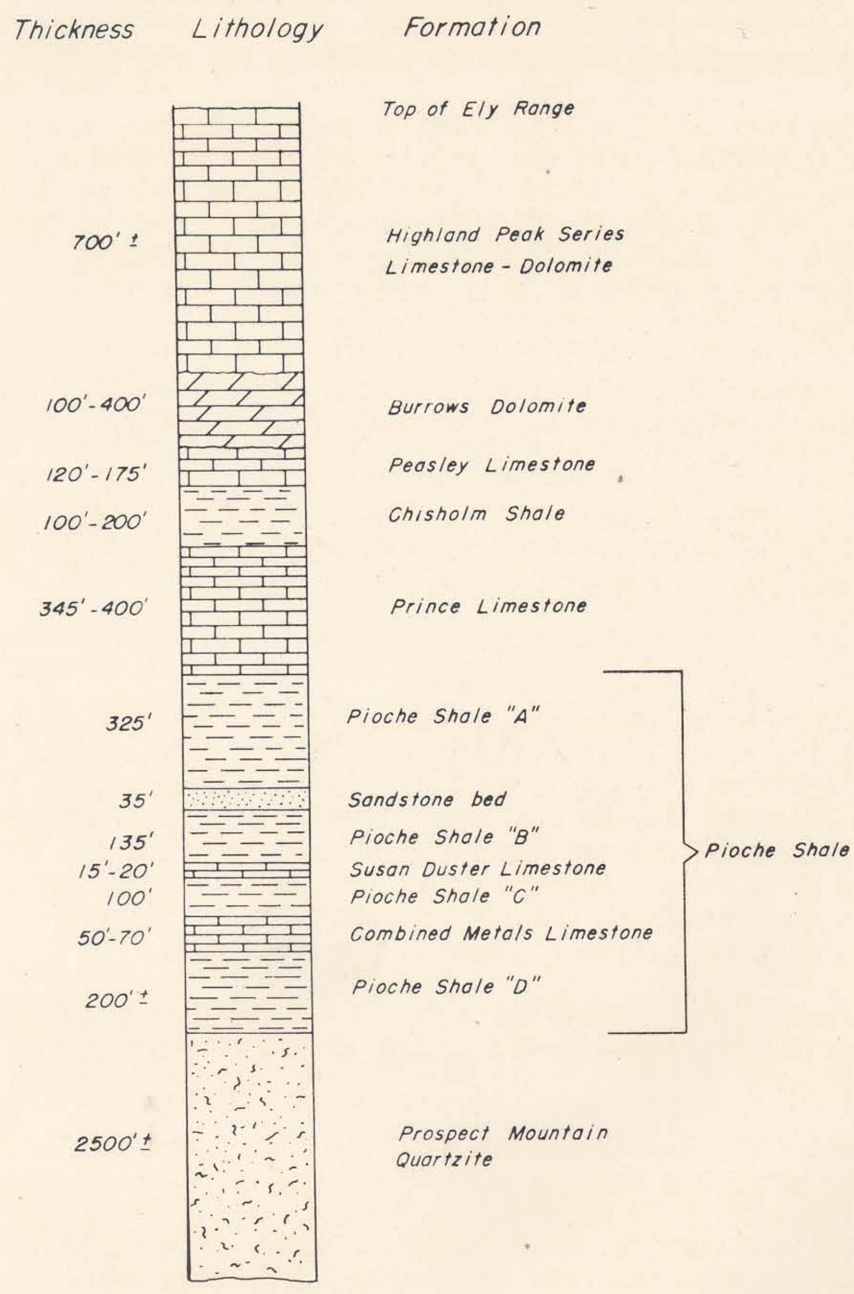
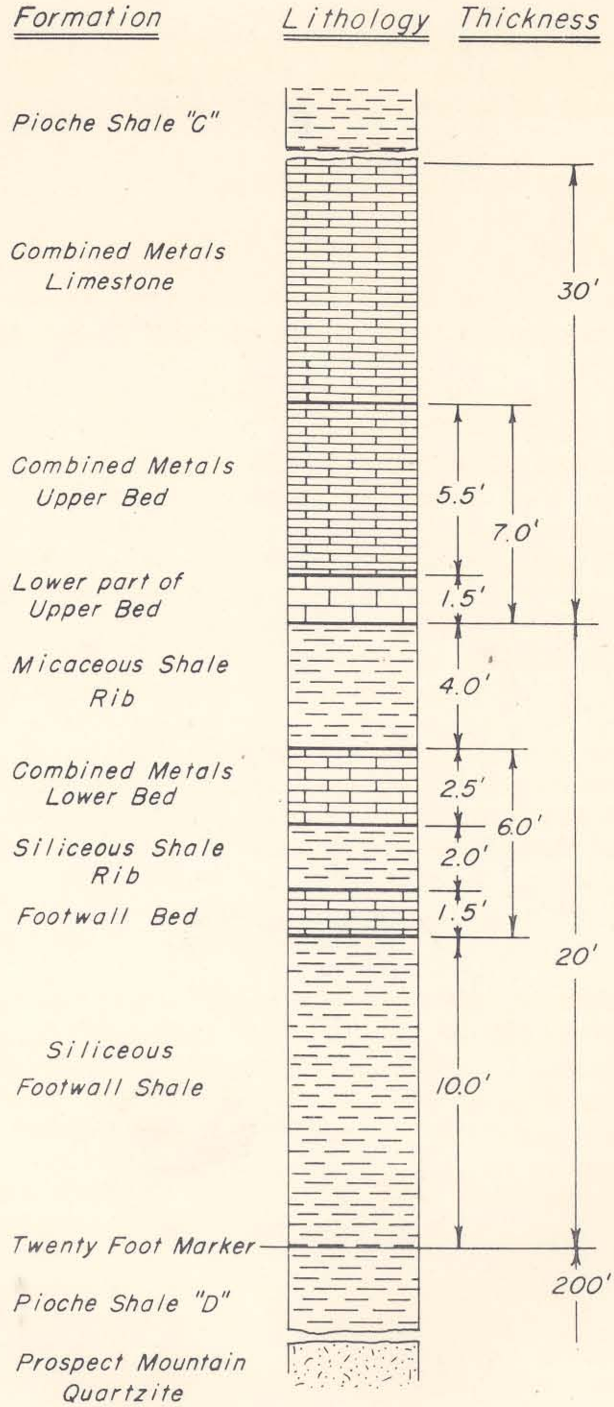


Figure 2. - Stratigraphic section at Caselton mine.



From Company Map

Figure 3. - Average section of ore horizon, Combined Metals limestone.

Conformably overlying the Pioche shale is the Lyndon (Prince) limestone, a fine- to medium-grained, light- to dark-gray limestone. This formation conformably underlies the yellow-buff to brown, fine-grained, micaceous Chisholm shale.

The dark-gray, massive Peasley limestone conformably overlies the Chisholm shale, and this formation is, in turn, unconformably overlain by the light- to dark-gray, sugary Burrows dolomite. Lying unconformably on the Burrows dolomite is the Highland Peak limestone, a limestone and dolomite with a very minor amount of interbedded shale and sandstone layers. This formation forms the top of the series in the Caselton area.

ORE DEPOSITS

The bedded ore deposits in the Caselton mine occur in the lowest limestone member in the Pioche shale and were formed by replacement of portions of this favorable bed by mineral-bearing solutions introduced through fissures that cut across the formations. The tabular deposits occur along and close to the mineralizing fissures and have been mined for lengths of 700 feet, widths of 450 feet, and thicknesses up to 50 feet. The average thickness of the deposits is 17 to 25 feet. An average section of the ore horizon in the Combined Metals limestone is shown on figure 3.

Essentially, the Combined Metals formation is a thin-bedded, nodular, carbonaceous limestone averaging 40 feet in thickness in the mine workings. Two shale strata, or ribs, which separate the Footwall and Lower Limestone beds from the Combined Metals limestone proper, occur in the lower part of the formation. The following descriptions, used in conjunction with the section shown in figure 3, explain the various ore-bearing and barren strata found in this formation.

The top mineralized bed is designated Combined Metals Upper Bed and includes all replaced limestone from the Pioche Shale "C" overlying the Combined Metals limestone down to the underlying Micaceous Shale Rib. The mineralized section of the bed ranges in thickness from 1.5 to 30 feet and averages 7 feet including the Lower Part of the Upper Bed. As the bottom of this bed contains heavy mineralization in a more massive limestone, it has been named Lower Part of Upper Bed. This section ranges from 6 inches to 3 feet in thickness and averages 1.5 feet.

Extending from the bottom of the Upper Bed to the top of the Combined Metals Lower Bed is the Micaceous Shale Rib, a dark-gray to black, soft, highly micaceous, sparsely mineralized, calcareous shale, which forms a good hanging wall for stopes in the lower beds. This rib ranges in thickness from 2 to 6 feet, averaging 4 feet.

The Combined Metals Lower Bed lies between the Micaceous Shale Rib and the Siliceous Shale Rib, ranges from 1.5 to 4 feet in thickness, and averages 2.5 feet. This bed is a massive blue limestone, although sometimes difficult to distinguish from the enclosing shale, and where mineralized it makes good ore.

The hard, sandy, Siliceous Shale Rib, averaging 2 feet in thickness, is interbedded between the Combined Metals Lower Bed and the Footwall Bed. Ore is usually found in this rib where the Footwall and Lower Beds are well replaced.

The lowest mineralized member of the series, designated Footwall Bed, is between the Siliceous Shale Rib and the underlying siliceous Footwall shale. Ranging from 6 inches to 2 feet in thickness, and averaging 1.5 feet, it is often difficult to distinguish from siliceous shales, but when replaced makes good ore.

The barren, underlying, siliceous Footwall Shale is a hard, sandy, siliceous, micaceous shale averaging 10 feet in thickness and is often mistaken for quartzite. It is usually darker gray and harder than the Pioche Shale "D".

A persistent band of quartz and lead-zinc sulfides, ranging in width from 1.5 to 6 inches, generally separates the Siliceous Footwall Shale from the Pioche Shale "D". It is known as the Twenty-Foot Marker and is usually found about 20 feet below the Combined Metals Upper Bed. The band is remarkably uniform throughout the mine and is a fissure type of mineralization between disssimilar formations.

Pioche Shale "D", the bottom layer of the Pioche Shale, is a light- to medium-gray, siliceous, micaceous shale extending between the Twenty-Foot Marker and the underlying Prospect Mountain quartzite. It averages 200 feet in thickness.

THE ORE

Principal ore-forming minerals in the Caselton mine are the primary sulfides galena and sphalerite plus large quantities of pyrite and minute quantitites of chalcopyrite. Silver occurs in association with the galena. An average analysis of the sulfide ore now being mined is 0.06 ounce gold, 4.0 ounces silver, 4.0 percent lead, and 10.0 percent zinc.

Oxidation of the sulfide ores in elevated fault blocks of the ore-bearing beds has resulted in alteration of the sulfides to carbonates and sulfates. Principal oxidized minerals are cerrusite and plumbojarosite, with smaller amounts of anglesite and hydrozincite. Owing to the absence of limestone beneath the ore beds, zinc has been almost completely removed in soluble form.

PROSPECTING AND EXPLORATION

Since 1926, exploring for sections of mineralized beds has been done intermittently by churn drilling from surface. A detailed study was made of the geology of the district and of ore occurrences in the Combined Metals bed and their relationship to major faults and fissures. Churn-drill holes have been spotted by using available evidence, both surface and underground, to delineate targets in the favorable beds. This work has resulted in the discovery of additional large ore bodies and has given much valuable information that is used repeatedly in further search for ore.

Widespread faulting makes detailed geologic mapping necessary to determine displacements of the bed and to locate the drill holes accurately. The number of holes drilled and their proximity to one another depends on the character and grade of the ore body.

Holes are drilled from surface to depths of 500 to 1,500 feet, according to the location of the displaced section of the Combined Metals bed. The size of the hole depends on the number of times it is estimated casing will be required. Experience has shown that a 2-inch reduction in diameter is required each time the hole is cased. The minimum size of the hole is governed by the space needed around the stem or bit for fishing and the minimum size that will give sufficient weight for drilling. A 4-inch diameter is about the minimum for deep holes; if the hole is originally started with a 10-inch diameter, it can be cased and advanced with 8-inch tools, again cased and advanced with 6-inch tools, followed by a third casing and advancing with 4-inch tools. A hole is started with a diameter of 12 inches if it is to reach 1,500 feet or more.

A hole drilled as deep as possible and still short of its objective can be cased and finished by diamond drilling from the bottom of the hole. Diamond drilling also can be used to deflect a hole around lost churn-drill tools and continue it to completion.

Four company-owned churn drills are used; two-man drill crews work under a straight labor contract, or bonus system, during drilling operations and on a straight days' pay basis when moving or repairing equipment.

Underground diamond drilling is used to explore for extensions and displaced sections of known mineralized areas. Holes are comparatively short, not exceeding 450 feet in depth. Three air-driven drills are owned by the company, but drilling usually is done under contract at present, as the work is intermittent and not sufficient to require the continuous service of a drill crew. Holes are drilled at varying angles from vertical up to vertical down holes, and most of the drilling is done with the AX size bet. Core recovery is good; little reaming and casing is required.

The diamond drill has been used for some exploratory holes from surface, but as most of these holes penetrate major faults, which contain broken ground and heavy gouge, it has not proved satisfactory under this condition. Churn drilling has been found more economical and efficient as holes can be kept dry above groundwater level, and below water level less caving results from non-circulation of the water.

Churn drill holes are sampled from cuttings taken at 5-foot intervals. Visual logs are kept of each hole; representative cuttings from the 5-foot intervals are cemented in 3-inch wide columnar sections mounted on 4-foot by 5-1/4-inch boards. Each 1/2-inch column intervals represents 5 feet of the drill hole. This method gives an excellent cross section of the formations penetrated.

Significant sections of diamond-drill core are split; half is used for assaying and half is stored in the core library for future reference.

Exploration equipment used for churn drilling comprises the following gasoline engine-powered drills:

1 Small truck-mounted unit that can drill a hole of small diameter 1,000 feet.

1 Unit, rated as capable of drilling to 3,000 feet.

2 Old drills that have been modernized.

DEVELOPMENT METHODS

Development procedure comprises driving main haulage drifts under mineralized sections of the Combined Metals bed, raising to the approximate level of the ore body, and driving development drifts and crosscuts to the limits of the ore zone. (Fig. 4). Secondary raises extend from development drifts to displaced sections of the ore body which are further developed by sub-drifts and raises. Sections 40 to 80 feet wide are blocked out for subsequent mining by a retreat system of stoping. Sub-levels are driven from main raises under stoping areas to facilitate handling the broken ore.

The following sections explain the current methods of shaft sinking, drifting and raising.

Shafts

The 1,470-foot Caselton shaft was sunk on the southwest side of the Ely range during the early 1930's, and nearly all mining is now carried on through this shaft. The older, No. 1, shaft, about 10,000 feet to the northeast, is used for ventilation and to service the few leasers operating on mineralized beds in this area.

The Caselton shaft is vertical and has four compartments - two for hoisting ore, one for auxilliary hoisting, and one for a manway, pump columns, power cables, airlines, etc. (fig. 5). Over-all size of the shaft is 17 feet 10 inches by 5 feet 10 inches; main hoisting compartments 4 feet 6 inches quare; auxilliary compart 4 feet by 4 feet 6 inches; and the manway 2 feet by 4 feet 6 inches. Timber is Oregon fir and Port Oxford cedar, 8- by 8-inch timbers being used for wall-plates, end-plates, and corner posts, and 6- by 8-inch timbers for dividers and side posts. Bearing set timbers are 8- by 10-inch and 6- by 10-inch fir placed in the shaft at 100-foot intervals. Two- by 12-inch and 2- by 6-inch lagging is used between the main hoisting and auxilliary compartments and along shaft walls.

