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MILLING METHODS AT THE CONCENTRATOR OF THE WALKER MINING CO., WALKERMINE, CALIFORNIA

BY

M. R. McKENZIE AND H. K. LANCASTER

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MILLING METHODS AT THE CONCENTRATOR OF THE WALKER MINING CO., WALKERMINE, CALIF.[1]

By M. R. McKenzie[2] and H. K. Lancaster[3]

INTRODUCTION

This paper describing the milling methods at the Walkermine concentrator, Plumas County, Calif., is one of a series being prepared by the United States Bureau of Mines on milling methods and costs in the various mining districts throughout the United States.

ACKNOWLEDGMENT

The authors wish to acknowledge their indebtedness to James O. Elton, manager of the International Smelting Co., and to Henry A. Geisendorfer, manager of the Walker Mining Co., for permission to present this paper; to H. A. Geisendorfer and J. D. Roberts, shift boss, for historical facts, and to D. D. MacLellan, geologist, for geological information.

LOCATION

The Walker mine and mill are located at Walkermine, Plumas County, in the northeastern part of California and at an elevation of 6,200 feet in the Sierra Nevada. Walkermine is about 27 miles northeast of Portola, a division point on the Western Pacific Railroad which is about 60 miles west of Reno, Nev.

Weather conditions and heavy snowfall usually make the road between Portola and Walkermine impassable during the winter and early spring months. During this period, transportation of passengers and supplies is conducted over an aerial tramway 9 miles long the terminal of which terminal is located at Spring Garden, Calif. Construction of this tramway, which was built chiefly for the shipment of concentrates, was completed in October, 1920.

GEOLOGY

The geology of the Walker mine deposit is described in detail by J. S. Diller in U. S. Geological Survey Bulletin 353, 1908, Geology of the Taylorsville Region, Calif.

In brief, the orebodies occur along a shear zone which cuts through a highly garnetiferous schist, known locally as the Robinson schist. The ore shoots, which are composed of chalcopyrite in quartz and silicified schist, are not connected and may be regarded as individual deposits. They range from 300 to 2,000 feet in length and from 5 to 100 feet in width.

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1 The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6555."

2 One of the consulting engineers, U. S. Bureau of Mines, and mill superintendent, Walkermine concentrator.

3 One of the consulting engineers, U. S. Bureau of Mines, and assistant mill superintendent, Walkermine concentrator.

ORE TREATED

The Walker ore has complex mineralogical associations but may be classified as a gold and silver bearing chalcopyrite-magnetite-quartz ore. Recent examination of the ore by R. E. Head, chief microscopist of the United States Bureau of Mines, showed the approximate percentages of mineral constitutents to be as follows:

	Per cent
Quartz	75.0
Garnet	5.0
Chlorite	2.5
Other nonopaque minerals	5.0
Metallic minerals	12.5
Total	100.0

The metallic minerals, which as stated amount to 12.5 per cent of the ore, are distributed as follows:

	Per cent, by weight	
Magnetite	59.76	
Pyrite	7.80	
Pyrrhotite	1.94	
Minor metallic gangue minerals	1.10	
Total metallic gangue minerals		70.60
Chalcopyrite	24.17	
Chalcocite	1.60	
Minor copper bearing minerals	2.55	
Noncopper-bearing minerals	1.08	
Total metallic ore minerals		29.40
All metallic minerals		100.00

The ore is very resistant to crushing and fine grinding. During the spring months considerable difficulty is encountered in crushing operations due to the moisture content in the ore.

The tabulation which follows presents a chemical analysis of typical mill heads averaged for a 6-month period.

Typical analysis of mill heads

Per cent					Ounces per ton	
Copper	Iron	Sulphur	Lime	Insoluble	Gold	Silver
1.687	9.0	2.1	1.1	79.2	0.05	0.833

HISTORY

Milling operations began in June, 1916, with the completion of a 75-ton capacity pilot plant, which was erected at a distance of 4,700 feet from the shaft and at a much lower elevation. Transportation of the ore from the mine to the mill was accomplished by an aerial tramway.