Levels were opened from the shaft at 660, 840, 1,200, and 1,400 feet. The Caselton 1,200 level connects with the 1,200 level from the No. 1 shaft, which is at the same elevation. The Caselton 1,400-foot level is connected through raises with the No. 1 1,200 foot level.

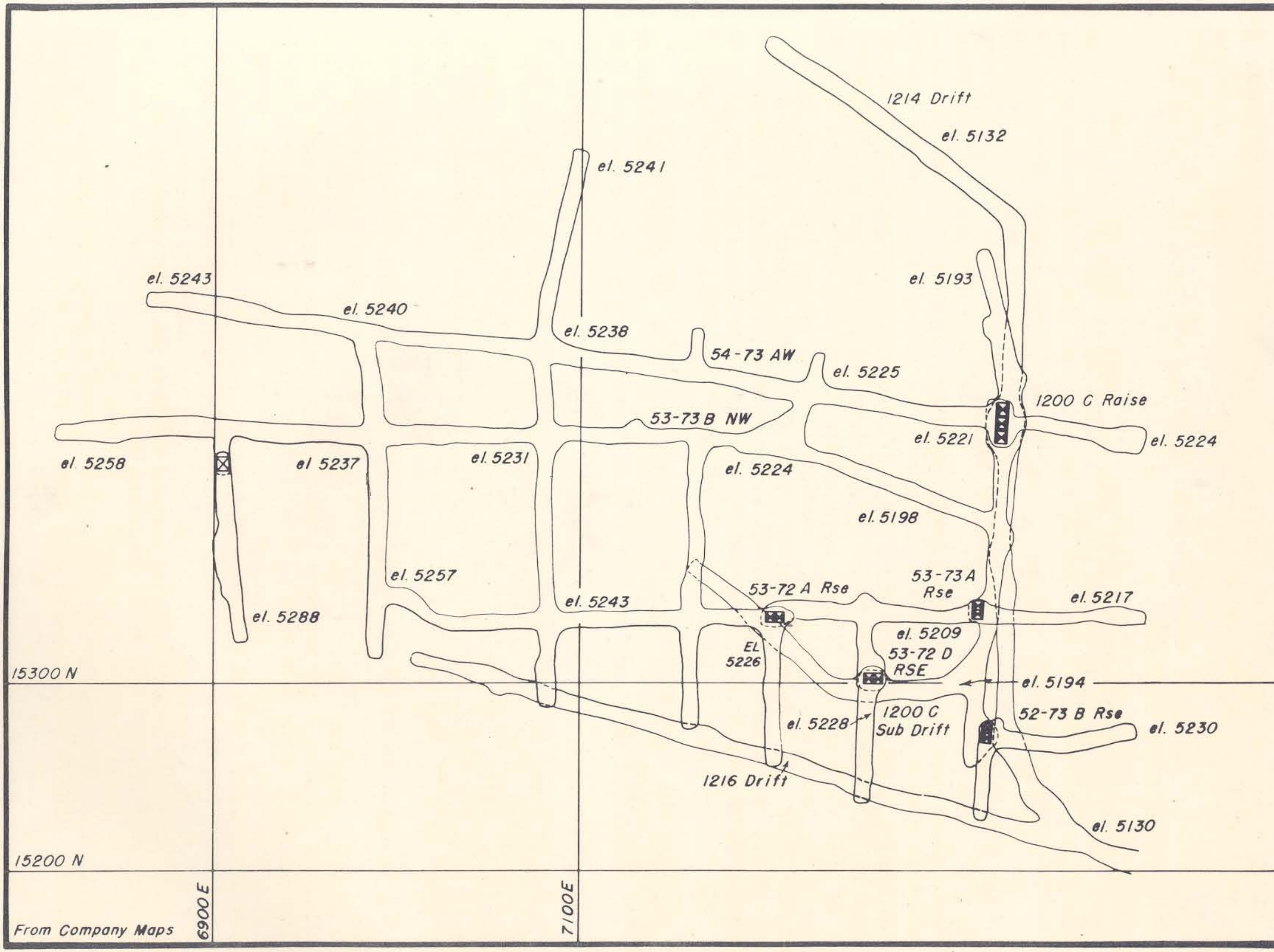


Figure 4. - Development method in mineralized area, Caselton mine.

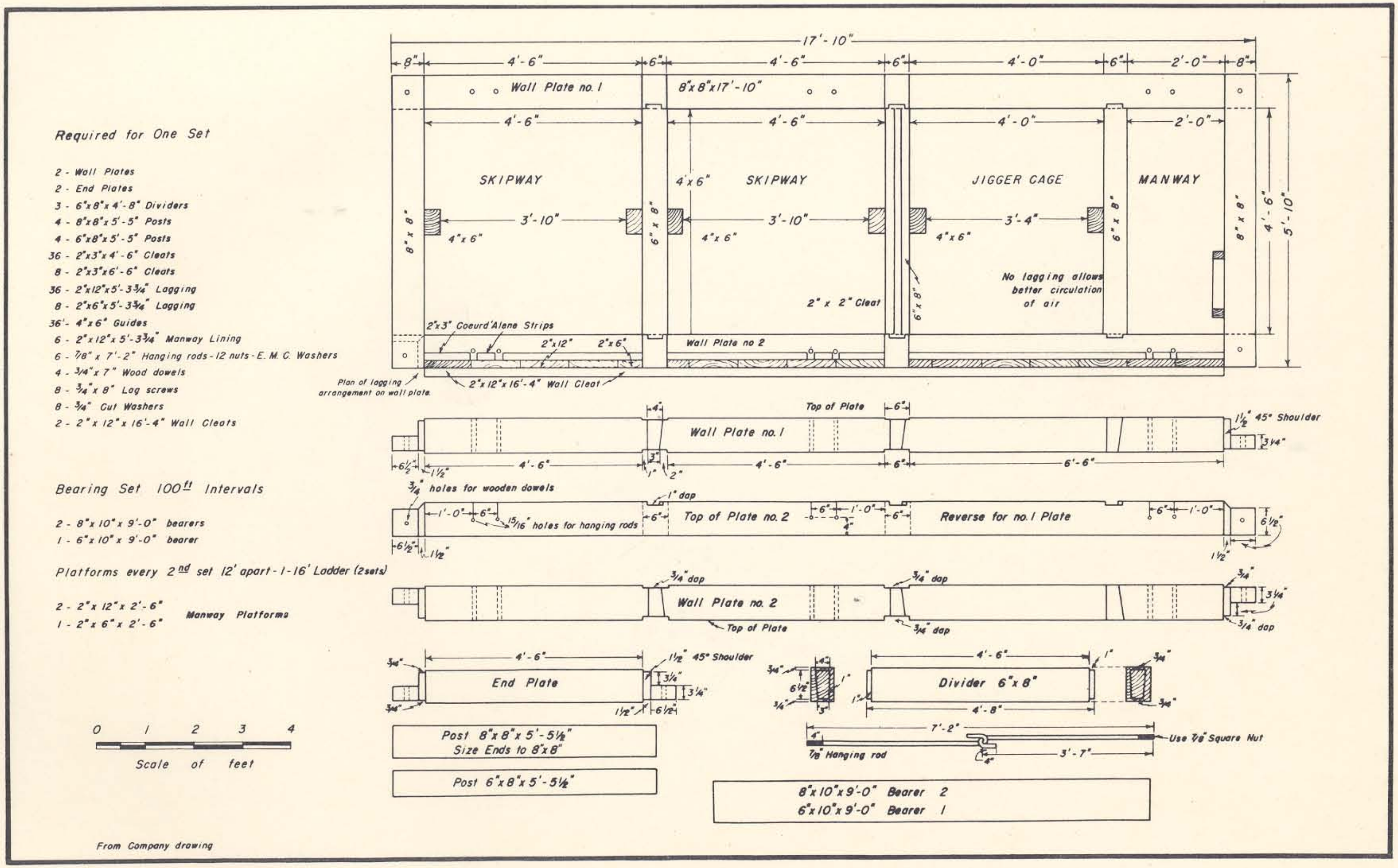


Figure 5. - Plan of Caselton shaft timbering.

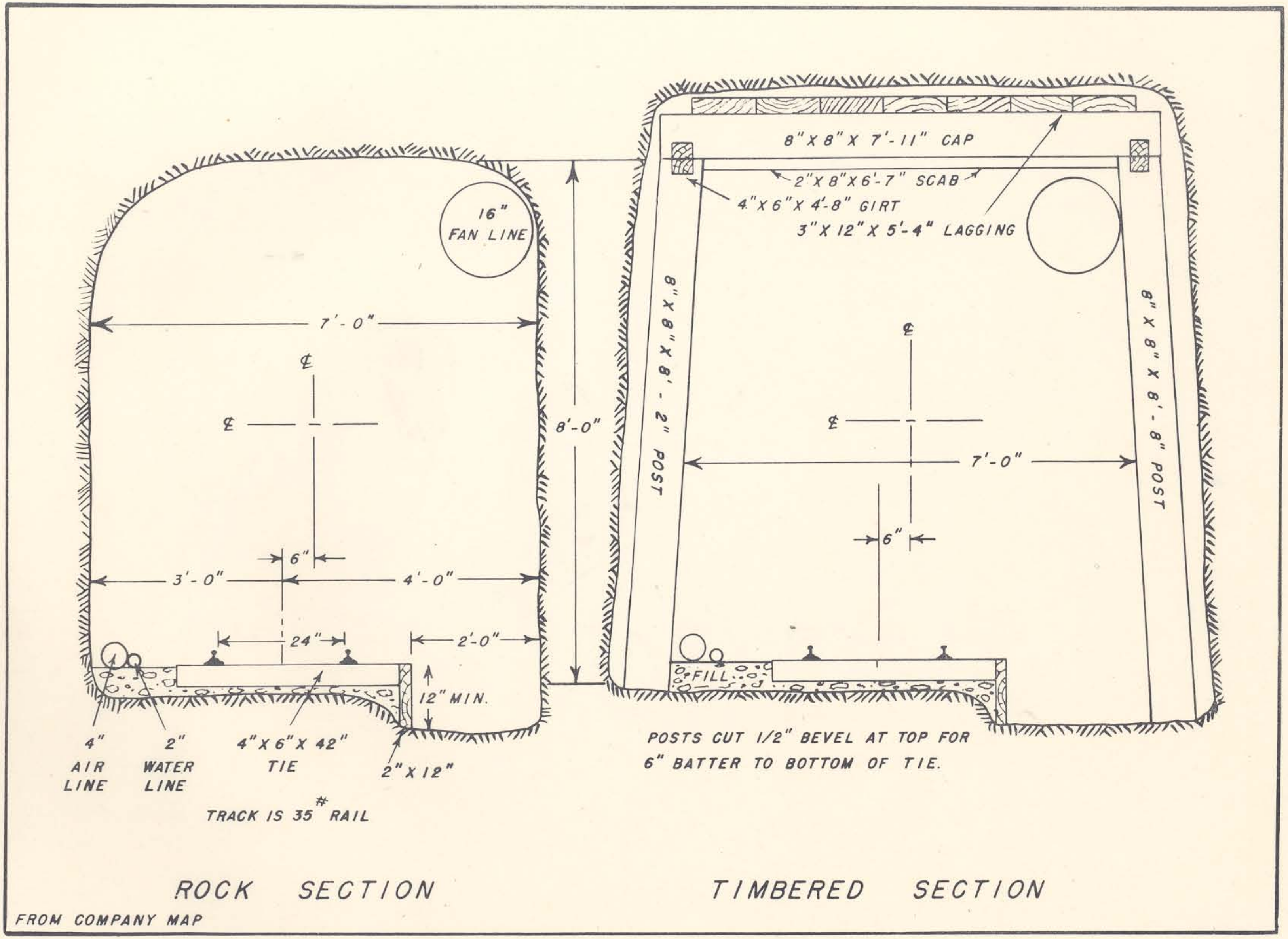


Figure 6. - Standard drift sections, Caselton mine.

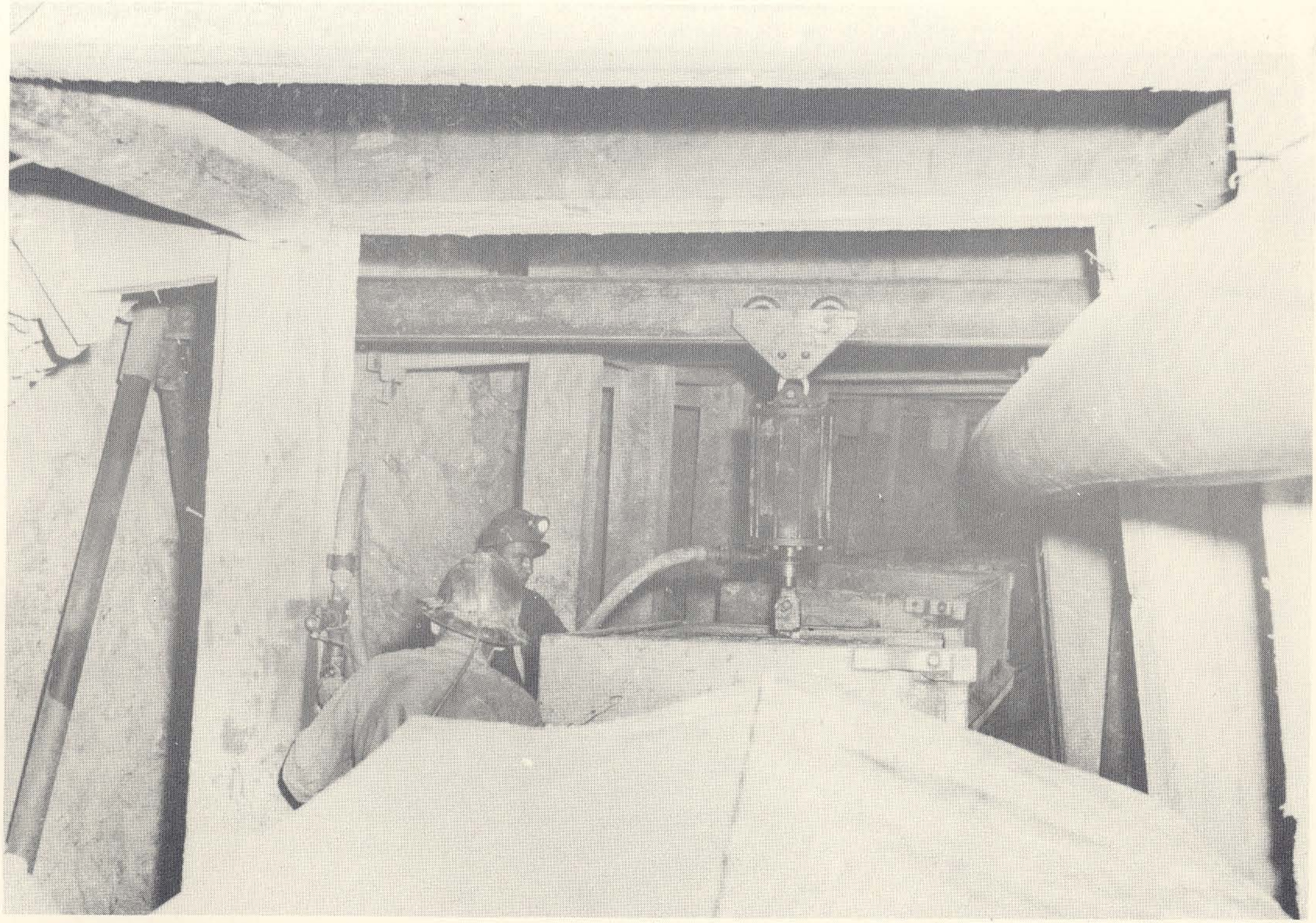


Figure 7. - Cherry picker in action, Caselton mine.

Drifts and Crosscuts

Main haulageway drifts and crosscuts are driven to provide a minimum cross section 6 by 8 feet (fig. 6). Drifts in soft or caving ground are driven up to 8 by 9 feet and are supported with 8- by 8-inch or 10- by 10-inch fir timber set on 5-foot 4-inch centers. Usual batter is 6 inches to bottom of rail ties. Girts or collar braces are 4- by 6-inch or 6- by 6-inch fir; top lagging is 3- by 12-inch fir, and side lagging is 2- by 8-inch pine. A recent innovation is the use of surplus Army Air Corps steel landing mat for side lagging in timbered drifts and stopes. This material is 3/16 inch thick, perforated with staggered 2-1/2-inch holes, and is made in interlocking strips 10 feet long by 18 inches wide. Its greater strength is a decided advantage in heavy ground and caving stopes in preventing a break-through into drifts or newly timbered stope sections.

A 21-hole V-cut round is used, but in hard quartzite a pyramid or burn-cut round gives better results. Drilling is done by two 3-1/2-inch automatic feed drifters mounted on a double-boom, hydraulically controlled jumbo and using 1-1/8-inch lugged, hollow, round steel in 4- and 8-foot lengths. Holes are drilled to a depth of 7-1/2 feet, and the round breaks from 5 to 7 feet. Some drifting also is done with a company-made jumbo designed to operate in small headings. This machine weights about 1,800 pounds and mounts two automatic drifters. Column-mounted, 3-1/2-inch, automatic drifters also are used occasionally. From 140 to 200 1-1/4- by 7-inch sticks of 45-percent gelatin dynamite are used for blasting a round. Detonation is by conventional fuse and caps; electric blasting caps are used in wet headings.

Detachable drill bits are used, the screw-on type being replaced by the newer push-on throw away type bit. Extensive experimenting with several types of detachable bits, including the tungsten-carbide insert type, has shown the punh-on bit to give higher drilling speed and a lower cost per foot of hole drilled. This single-use bit has a lower initial cost, is used to destruction, and requires no resharpening. Preparation of drill-steel shanks is simplified, as no threads are required. Smaller-diameter holes are drilled, starting with the 1-7/8-inch size and with 3/32-inch reductions in gage to bottom the hole at a diameter of 1-19/32 inches. These bits also are used for stoping and raising.

Mucking is done with mechanical mine-car loaders, which load directly into 50 cubic foot-capacity, roller bearing, side-dump cars. Cars are spotted by the haulage locomotive and are changed by use of an air-operated "cherry picker," which lifts an empty car from the track, transfers it to one side, and permits the loaded car to be pulled back from the loader (fig. 7). Trains are made up of 12 to 20 cars and hauled to the station by storage-battery locomotives.

Sublevel drifts in ore are driven 5 by 7 feet or 6 by 7 feet in the clear. A 14-hole V-cut round is used, drilled by 3-1/2-inch automatic or 3-inch hand-cranked drifters mounted on a 4-inch column and using 1-1/8-inch lugged, hollow, round steel. About 60 sticks of 45-percent gelatin dynamite are used per round with a usual advance of 5 feet.

Mucking is by mechanical loaders, which load directly into 20 or 50 cubic foot-capacity side-dump cars, which are hauled by storage-battery locomotives to haulage-level raise chutes.

Compressed air pressure at the drills is maintained at 90 pounds. It passes down the shafts through 8-inch pipe lines and along drifts and raises through 6- and 4-inch lines. Two-inch lines are extended to stoping areas.

Water for the drills is taken off the 6-inch pump columns in the shaft in 1- and 2-inch pipe lines and carried under 100 pounds pressure to mine workings. One-half inch water lines extend to the stoping areas.

Pipes are coupled by self-alining couplings.

Major equipment used for drifting and crosscutting comprises:

- Automatic 3-1/2-inch drifters
- Automatic 3-inch drifters
- Hand-cranked 3-inch drifters
- Twin hydraulic drill jib on track-mounted jumbo
- Rocker shovels, 4,200 lb. class
- Rocker shovels, 7,400 lb. class
- Mine-car loader, 4,100 lb. class
- Mine-car loader, 4,400 lb. class

Raises

Raises from main haulage drifts and sublevels vary from 20 to 375 feet in height and are of several different designs. The types most commonly used are shown, with timbering details and specifications, in figures 8 and 9. Both are three-compartment raises with two ore chutes and a combination manway and hoisting compartment. Principal difference is the location of the ore chutes - adjoining in one type and separated by the manway-hoist compartment in the other. A disadvantage of the former is the difficult experienced when broken ore is hung up in the outer chute; an advantage is the protection of the manway-hoisting compartment in heavy ground.

Hoisting compartments are used for transporting men and supplies. Two main-level raises have cages operated unbalanced by 30- and 50-horsepower, single-drum, manually operated, electric hoists; a third has a 20-horsepower, automatic, counterweight hoist with both cage and station push-button controls. Other raises use 20-horsepower, spur-gear, unbalanced, single-drum, electric hoists. Cages are fitted with doors and safety dogs and 1/2- and 5/8-inch, 6 by 19, plow-steel, hemp-center wire rope is used. Smaller cages or crossheads in raises from sublevels to stopes are operated by 7-1/2-horsepower, single-drum, utility-tugger air hoists.

The manway section of the compartment is fitted with ladders for an emergency exit and carries the compressed-air and water lines and power cables.

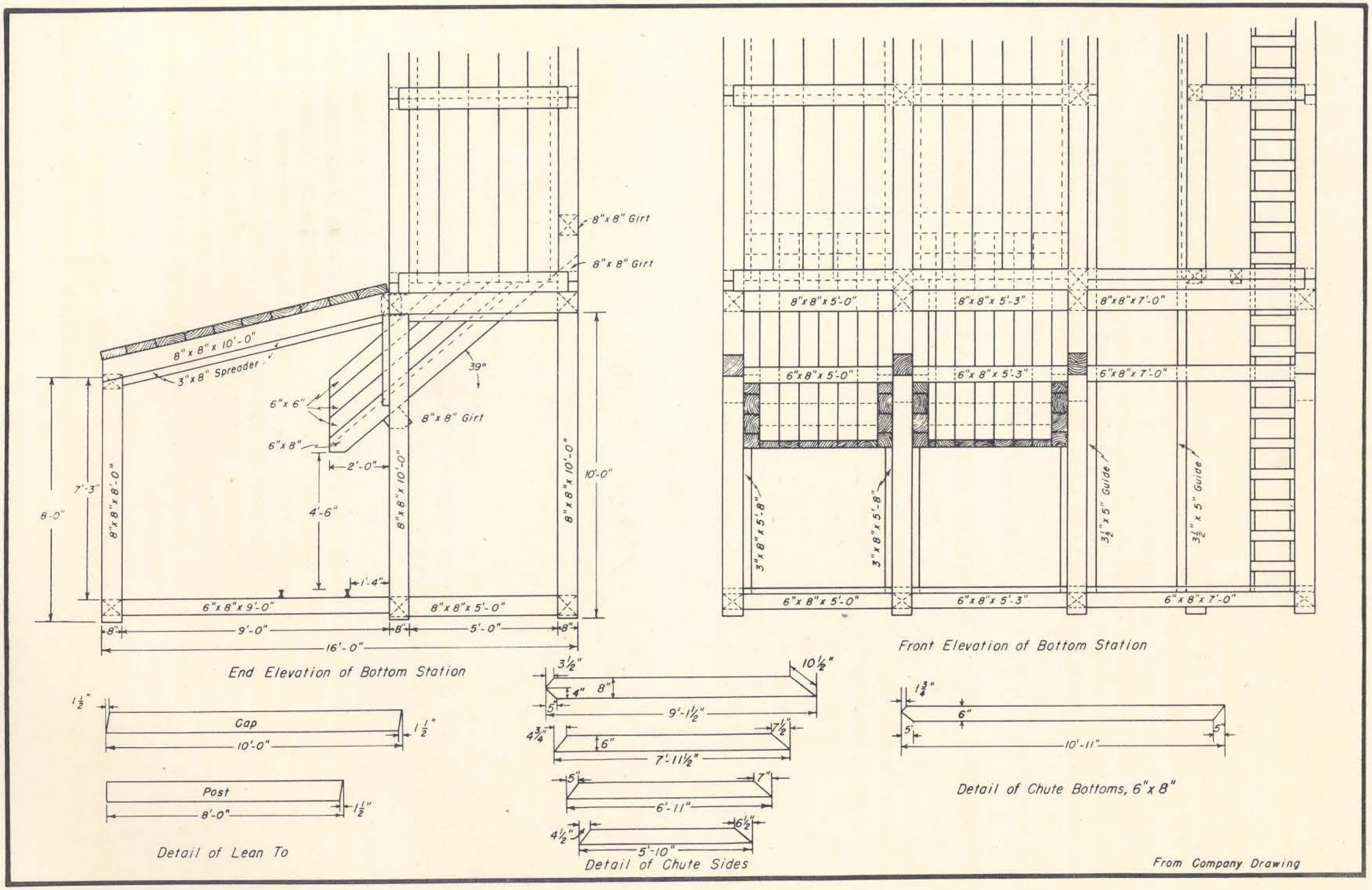


Figure 8. - Three compartment square set raise, Caselton mine.

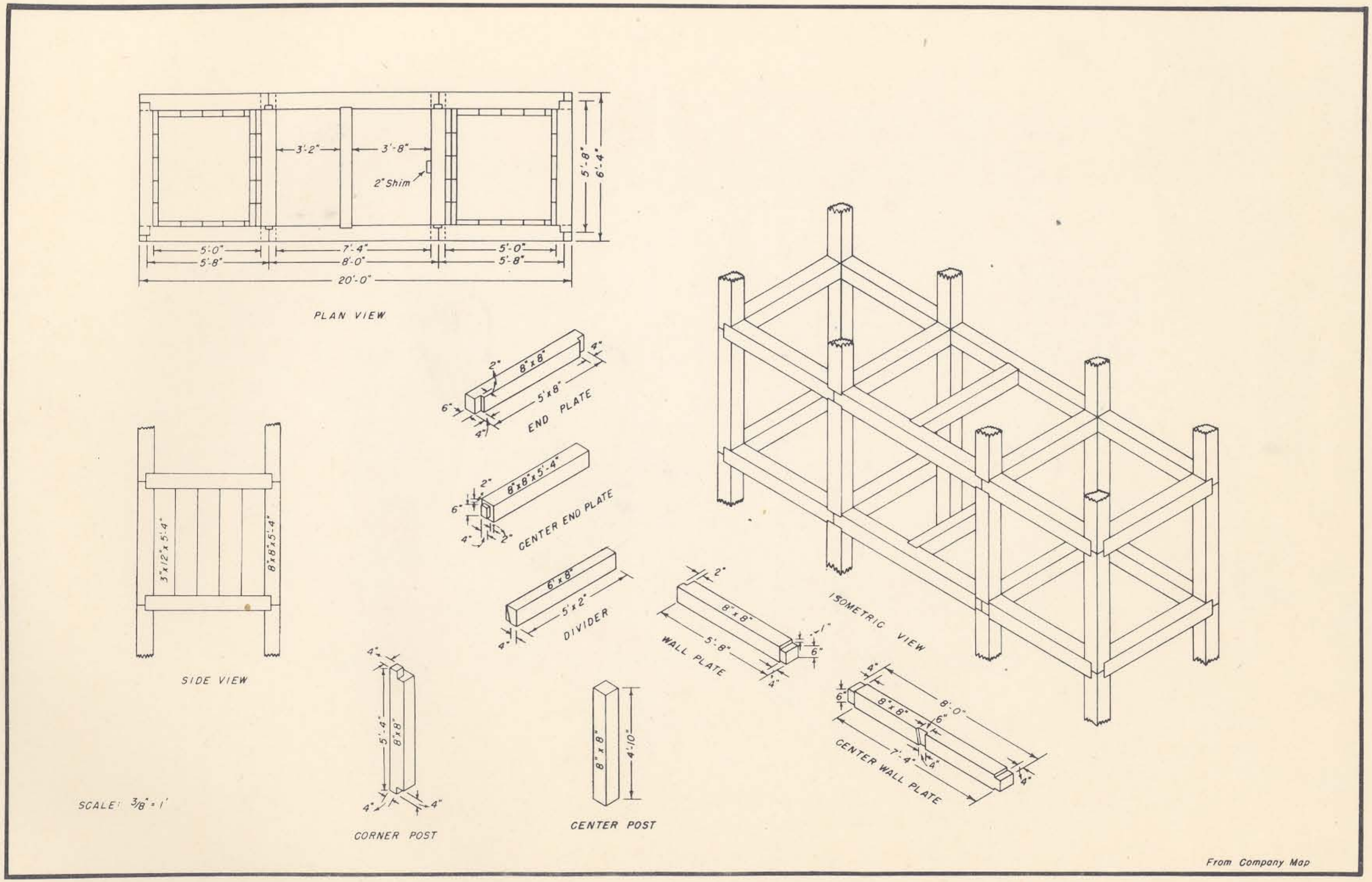


Figure 9. - Standard square set raise, skipway manway in center, Caselton mine.

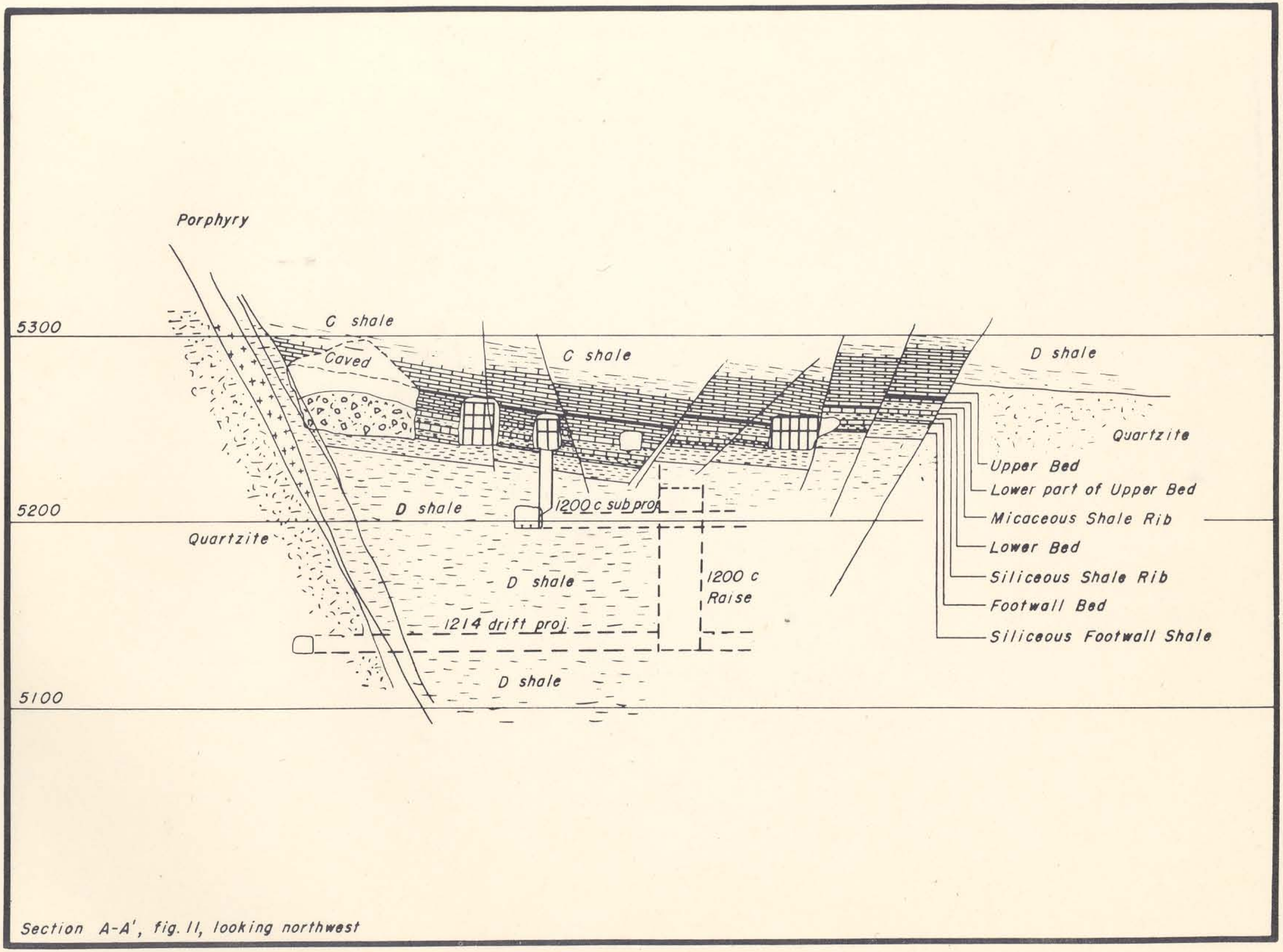


Figure 10. - Section through stoping area, Caselton mine.