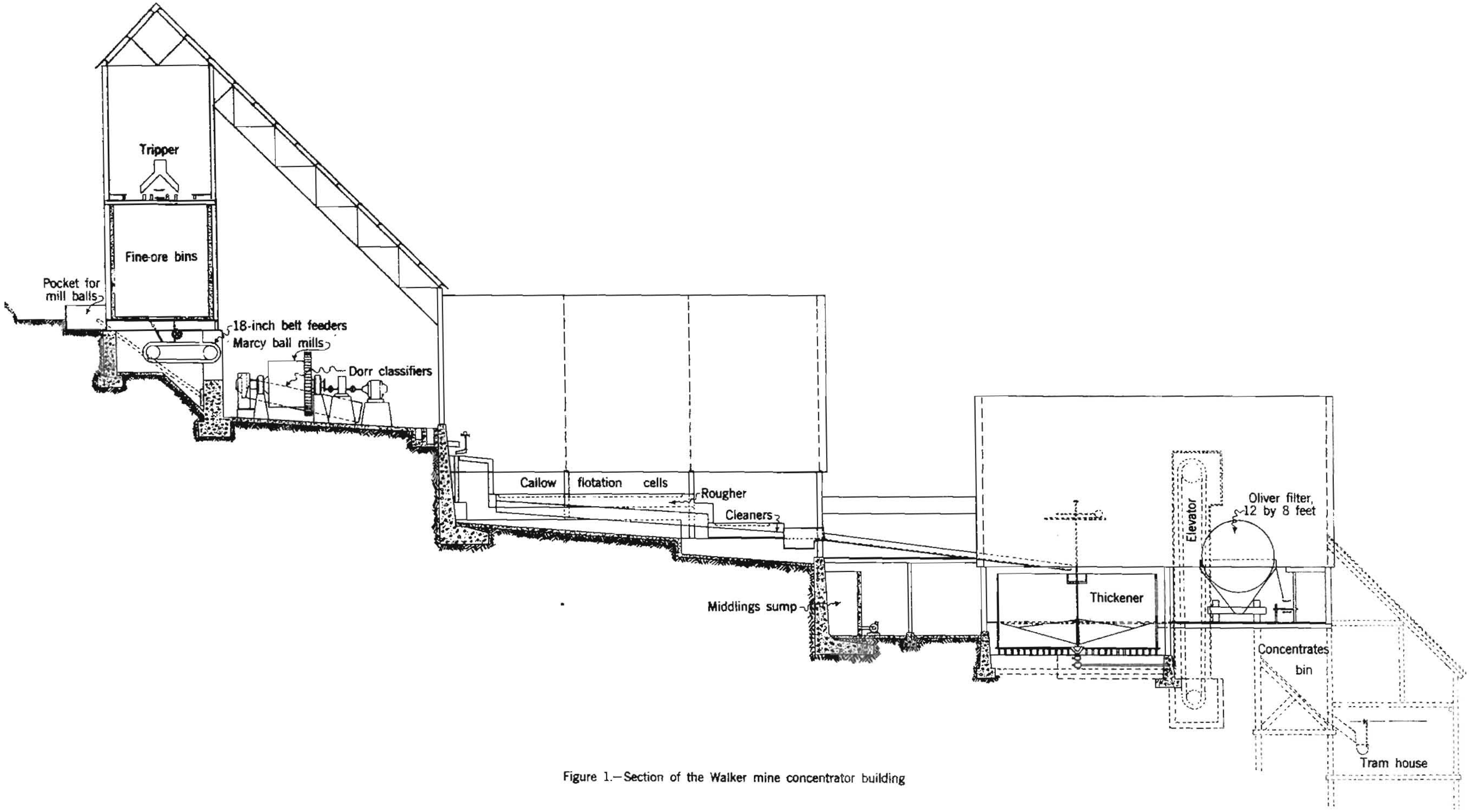

Figure 1.—Section of the Walker mine concentrator building

The treatment of ore in this pilot plant may be briefly summarized as follows:

(a) The mine ore was crushed to 2-inch size by Joshua Hendy crushers, one 12 by 24 inch and one 9 by 15 inch.

(b) The crusher product was ground to 4 per cent plus 48-mesh in two No. 64½ Marcy ball mills, each operated in closed circuit with a 4-foot 6-inch by 15-foot 9-inch Dorr classifier.

(c) The classifier overflow pulp, which contained 42 per cent of solids, was elevated a distance of about 60 feet to the flotation division, comprised entirely of sloping bottom Callow cells.

(d) The flotation concentrates were partially dewatered by two Callow cones, further thickened in a Dorr thickener and filtered by one 6 by 8 foot Oliver filter.

(e) The tailings were discharged into a canyon and no attempt was made to recover water except that contained in the concentrates thickener overflow.

Power was furnished locally by a steam plant of 350-hp. capacity until 1917 when electric power was made available by the completion of a power transmission line 14 miles long by the Great Western Power Co.

Reagents used in the pilot mill were lime, coal tar, and pine oil. Coal tar was replaced by thiocarbanilide in 1922.

During the operation of the pilot plant the International Smelting Co. acquired an interest in the property and, in addition to securing electrical power previously mentioned, drove a working tunnel 1 mile long for the purpose of developing the mine 1,000 feet vertically below the outcrop. This tunnel was also connected with the upper workings and since 1922 has served for transporting mine ore to the mill, the aerial tramway formerly used for this purpose being abandoned.