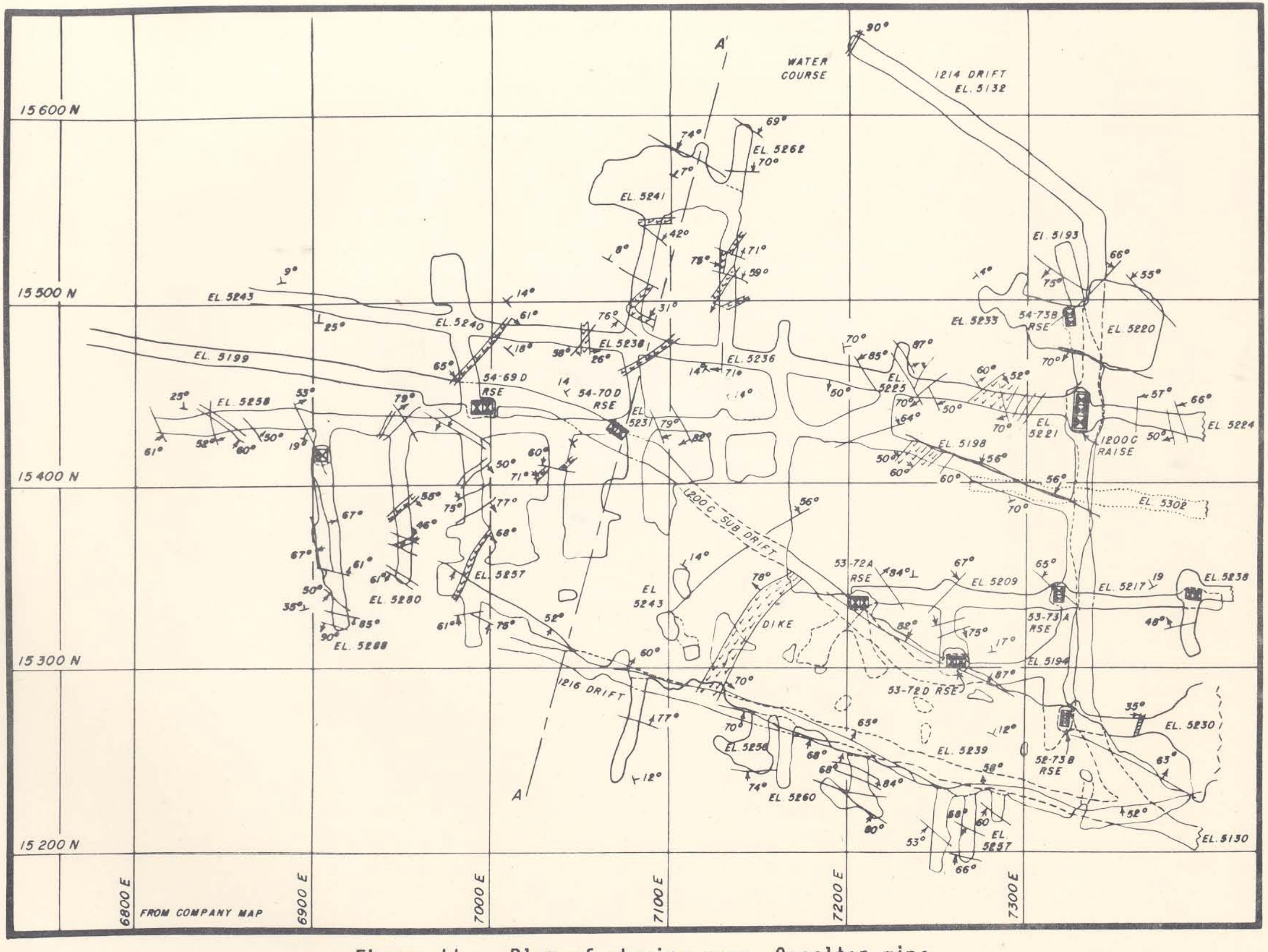


Figure 11. - Plan of stoping area, Caselton mine.

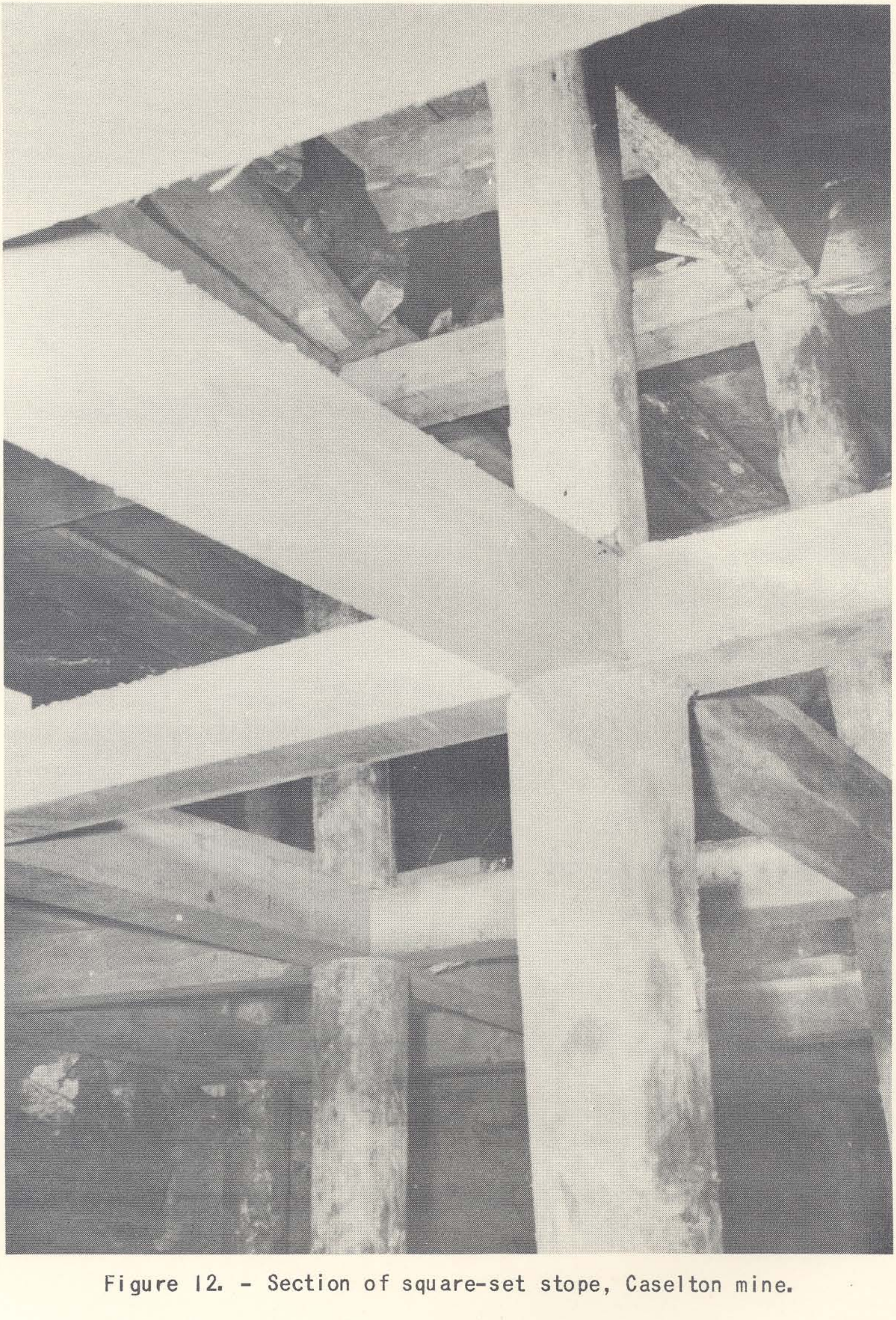


Figure 12. - Section of square-set stope, Caselton mine.

MINING METHODS

Stoping

The irregular, flat-dipping, displaced sections of the Combined Metals bed occur between major pre-mineral faults; the mineralized strata comprising the upper and lower beds separated by the micaceous shale rib (fig. 10). Minor faulting within the blocks has further displaced the ore bodies, causing variations in dip and strike and complicating their mining.

A retreat system of stoping with two variations is used, mining the upper and lower beds separately or simultaneously. Prior to 1941, the beds usually were mined separately, as higher grades had to be maintained to ship the ore to the company's Utah mills. In areas mined in recent years, the micaceous shale rib generally has been better mineralized than in the older sections of the mine. Construction of the mill made possible mining of lower-grade ores, and generally the beds now are mined concurrently. This latter method has proved the more economical, despite the necessity of including the lower-grade micaceous shale rib with the upper and lower mineralized beds.

Mineralized areas are prepared for stoping by driving drifts from the main raises along the strike to the end of the ore zone and crosscutting from these drifts to its outer limits. Blocks are 40 to 80 feet wide (fig. 4). The ground between two crosscuts is mined from the end of a block by retreating back to a development drift. Stoping is done by a series of successive cuts, with stopes supported by stulls or square-set timbering. Pillars also are left to support bad ground (fig. 11).

Height of stope determines timbering method; stopes in comparatively narrow beds are adequately supported by stulls until exposure starts caving of the overlying limestone. Square-set stopes are supported by round timber posts and 8- by 8-inch caps and girts set on 5-foot 4-inch centers. Post lengths in the bottom or initial set range from 7 to 14 feet, according to the dip of the bed, and are cut so that the second and successive stope floors will be level. Posts in regular sets are 7 feet long. Short sets are used, if required, between top floors and back of the stope (fig. 12).

Width of the square-set stope is dependent on the character of the ground but usually is 6 to 8 sets. The cut and subsequent timbering are completed across the block, and a successive similar cut is started closer to the development drift. Stoping and timbering in the second stope always is toward the old stope or pillar. Stopes are safely maintained until the block has been mined; timbers are re-enforced by angle-bracing between sets and tying with used slusher cables.

Timber is some square-set stopes has been salvaged successfully, but usual procedure allows the old stope to cave. Side lagging between adjacent stopes prevents caved material from damaging the operating stope. Pillars ultimately are recovered by stoping, undercutting, and caving or from sub-drifts driven beneath the pillar.

Drilling is done with stopers or column-mounted hand-crank drifters. One-inch, quarter-octagon, hollow drill steel and push-on type detachable bits are used. Blasting is with 45 percent gelatin dynamite, and detonation is by conventional fuse and caps.

Drilling equipment comprises:

3-inch drifters
Automatic stoping drills,
92-, 100-, and 121-lb. classes

Slushing

Mucking in stope development drifts and crosscuts and from both stuff and quare-set stopes is done by slushing, a method that has proved more effective and flexible than the old system of hand-mucking into wheelbarrows or mine cars and hand-tramming to transfer chutes. Cross-slushing is employed; in stope preparation, muck is slushed from crosscuts to main development or slusher drifts, where it also is moved by slushing to transfer chutes. Broken ore from stopes is slushed to crosscuts or development drifts and on to the chutes. Muck from four or five development corsscuts or stopes can be pulled to the main slusher way and easily handled by the large slusher-drift scrapers.

Slushers used for corss slushing from stopes and headings are 5-horsepower, electric, 2-drum, portable type with 3/8-inch pull and 1/4-inch pull-back wire ropes. They pull 26-inch, one-piece, hoe-type scrapers, on which manganese-steel digging edges have been welded. Maximum effective operating distance is 100 feet; the average pull is 50 feet. Semipermanent installations having an average slushing distance of 100 feet use 10- and 15-horsepower double-drum, electric slushers, with 1/2-inch pull and 3/8-inch pull-back wire ropes.

Main slusher drift installations that will be used 6 months or longer utilize 20-horsepower, double-drum, electric slushers with 1/2-inch pull and 3/8-inch pull-back wire ropes attached to 32-inch hoe-type scrapers, also fitted with manganese-steel digging edges. Two scrapers frequently are used in tandum, spaced to give an effective range of 300 to 500 feet (fig. 13). Average slushing distance is 300 feet.

The type of wire-rope construction used by the slushers is 6 by 19, preformed, improved plow steel with hemp centers. Six- and 8-inch, snatch type, roller-bearing-equipped slusher blocks are used. Wire-rope consumption is high, but it is more than offset by the saving in labor cost. Scrapers are made in company shops.

TRANSPORTATION

On sublevel haulage drifts, ore from stope-raise chutes is loaded into 20 or 50 cubic foot-capacity, side-dump cars and transported by light, portable, battery locomotives to main-level transfer chutes. Trains comprise four 50-cubic-foot or ten 20-cubic-foot cars; track gage is 24 inches, and 35-pound rail is used. One-outlet charging panels service the battery locomotives.

Haulage on main levels is by 6-ton battery locomotives pulling trains of twelve to twenty 50-cubic-foot side dump cars. Ore from transfer chutes

Figure 13. - Tandem slushing, Caselton mine.

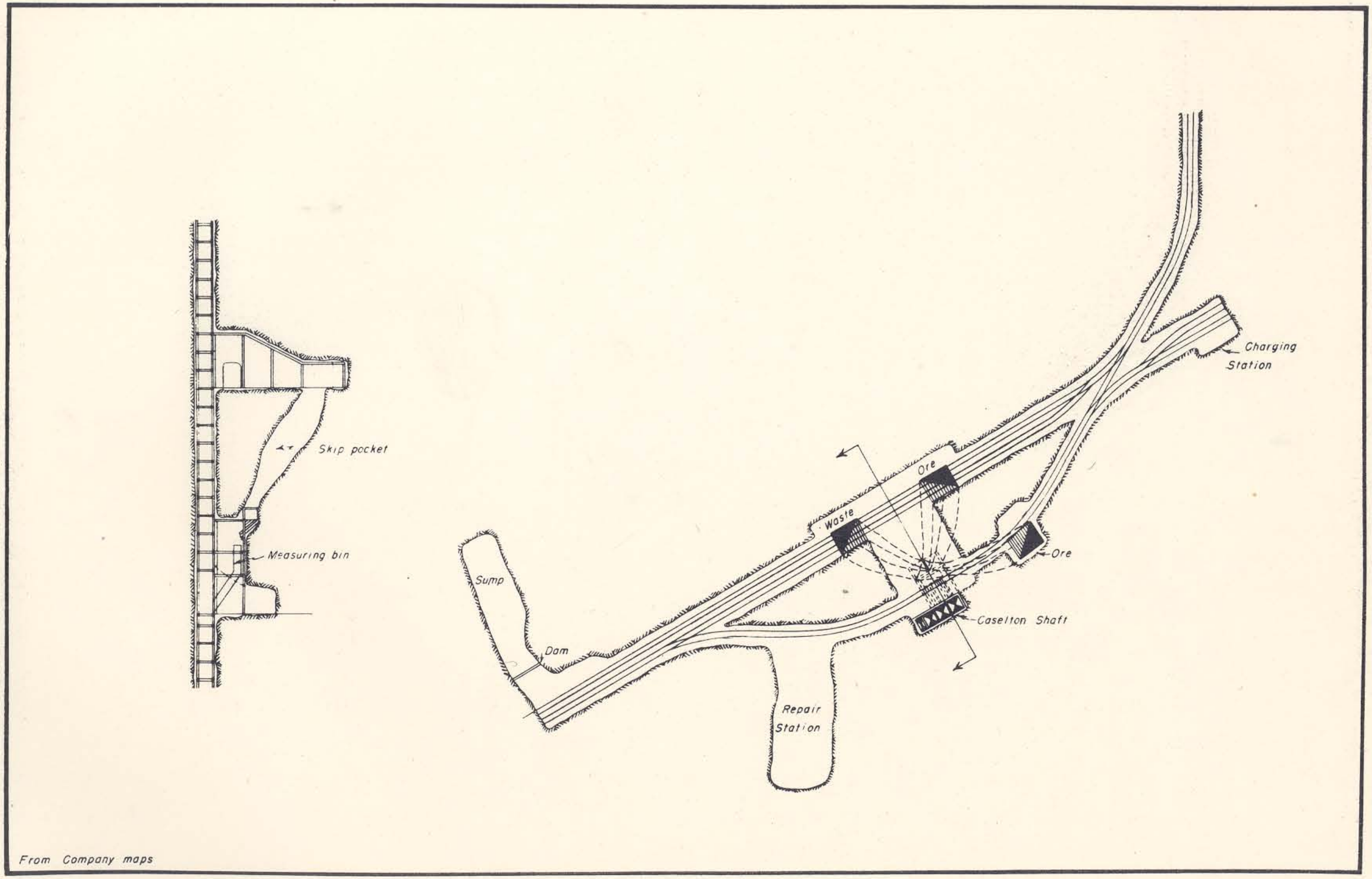


Figure 14. - Station lay-out, 1200 level, Caselton mine.

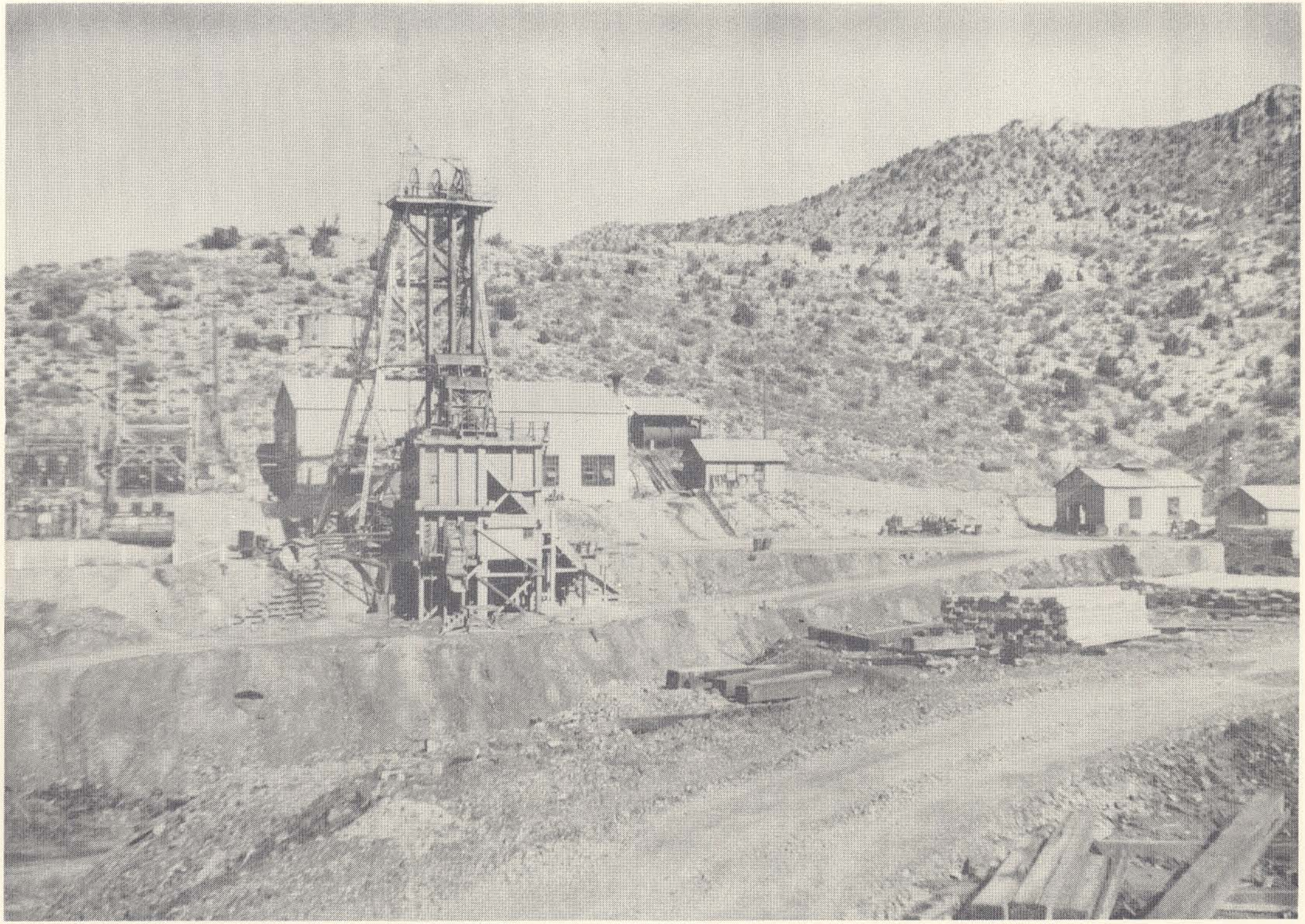


Figure 15. - Headframe and hoist house, Caselton mine.

is loaded into the cars through manually operated, arc-type, steel chute gates; mechanical muckers are used for loading in development headings. Trains are hauled to stations and dumped by hand over grizzlies into skip pockets. Track gage also is 24 inches, and 35- and 50-pound track is used. Three-outlet charging panels situated near the stations are used for recharging locomotive batteries.

Mine cars are made locally in the company"s machine shop, are rectangular in shape, and are equipped with roller-bearings and automatic couplings.

Battery locomotives used are manufactured by three different companies, range from 6-ton to 1-1/2-ton, and are equipped with lead-acid type batteries.

HOISTING

The general plan of ore- and waste- loading arrangements on main-level stations is shown in figure 14 and consists of two 150 ton-capacity skip pockets for ore and a third 150-ton pocket for waste. Ore or waste is drawn manually through arc-type steel chute gates into a measuring bin, from which it is passed to 3-ton-capacity self-dumping skips. Skips are suspended beneath cages and are operated in balance, one skip dumping at the surface while the other is loading at a skip pocket. Skips dump ore into a 120-ton wooden bin, from which it is transported in 12-ton end-dump trucks to stock piles adjacent to the crushing plant. Waste is diverted to a 60-ton bin and hauled by truck to waste dumps.

Hoisting is done by a double-drum hoist driven through a speed reducer by a 200-horsepower induction motor. Cylindrical hoist drums have 3-foot faces and are 5 feet 4 inches in diameter. Hoisting rope is 1 inch-diameter, 6 by 19, plow steel, hemp-center construction; hoisting speed is 900 feet per minute. A 76-foot high steel headframe supports three 9-foot-diameter sheave wheels (fig. 15).

The hoist is controlled through an automatic magnetic controller; post-type brakes are operated by an oil-hydraulic system. A company-developed electronic-overwind safety device prevents overwinding. Signals from cage and stations to the hoisting engineer are through shaft bells and buzzers; a two-way intercommunication system, in addition to the mine phones, permits contacts between operator, skip tenders, and shaft stations. Cages are equipped with doors and safety dogs. Cages and skips are constructed of alloyed steels in the company shop.

VENTILATION

The effective ventilation system at the Caselton mine utilizes the Caselton and No. 1 shafts and churn-drill holes. Air enters the mine through the downcast Caselton shaft and from main haulage levels is circulated through stopes and headings by 5- and 15-horsepower motor-driven blowers and canvas tubing. A 50-horsepower electric motor-driven booster fan on the 1,200 level exhausts air at the rate of 40,000 cubic feet per minute to the upcast No. 1 shaft.

Where mining has encountered exploratory churn-drill holes, they also are used for ventilation. Fresh air is forced down from surface by motor-driven fans placed over the holes and circulated in stoping areas through canvas tubing.

Motor-driven 5- and 15-horsepower, fan type blowers and ventube in 8-, 12-, and 16-inch sizes are used for air circulation.

DRAINAGE

Shaft sinking and development operations at the Caselton mine encountered heavy flows of water, which presented a serious pumping problem. A deep-well type pump mounted on a crosshead and raised and lowered by a hoist was installed in the auxilliary shaft compartment. This pump had an 800 g.p.m. capacity and greatly aided sinking operations.

On completion of shaft sinking, three deep-well pumps were set in the shaft at the 840 level supported on 20-inch I-beams placed across the auxilliary compartment, with pump columns extending to bowls in the 1,400-level sump and at the bottom of the shaft. Two pumps lifted water from the 1,400 to the 840 level, and the third pump lifted from the shaft bottom to the 840-level sump. Water was pumped from the 840 level to the surface by centrifugal pumps.

Additional water from development headings required more pumping capacity, so the arrangement was changed to include five 2-stage, centrifugal, station pumps on the 1,400 level in addition to two of the deep-well pumps mounted in the shaft, all pumping from the 1,400 level to the 840-level sump. Five 2-stage centrifugal pumps (three in continuous operation) pumped water from the 840 level to the surface. The maximum flow pumped for any extended period was 5,600 g.p.m.

The mine now makes about 2,500 gallons per minute, and the present pumping system comprises five 2-stage centrifugal pumps on the 1,400 level and five similar pumps on the 840 level. Each pump is driven by a 300- or 350-horsepower motor at 3,600 r.p.m. and has a capacity of 1,000 gallons per minute at a 1,000-foot head. Two pumps on each level are in continuous operation, pumping from the 1,400 to the 840 level sump and from this sump to surface storage tanks. All pumps operate on a 2,300-volt circuit. Steel and concrete bulkheads control the flow of water to the 1,400-level shaft-station sumps.

SAMPLING AND SURVEYING

The character of the bedded deposits and the variations in grade of the different mineralized beds makes close sampling mandatory. Control samples are taken by assistant engineers or shift bosses after every round in development headings and stopes. Grap samples of the ore are taken from mine cars and skip measuring pockets.

An interesting quick test for cerrusite ($PbCO_3$) is made underground in the oxidized areas. The sampler places a few drops of nitric acid on the sample, followed by a drop or two of potassium iodide. If cerrusite is present, the area covered by the chemicals will turn a bright yellow.

Accurate surveys are made of all underground workings; an engineer and two assistants run transit surveys on levels and sublevels, control surveys being carried to stope development headings. Surveys are closed by raise plumbing; a circuit is made from haulage level to sublevel through one raise, carried along the sublevel and development headings, and back down to the main haulage level through a second raise. Brunton surveys are made of stopes.

Mining is on a contract basis, and stopes and headings are measured every 2 weeks.

Extensive sets of mine maps are kept, ranging from large-scale detail maps for underground use to samller-scale generalized maps for permanent records. Sets of geologic maps also are maintained.

SURFACE PLANT

The surface plant at the Caselton mine, excepting the mill and crushing plant, comprises several concrete and steel structures with corrugated iron siding. Office buildings are lined with metal-covered sheetrock.

The main office building is sectionalized, containing offices for the superintendent, engineers, mine foreman and shift bosses, and the safety inspector, with separate change rooms for bosses and miners. Modern, well-ventilated change rooms contain shower baths, toilet facilities, and basket-type clothes hangers.

A combination hoist-compressor house contains the 200-horsepower, double-drum, electric hoist; a horizontal, 2-stage, 750-c.f.m. compressor, flat-belt driven by a 150-horsepower induction motor; and a horizontal, 2-stage, 2.700-c.f.m. compressor direct-connected to a 468-horsepower synchronous motor. Compressed air is discharged to two 6- by 17-foot horizontal-type air receivers adjacent to the building.

A lamp house contains charging panels and equipment to service 300 electric, battery-type, cap lamps.

The blacksmith shop is equipped with two drill-steel sharpeners, two oil-fired furnaces, an electric-motor-driven hot mill for resharpening screw-on type detachable bits, a drill-steel cutter and shank grinder, quenching tanks, bench and pedestal grinders, forges, and anvils. Since changing to the single-use bits, the sharpening equipment is used only for custom work.

Rock drills, hoses, line oilers, etc., are serviced and repaired in a well-equipped drill shop, and the new timber-framing shed houses a 36-inch swing saw, a 4-blade timber-framing saw, a 24-inch table-trim saw, and several power-driven hand saws. A unique feature developed by the company is the binding of mine timbers with steel straps to facilitate handling and transportation from shop to shaft stations. Up to 16 posts 8 by 8 inches by 7 feet long can be bound together by 5/8-inch wide steel strapping placed tightly around the timbers by a portable stretcher and sealer and taken underground as a unit. Timbers are removed from the cage at shaft stations by use of a crawl and chain block. Bundles of 24 wedges are bound together by 1/4-inch wide strap.

The machine and electric shop contains lathes, drill presses, shapers, rolls, welders, and equipment to maintain repairs on all mobile equipment. Mine cars, cages, skips, and scrapers are built in the shop, and mechanical muckers, churn drills, slushers, hoists, locomotives, pumps, and electric motors are overhauled and repaired. Patterns and tools for special jobs also are made. Drill steel for use with the new push-on type detachable bits is prepared on shop lathes. Heavy equipment is moved about by 3-ton storage battery-driven lift trucks.

Two large warehouses stock supplies and equipment for mine and mill use.

The assay laboratory and the mechanical engineering office are in a new concrete and steel structure, and the time-keeping and accounting offices and the geological department occupy a building at the entrance to the mine yard. The microscopic laboratory is adjacent to this building.

Surface buildings at the No. 1 shaft house a complete hoisting plant comprising a double-drum air hoist, which has been converted to electric drive, and which handles a skip and counterweight operating in balance, and the old boiler plant and steam-driven hoist and compressor in use before transmitted power was brought into the district. A horizontal, 2-stage, 2,700-c.f.m. compressor driven by a 463-horsepower synchronous motor and used as a stand-by unit for the Caselton compressors is located in a new corrugated-iron building.

CRUSHING PLANT

Ore from the Caselton mine and other lead-zinc properties in the district is hauled by dump trucks to stock piles adjacent to the crushing plant. A large tonnage of custom ore also is delivered to the plant in carload shipments. Stock piles are maintained of the company's oxidized and sulfide ores and of custom ore from the various shippers.

A bulldozer pushes the stock piled ore over grizzly bars, spaced 8 inches apart, into a 300-ton track hopper; ore from rail cars is dumped directly into track hoppers. The ore passes to a 42-inch feeder belt, motor-driven through a variable-speed control, is discharged from the feeder through a grizzly onto a 36-inch inclined conveyor belt, and is carried to a single-deck vibrating screen fitted with a 1-inch screen (fig. 16). The plus 1-inch rock passes to a gyratory crusher set with a 1-inch opening on the closed side; the minus 1-inch product drops to a 30-inch inclined belt conveyor. The crusher is V-belt driven by a 150-horsepower motor.