In 1922 the size of ball-mill feed was reduced from 2 inches to 1 inch by the installation of rolls. At this time the mill capacity was increased to about 300 tons of ore per day.

A larger mine production necessitated the building of a new mill of 750-ton capacity, which was completed and started to operate in December, 1923.

GENERAL DESCRIPTION OF PRESENT MILL

The present mill is built on a hillside a short distance from the portal of the main working tunnel. The location selected was well suited to standard mill construction and provided reasonable fall for gravity flow of pulp through the mill and down the valley to the tailings pond. The mill buildings are of steel and concrete with sides and roofs made of Anaconda corrugated zinc.

A typical longitudinal section of the concentrator building is presented in Figure 1.

The coarse and intermediate crushing plants are located in separate buildings at one side of the mill proper. The mill proper includes four sections. Each section is equipped with a Marcy ball mill which operates in closed circuit with a Dorr classifier; these are followed by rougher, cleaner, and scavenger Callow flotation units. A thickening and filtering unit handles the combined flotation concentrates from the four mill sections.

On account of the isolation of the mine and mill, it is necessary to maintain well-equipped machine, electrical, blacksmith, and carpenter shops. These shops can meet almost any emergency, which insures continuity of operations.

Capacity

The mill as first designed, with three No. 75 Marcy ball mills and three flotation sections, was operated for some time at the rate of 750 tons of ore per day. Grinding during this period was maintained at 4 per cent plus 48-mesh size. The mill capacity was later increased to 1,200 tons per day by changing the degree of grinding previous to flotation treatment from 4 to 14 per cent plus 48-mesh size. It might be interesting to note that the small sacrifice in recovery entailed by coarser grinding was more than offset by the lower cost of milling which resulted from the larger tonnage treated.

In September, 1929, the capacity was further increased from 1,200 to 1,700 tons per day by the installation of a fourth mill section. This latter section is identical with the three original sections except that the grinding unit is larger and comprises a No. 77 Marcy ball mill followed by a suitable classifier; the larger grinding mill accounts for the additional 100-ton ore capacity of this section.

Water Supply

Fresh water is obtained from springs and from the mine. The spring-water supply amounts to approximately 100 gallons per minute but this water is only available for mill use after camp requirements are satisfied. Water is pumped from the mine at the rate of about 300 gallons per minute, and this source provides the chief new water supply for the mill. The only water reclaimed from milling operations is that from the concentrates dewatering division. This amounts to approximately 60 gallons per minute and is returned to the supply tank located above the mill, where it is mixed with the fresh water.

Power

The Pacific Gas and Electric Co. furnishes power to the mine and mill transformers from Caribou through its Veramont substation at 22,000 volts. Motors of 100 hp. or larger are operated at 2,200 volts and smaller motors at 440 volts. A 110-volt circuit is used for lighting.

PRESENT METHOD OF CONCENTRATING

A flow sheet of the crushing plant and concentrator with a legend which gives details of machines used is presented in Figure 2.

Coarse Crushing

Longitudinal sections of the coarse and intermediate crushing units are given in Figure 3.

Ore is hauled from the mine to the crushing plant during three shifts. Ore trains which comprise eleven 3¼-ton capacity side dumping cars are drawn by 35-hp. Baldwin-Westinghouse electric locomotives. The ore is dumped onto a sloping steel rail grizzly having 11-inch spaces and after passing through the grizzly falls into a 1,500-ton capacity, cylindrical, steel receiving bin.

Ore is drawn from this bin by a motor-driven, 42-inch, Anaconda-type pan conveyor which discharges onto an inclined grizzly having 1½-inch spaces. The oversize is fed to a Traylor crusher set at 3½ inches. The crusher is 15 by 24 inch size, is driven by belt from a 150-hp. motor and will handle 85 tons of material per hour.

The grizzly undersize drops directly onto an inclined 20-inch conveyor belt and provides a cushioning layer for the crusher product which drops onto the same belt. This belt is driven by a 15-hp. motor and delivers the ore to the intermediate crushing unit passing under an electromagnet enroute for the removal of tramp iron. A picker is stationed at this conveyor for the removal of wood.