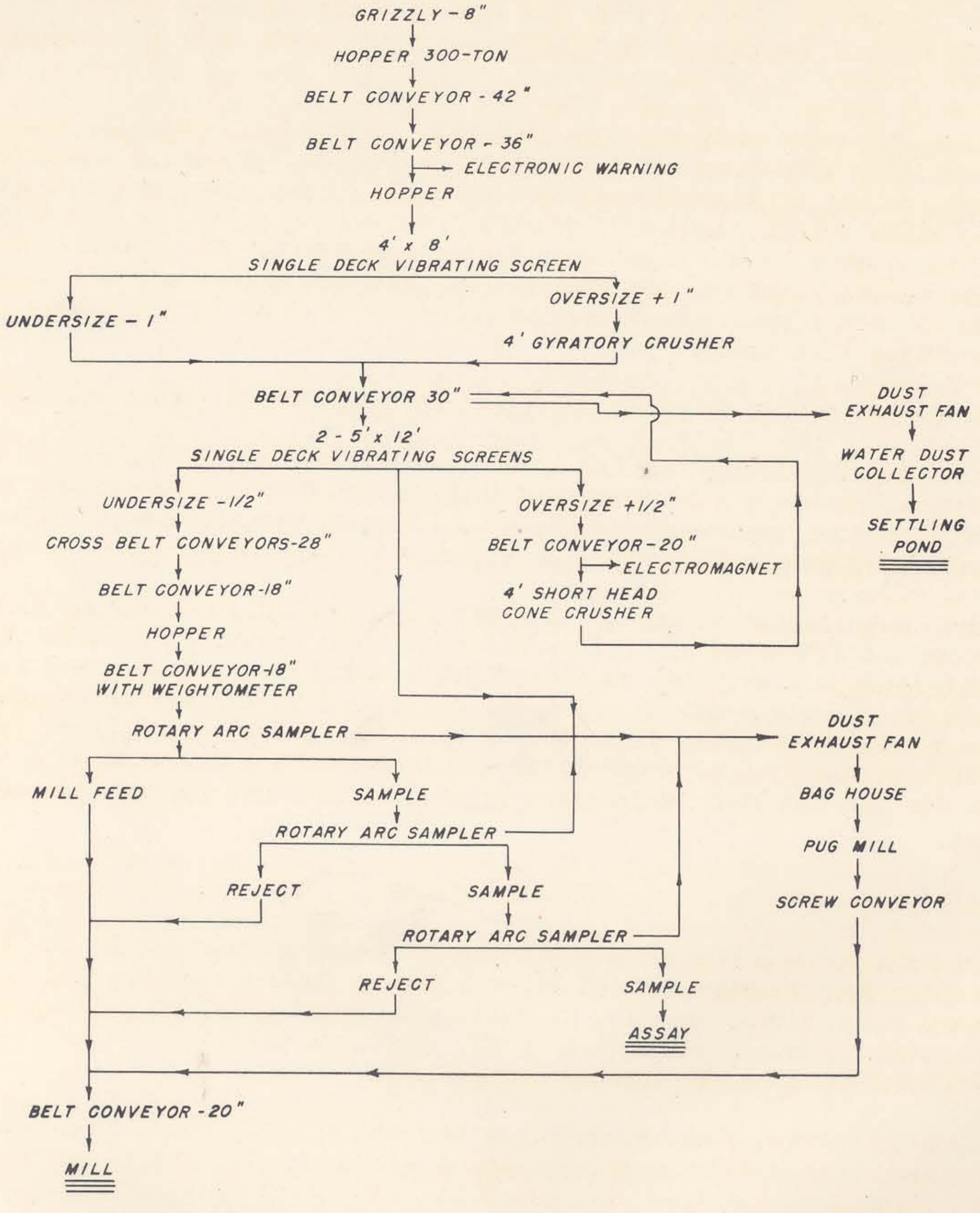


Figure 16. - Flow sheet of the Caselton crushing plant.

An electronic device on the 36-inch conveyor belt warns of tramp iron in the feed by sounding a warning signal and dropping a small amount of finely ground perlite on the belt to indicate the location of the iron. It is subsequently removed by the operator at the discharge end of the belt.

Discharge from the gyratory crusher also drops to the 30-inch inclined-belt conveyor and, with the minus 1-inch screen product, is conveyed to two parallel, single-deck, vibrating screens equipped with 1/2-inch screens. The plus 1/2-inch size passes to a 20-inch inclined belt conveyor and is carried to a short-head cone crusher set with a 3/8-inch opening on the closed circuit with the two vibrating screens. A lifting magnet over the belt removes tramp iron from the feed. The crushed product goes to the 30-inch inclined belt conveyor and is returned through the circuit. The cone crusher also is V-belt driven by a 150-horsepower motor.

The minus 1/2-inch screen product, which comprises the mill feed, falls on 28-inch cross-belt conveyors, which in turn discharge it onto an 18-inch inclined belt conveyor. The material is conveyed through a hopper to a second 18-inch inclined belt conveyor, which passes the crushed ore over an automatic weightometer and discharges it through a series of three Vezin-type rotary-arc samplers. Each sampler is designed to cut one-tenth of the feed, so that the final head sample will comprise 1/1,000 of the original ore stream. A conveyor belt, built on a 13-1/2 degree incline and spaced on 308.5-foot centers, elevates the rejected material to the mill.

The crushing plant is housed in a large, windowless, steel and concrete building, with the crushing, screening, and conveying equipment arranged for easy access and to insure maximum plant capacity. Operations are on a 1-shift, 6-day weekly basis. Hoppers and discharge chutes are rubber-lined to prevent excessive wear, and conveyor belt life has been comparatively long, as present belts have been in service 8 years. Conveyors are chain and sprocket driven through speed reducers by 10-horsepower motors.

Dust is effectively controlled through use of exhaust fans. The area beneath the primary vibrating screen and crushers is enclosed, or hooded in, with a connection to an exhaust blower. The blower creates a down draft and draws dust from the screening and crushing into a tank fitted with volute nozzles. Water from the nozzles collects the dust and carries it to a settling pond.

A suction fan with connections to the secondary vibrating screens and samplers pulls dust to a small, steel-enclosed bag house. Dust drops to a V-type bin and is carried by screw conveyor to a pug mill. The pulp passes to the 20-inch conveyor and on to the mill.

Major crushing and screening equipment includes:

1 4- x 8 ft. vibrating screen.
2 5- x 10 ft., vibrating screen.
1 4-foot gyratory crusher.
1 4-foot, short-head cone crusher.
1 Weightometer.
3 Rotary-type mechanical samplers.
1 Exhaust fan.
1 Discharge suction blower.

MILLING

Fine Grinding

The method of concentration for Pioche ores utilizes fine grinding and selective flotation of the lead and zinc in an alkaline circuit.

The 1,000-ton capacity Caselton mill comprises a spacious steel and concrete, windowless building designed to give maximum operating efficiency (figs. 17 and 18). Elimination of windows in the structure made for lower building and maintenance costs, better ventilation, and tighter construction. Outer walls are of corrugated iron separated by an air space from the inner, flat, galvanized-iron walls. The building is air-conditioned, and fluorescent lighting is used throughout. This latter feature permits close metallurgical control in the flotation section, as the intensity of the light is unchanged during day or night. Ample space around each piece of equipment allows easy access for servicing and cleaning and eliminates accumulations of dust and dirt. Operations are on a 3-shift, 6-day-week basis.

Mill feed from the crushing plant, arriving at the mill on a 20-inch inclined conveyor belt, is discharged onto a horizontal 18-inch belt conveyor and diverted by an automatic tripper into one of eight 20-foot-diameter, 500-ton-capacity, circular, steel storage bins (figs. 19 and 20). Use of eight bins simplifies handling the several classes of ore from the Caselton mine and custom ores. About one-third of the mill feed is custom ore, and payments are based on crushing-plant weightometer records and control-sample assays.

A safety feature to prevent workers from falling into ore bins is 1-inch wire hoisting rope strung over the top of the bins in parallel lines 8 inches apart (fig. 21). Cables extend over sets of four bins, are anchored at the ends, and are welded to every third I-crossbeam.

Ore is drawn from the bins by 24-inch feeder belts, which extend under the bottom of each bin, and is fed to 18-inch gathering conveyor belts, Varidrive controls on the feeder belts assures close control of feeding rates and makes possible the blending of ores from several bins. The two parallel gathering belts discharge the feed through automatic samplers onto 18-inch cross-conveyor belts, which, in turn, pass it over weightometers and on to the two ball mills. Belts are driven through speed reducers by 10-horsepower motors.

Dual 10-foot by 48-inch conical-type ball mills, each operating in closed circuit with a spiral-type classifier, grind the feed to an average of 75 percent through minus 200 mesh. Mills are V-belt driven through a pinion and bull gear by 300-horsepower motors. The V-belt drives comprise matched sets of 28 V belts extending from a grooved drive to a flat driven pulley on the counter shaft. Belt life is long; the set on the No. 1 mill has been in service over 8 years. Block-type, ribbed, manganese-steel shell liners used have an average life of 17 months. An inverted weir grate in the discharge end increases the capacity of the mill and hinders ball discharge. Mills carry ball charges of about 25 tons; using either 3-inch diameter, 4-pound, cast moly-steel or forged-steel balls. About 275 forged- or 300 cast-steel balls are added daily.

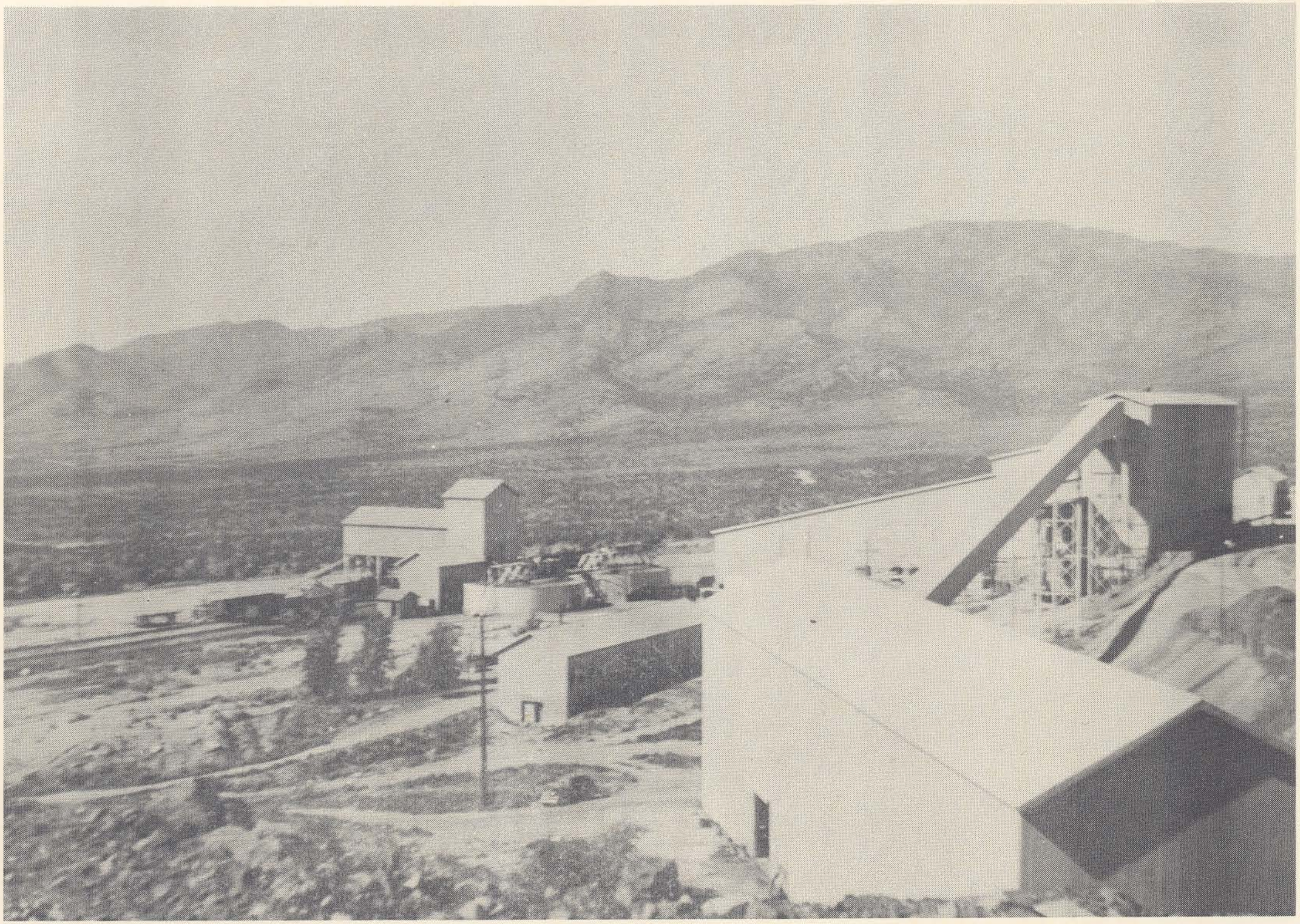


Figure 17. - Caselton crushing plant, mill, and filter plant.

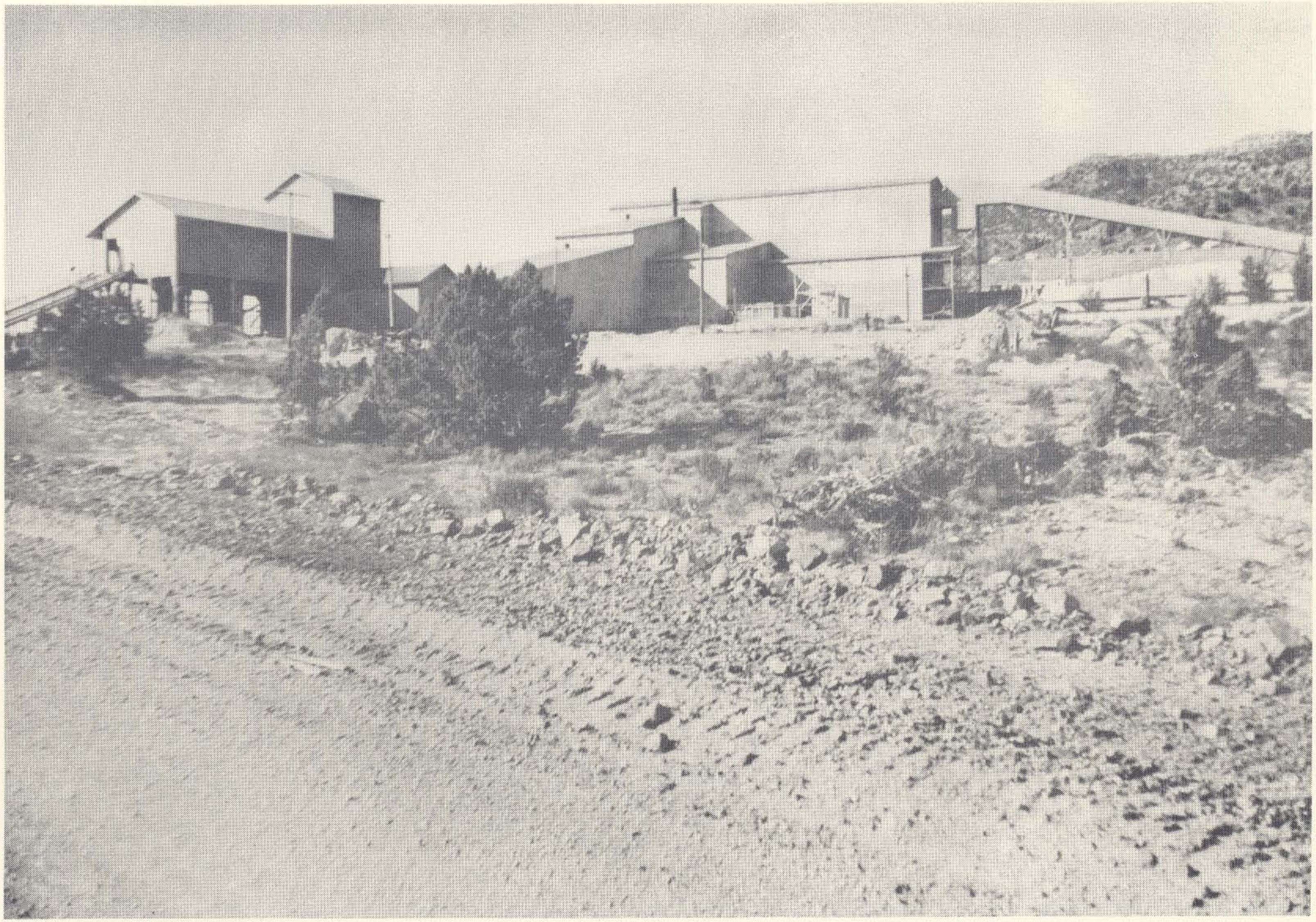


Figure 18. - Caselton mill and filter plant.

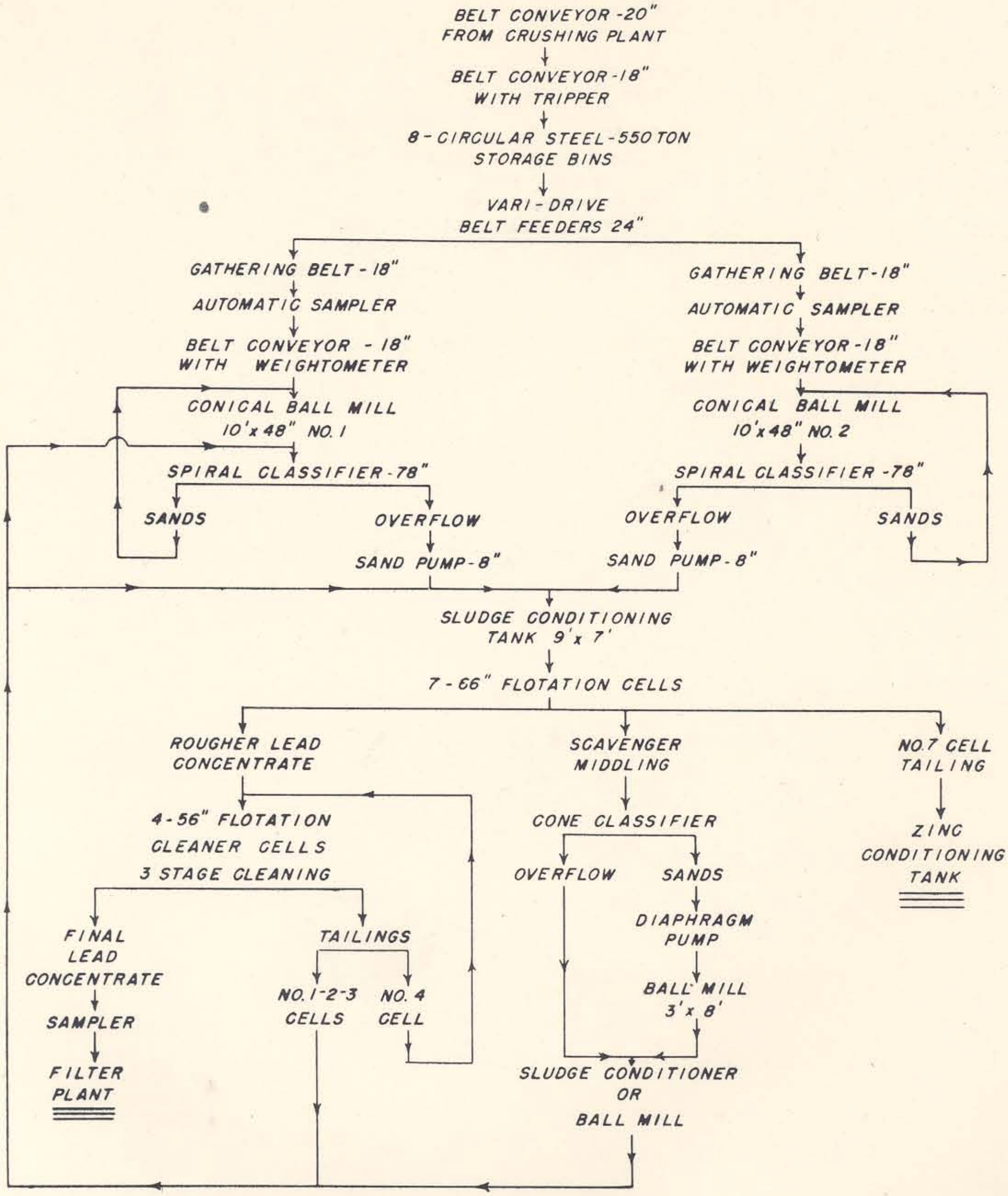


Figure 19. - Flow sheet of the Caselton mill; fine-grinding, and lead circuit.

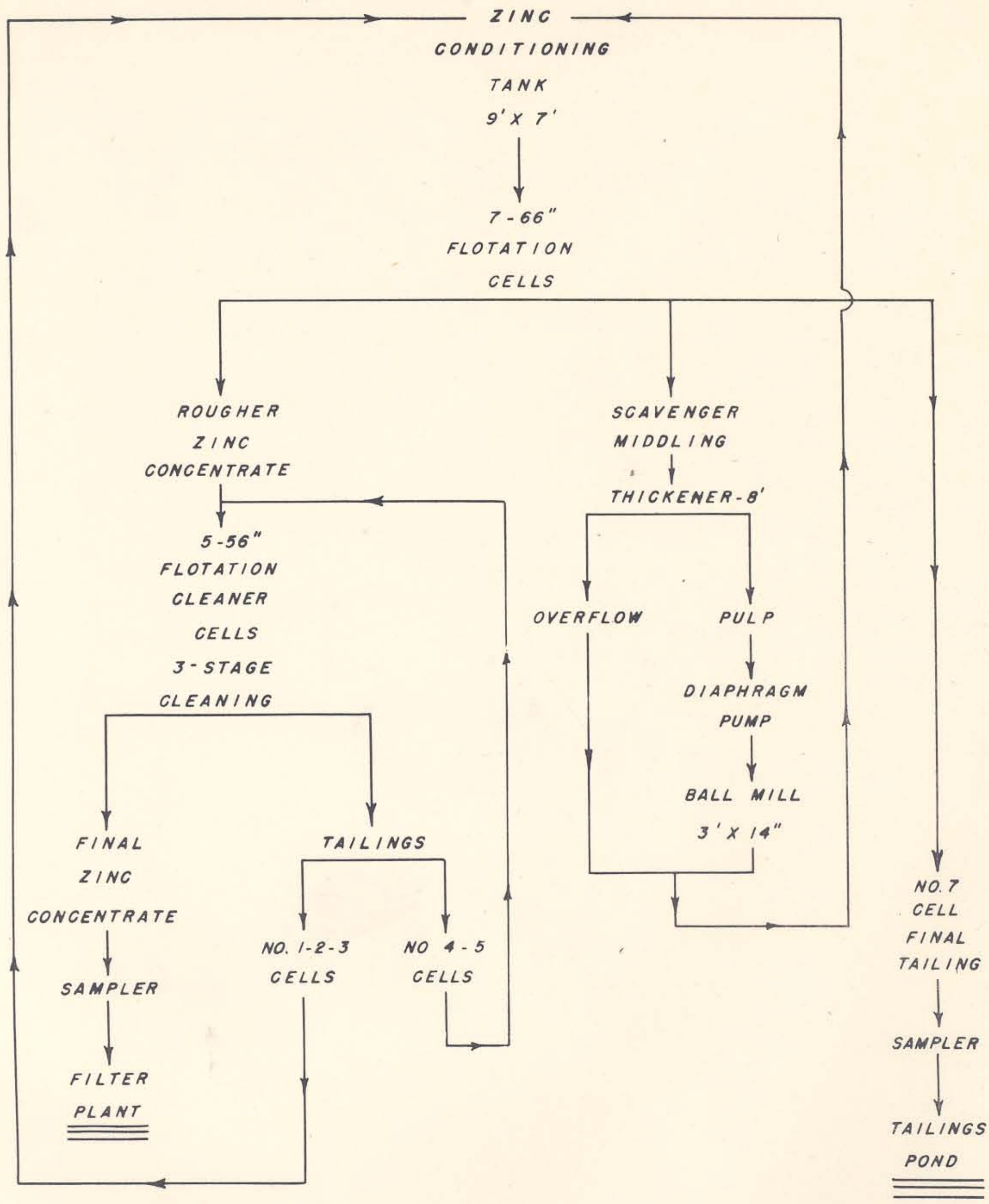


Figure 20. - Flow sheet of the Caselton mill zinc circuit.

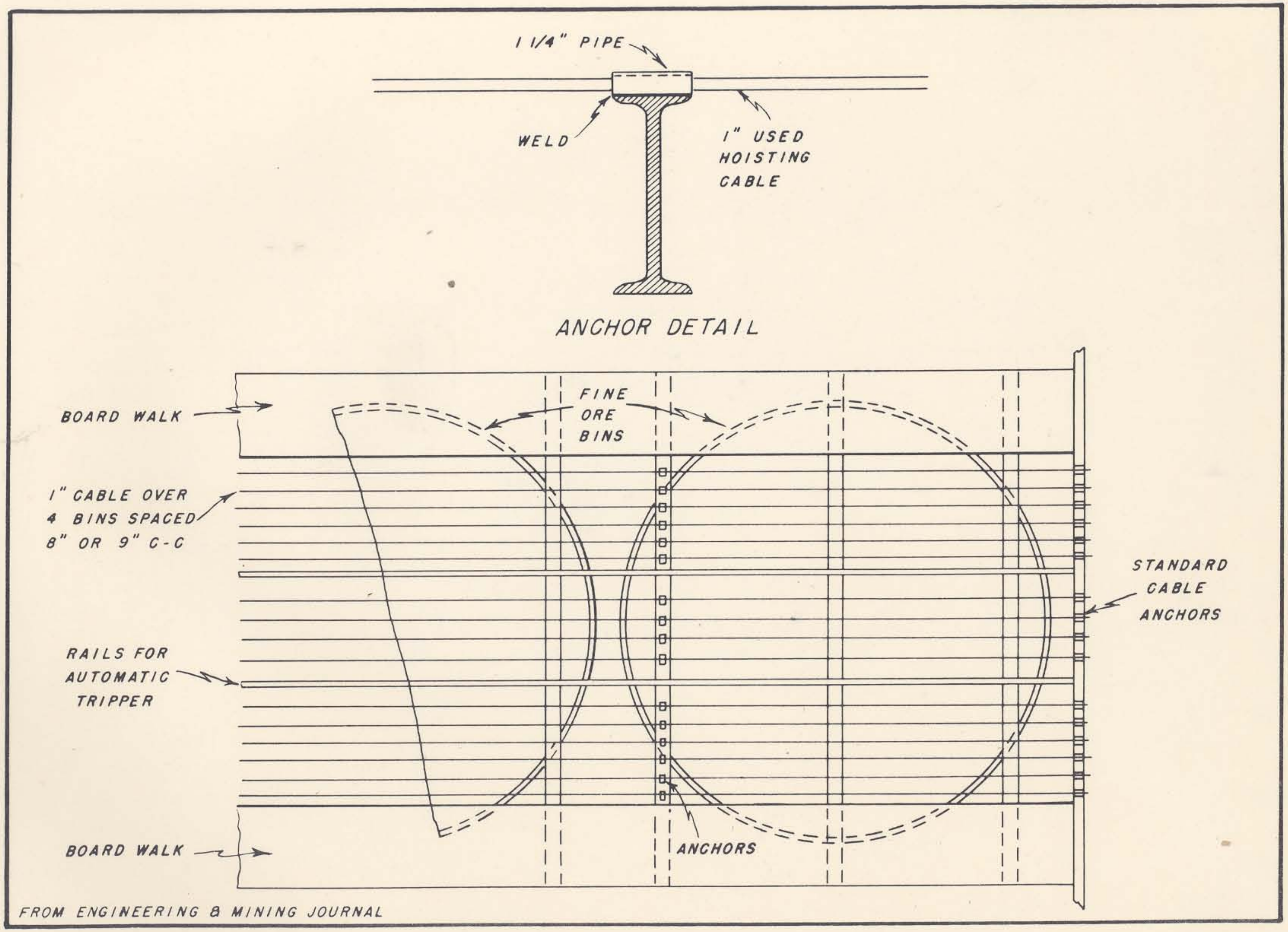


Figure 21. - Safety ropes over fine ore bins, Caselton mill.

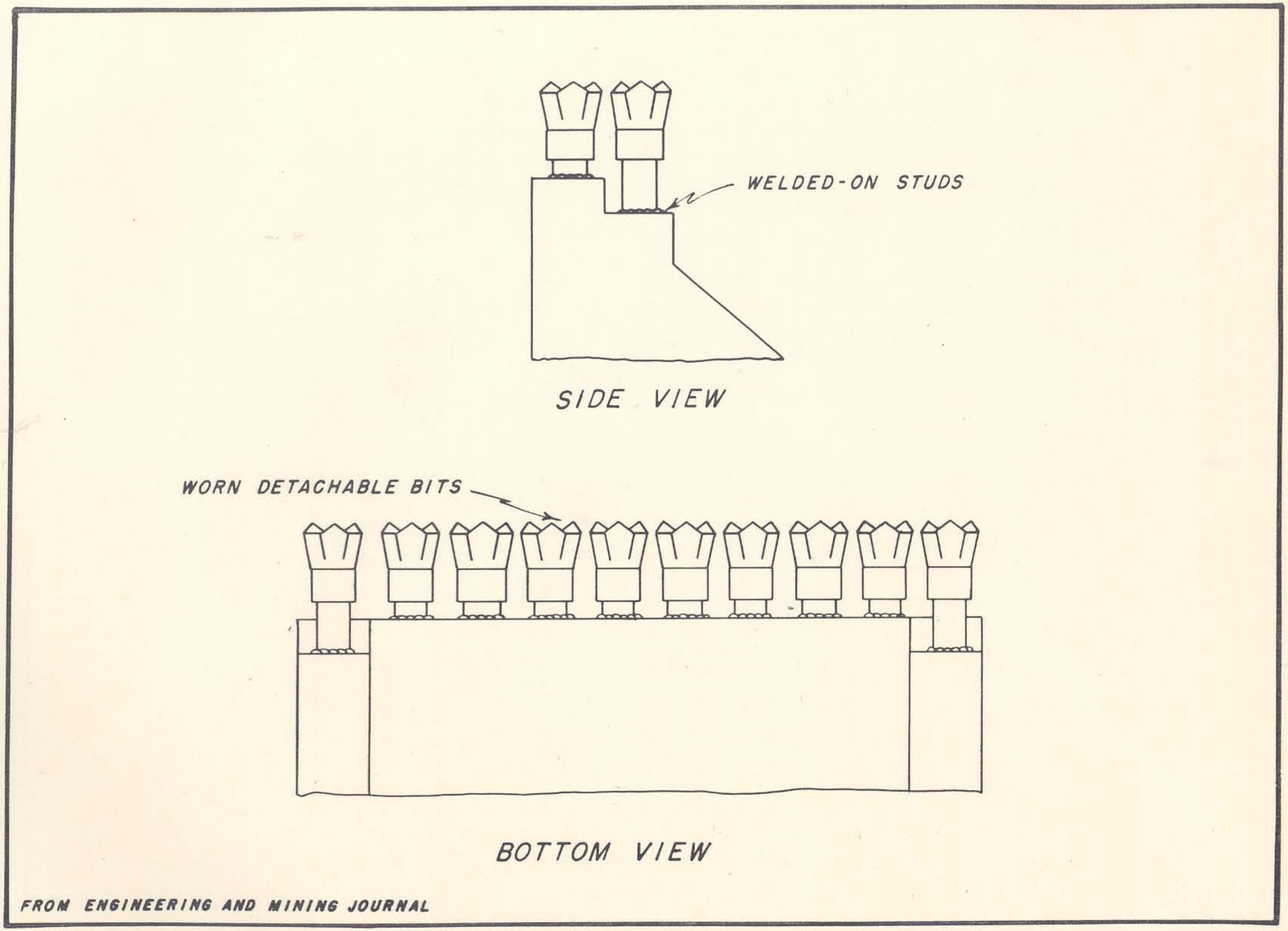


Figure 22. - Detachable bits on ball mill scoop lip, Caselton mill.

The rubber-lined ball-mill scoop is of company design and employs worn, detachable drill bits mounted along the edge of the scoop, which is accomplished by welding 12 short, threaded, drill-steel studs to the cutting edge of the lip (fig. 22). Bits are changed weekly.

The ball-mill discharge flows to a 78-inch, spiral, high weir type classifier. Classifier sands are returned to the ball-mill scoop box through a rubber-lined chute, and the overflow, consisting of about 36 percent solids, is pumped by a rubber-lined pump to a sludge-conditioning tank. Dual pump installations at each classifier have an 8-inch suction and a 6-inch discharge. One pump is maintained for standby service.

The classifier spiral is chain and sprocket driven through a synchrogear reducer by a 7-1/2-horsepower motor. Speed is 6 r.p.m. Spirals are equipped with replaceable wear plates and shores. A chip remover at the overflow end prevents small pieces of wood from passing to the sand pump. This device, designed by the company, comprises an arc of 3/16-inch mesh screen, placed along the end of the tank, through which the pulp flows. A series of paddles attached to a revolving shaft above and parallel to the screen remove the chips.

Major fine-grinding equipment comprises:

2 10-foot by 48-inch conical ball mills.
2 78-inch spiral classifiers.
4 8-inch centrifugal B-frame, sand pumps.

Flotation

The sludge-conditioning tank is a Devereaux-type containing a 30-inch downthrust-propeller V belt driven from a vertical shaft. A square, 6-inch-thick, cement block placed in the bottom of the tank protects it from excessive wear. The pulp flows by gravity to a bank of seven 66-inch rougher flotation cells, which make three products - a rougher lead concentrate, scavenger middling, and a tailing (fig. 19).

The rougher lead concentrate flows to a cleaner circuit comprising four 56-inch flotation cells in which a 3-stage cleaning is effected. Overflow from the No. 1 and 2 cells passes to the No. 3 cell; in turn from the No. 3 cell to a final cleaning in the No. 4 cell. Concentrate from the No. 4 cell is the final lead concentrate. Tailings from the No. 1, 2, and 3 cells are returned to the ball-mill circuit; tailing from No. 4 cell is returned to the No. 1 lead cleaner cell.

Scavenger middling goes to a cone classifier. Classifier sands are ground further in a 3- by 8-foot ball mill and, with the classifier overflow, are pumped back to the sludge conditioner or the conical ball-mill circuit. Return of the scavenger middling to the ball-mill discharge cuts down the amount of fresh water needed and maintains pulp density.

Tailing from the No. 7 rougher cell, comprising the zinc heads, is pumped to a zinc-conditioning tank similar in construction to the sludge conditioner. Pulp flows to a battery of seven 66-inch rougher flotation cells, in which three products are made - a rougher zinc concentrate, scavenger middling, and a final tailing (fig. 20).

The rougher zinc concentrate flows to five 56-inch flotation cells for a 3-stage cleaning. Overflow from Nos. 1, 2 and 3 cells passes to the No. 4 cell and from the No. 4 to the No. 5 cell, in which the final zinc concentrate is produced. Tailings from the Nos. 1, 2, and 3 cells are returned to the zinc conditioner and from the Nos. 4 and 5 cells to the No. 1 zinc-cleaner cell.

Scavenger middling flows by gravity to a thickener. Thickener pulp is reground in a 3- by 14-foot ball mill and, with the thickener overflow, is pumped back to the zinc conditioner.

Tailing from the No. 7 rougher cell comprises the final mill tailing and flows to the tailings pond.

One lead circuit and two zinc circuits comprise the flotation section, the lead and one zinc circuit being used for sulfide lead-zinc ores and the three circuits for treating oxidized lead ores. Flotation cells are individual, subaeration type, successive units being placed in a step down position to permit gravity flow of the pulp. The rotor of each cell is V-belt driven by 10- or 15-horsepower motors. Rubber-lined, V-belt-driven, 3- and 4-inch sand pumps are used for returning pulp and tailings. Pumps are driven by 10- and 20-horsepower motors, duplicate standby pumps being maintained at each unit. Flexible wire-wound hose is used in conjunction with pipe lines, replacing the usual tees and elbows.

Electric conduit lines to flotation cells, pumps, and other milling equipment are strung through pipes from master-control panels, although each unit is separately operated through a push-button control.

Reagents are mixed in a room above the grinding and flotation circuits and automatically fed into gravity feed lines by belt-driven cup-type feeders. Reagents are fed to the ball-mill intake, classifier, conditioning tanks, and at various points in the flotation circuit. Dry reagents are fed automatically to gathering conveyor belts.

A mixing plant near the mill building contains equipment for making up the various reagents used in the mill, which are pumped to secondary mixing tanks on the reagent floor.

Spillage from fine-grinding equipment and flotation machines is washed down the inclined floor to concrete sumps at the lower end of each circuit, from which it is pumped back to conditioning tanks by sand pumps. In each sump, an impeller attached to the bottom of a vertical motor-driven shaft prevents the settling of solids in the sludge.

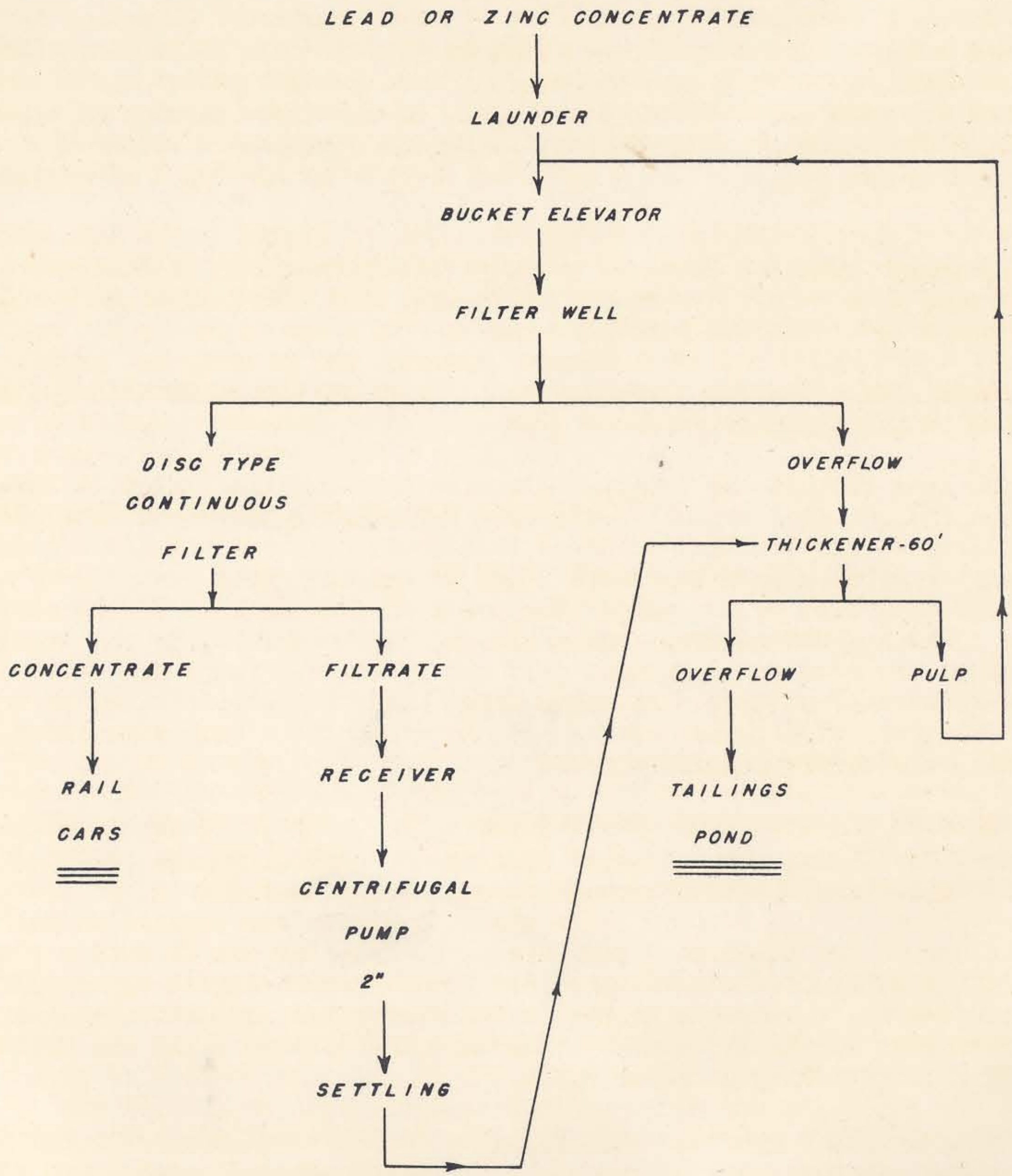


Figure 23. - Flow sheet of the Caselton filter plant.

Flotation equipment includes:

66-inch rotary-type flotation machines.
56-inch rotary-type flotation machines.
3-inch, centrifugal, A-frame sand pumps.
4-inch, centrifugal, B-frame sand pumps.
Ball mill, 3 by 8 feet.
Ball mill, 3 by 14 feet.

Sampling

Samples are taken of lead and zinc concentrates and the final tailing by automatic samplers as they flow in launders from the mill. Sampling intervals are 20 minutes, over 24-hour periods, although intermediate samples also can be taken. Samples are filtered, dried, screened and rolled, and sacked. Compressed-air, pressure-type filters are used, and drying takes place on electric hot plates. An electrically driven portable compressor supplies the compressed air.

FILTER PLANT

Lead and zinc concentrates flow to the filter plant in launders, are elevated by bucket elevators to discharge hoppers, and flow by gravity to filter wells (fig. 23). Filtration is accomplished by two vacuum-type, 6-foot diameter, 6-disk, continuous filters. A third filter is available as a standby.

Two horizontal, double-acting, vacuum pumps connected with vacuum tanks provide the vacuum, the filtrate passing to receivers. Vacuum is maintained between 21 to 22 inches of mercury. Filtrate is pumped from receivers to settling by 2-inch centrifugal pumps. A rotary blower provides sufficient air pressure to loosen the filter cake, which drops through vertical chutes directly into rail cars below the filters.

Overflow from filter wells flows by gravity to two 60- by 12-foot continuous thickeners. Thickener underglow returns to bucket elevator wells, andoverflow goes to settling ponds.

Bucket elevators equipped with 7- by 14-inch buckets are V-belt driven at the head end through a pinion and bull gear, and their use permits direct flow of concentrates to filter wells. In addition, the elevators handle fluctuating quantities of concentrate flow and bad froth conditions better than do pumps.

Final lead and zinc concentrate in rail cars contains about 10 percent moisture. Twelve auger samples are taken from each car, weighted, and dried to determine moisture content in a sample room adjoining the filter plant and are then sent to the assay laboratory for analyses.

Principal filter-plant equipment is:

3 6-foot by 6-disk, continuous filters.
2 Horizontal vacuum pumps (different makes).
1 Rotary blower.
3 2-inch centrifugal pumps.
2 60- by 12-foot continuous thickeners.

ASSAY OFFICE

The modern assay office is housed in a steel and concrete building close to the mill and comprises furnace and weighting rooms and a chemical determination laboratory.

Mine and head samples are prepared at the crushing plant. Samples are split, weighted, dried to determine moisture content, then crushed and pulverized.

Fire assaying is done in an electrically heated furnace controlled by an electric pyrometer, which enables the operator to maintain exceptionally close heat control. Weighing is performed on three analytical balances, and determinations are made in a well-equipped laboratory. An average of 250 assays are made daily on samples from the mine, crushing plant, mill, and filter plant.

Sample-preparation and assay equipment includes:

Laboratory jaw crushers.
Pulverizers.
Electric drying chest.
Electric assay furnace.
Analytical balances.

SAFETY3/

Safety is stressed continually at the Caselton plant. The safety program is the direct responsibility of a full-time safety inspector, but all supervisors are responsible for the safety of the men under their supervision.

Operations offer no unusual health hazard; mine and mill are well ventilated with suitable dust-control equipment and practices. Underground temperature approximates the mean annual surface temperature, and most working places are dry. Well-equipped change rooms are maintained.

The following safety inspections are in force:

1. Daily inspection of all hoisting equipment, including hoist ropes, safety and control devices, cages, skips, and hoisting compartments.

2. Semi-weekly inspection of all active mine workings by safety inspector.

3/ Based on "Health and Safety Practices at Pioche", by S. S. Arentz, General Superintendent, Nevada operations.

Figure 24. - Underground first-aid instruction, Caselton mine.

3. Semi-monthly inspections of main shaft by maintenance crew.

4. Regular inspection by State mine inspector or his deputy.

5. Monthly inspection of all mine workings by employees safety group headed by the chairman of the Union Safety Committee, assisted by two experienced miners appointed by the management. The group is accompanied by the safety inspector, the mine foreman, or a shift boss.

6. Regular mechanical inspection covering condition of equipment, safety guards, etc.

In addition to the above regular safety inspections, there are numerous special inspections, including the investigation of all lost-time accidents.

Attention is given to the prevention of accidents through the proper installation and use of equipment, the use of protective equipment, and warning signs, i.e.

1. Machinery is equipped with safety guards, and electrical installations are grounded.

2. Warning signs and signals are maintained. Reflecting tape is widely used for signs underground and for indicating obstructions such as projecting chute lips. Patches of the tape on men's hats have prevented several possible haulage accidents.

3. All underground men wear hard hats, steel-toed boots, and battery lamps. Candles and matches are provided at convenient locations for use in testing air in workings off ventilation courses.

4. Entrances to abandoned workings are barricaded. Signs indicating nearest exit are posted at raise stations and drift junctions.

5. Well-equipped and maintained first-aid stations are located on all levels underground and at control points on the surface.

6. Scaling bars and similar equipment are painted a bright yellow to aid in identification and as a reminder of their regular use.

Training is an essential point of the safety program. Good use has been made of the excellent training courses offered by the U. S. Bureau of Mines, and these courses have been supplemented with a training program conducted by the plant safety inspector (fig. 24). All Pioche supervisors and many key employees have completed the Bureau of Mines course in accident prevention, and about 75 percent of the crew have completed the course in first aid to the injured. Many supervisors have instructior certificates in first-aid training. Attendance at accident-prevention and first-aid classes is voluntary and on the employees' own time.

ORGANIZATION

Company organization of the Caselton plant consists of several operating and staff departments under a general superintendent. The several departments and their organization are as follows:

1. Caselton mine operation is under the supervision of an assistant mine superintendent, who is assisted by a mine foreman in charge of the mine crew and a surface foreman in charge of timber framing, ore and waste disposal, supply distribution, change houses and watchmen. Mine shift bosses and special miners direct the men in the mine workings.

2. Exploration and engineering is under the direction of a geologist, who is assisted by a mine engineer and two assistant engineers on mine mapping, sampling, and general mine engineering and by an assistant geologist and a drill foreman on areal geology, mine examination, and exploration.

3. Caselton mill operation is under the supervision of a mill superintendent assisted by an assistant superintendent-metallurgist, an assistant metallurgist, mill shift bosses, and a crusher foreman.

4. Maintenance and construction in all departments is under the supervision of a plant engineer, who is assisted by a master mechanic, a construction forman, an assistant engineer and draftsmen as they may be required. The master mechanic is in charge of mine pumpmen, hoitman, and mechanics as well as the machine shop, blacksmith shop, trucks, and automotive equipment. He is assisted by a chief electrician, shop foreman, and several lead mechanics. The construction foreman is in charge of carpenters and laborers, bulldozers, concrete equipment, and car loading and unloading of supplies and equipment.

5. The assay office is under a chief chemist, assisted by several technicians and laborers.

6. Accounting and warehousing is under the supervision of the chief clerk, who is assisted by a payroll clerk, a warehouseman, a stenographer, and several laborers. The chief clerk also is in charge of the commissary and dormitory.

7. A perlite operation, which will be covered by a subsequent Information Circular, is under the directin of an assistant superintendent, assisted by an assistant engineer. The operation includes an open-pin mining operation, truck haulage, a crushing plant, and storage and loading operations.

Interior - Bureau of Mines, Pittsburgh, Pa.