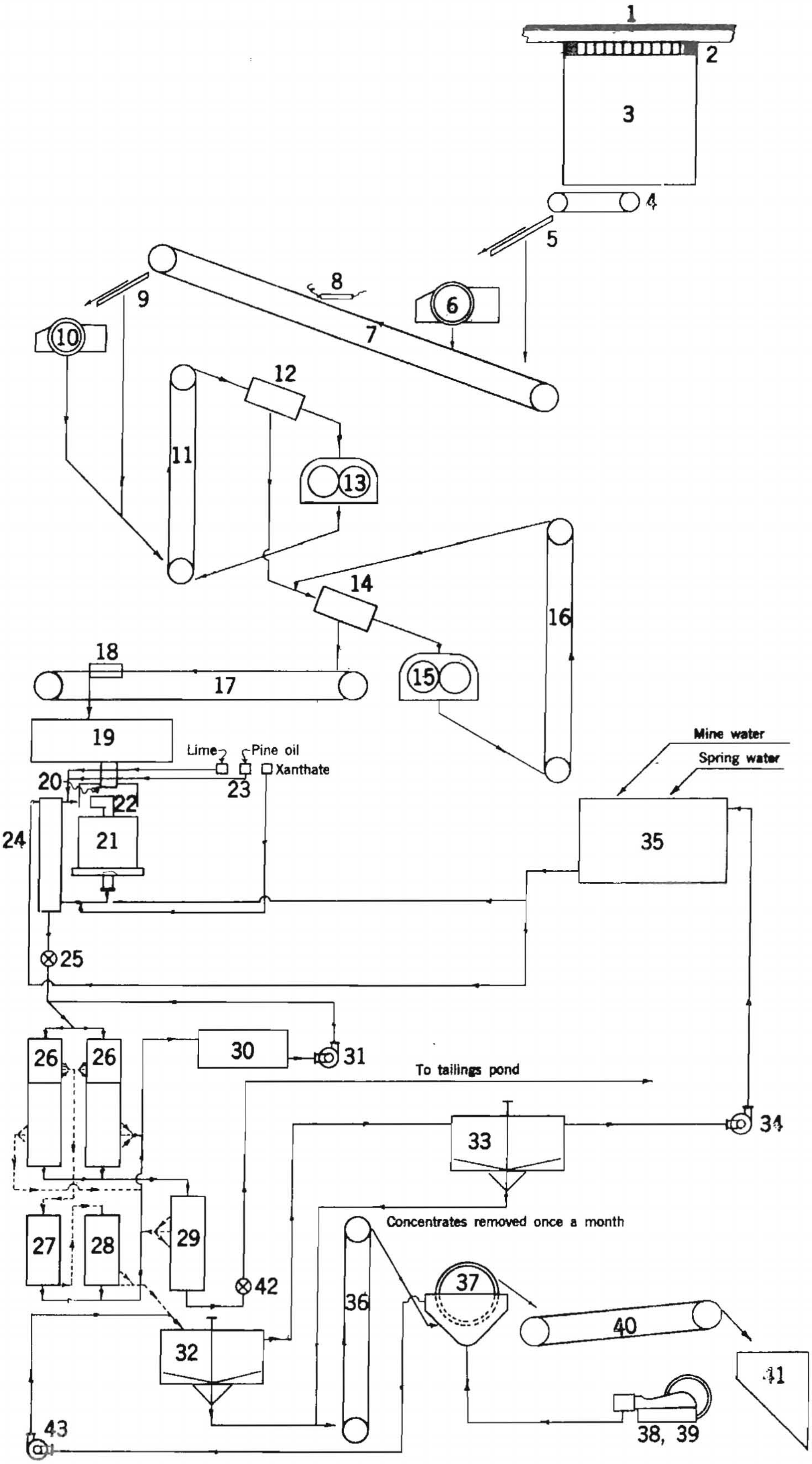

Figure 2.— Flow sheet of crushing plant and concentrator

Legend for flowsheet of crushing plant and concentrator

Number[1]	Description of machines
1	Track from mine.
2	One grizzly, 11-inch spaces.
3	Ore bin, 1,500-ton capacity.
4	One pan conveyor, 42-inch.
5	One grizzly, 1½-inch spaces.
6	One Traylor jaw crusher, 15 by 24 inch.
7	Belt conveyor, 20-inch.
8	Electromagnet.
9	One grizzly, 1¼-inch spaces.
10	Two Anaconda jaw crushers, 8 by 20 inch.
11	One bucket elevator, 16-inch.
12	One trommel screen, 1¾-inch holes.
13	One set Anaconda rolls, 24 by 55 inch, set at 1-inch.
14	Two trommel screens, 1-inch holes.
15	One set Anaconda rolls, 24 by 55 inch, set at ⅝ inch.
16	One bucket elevator, 16-inch.
17	One belt conveyor, 20-inch.
18	One tripper conveyor.
19	Fine-ore bin, 2,400-ton capacity.
20	Four feed conveyor belts, 18-inch.
21	Four Marcy ball mills, three No. 75 and one No. 77.
22	Four scoop boxes.
23	Reagent feeders.
24	Four Dorr duplex classifiers, three 6 feet by 18 feet 4 inches and one 6 feet by 23 feet 4 inches.
25	One Galigher sampler for heads.
26	Eight Callow rougher flotation machines, two 3-foot 11-pan units per mill section.
27	Four primary Callow cleaner machines, one 3-foot 4-pan unit per mill section.
28	Four secondary Callow cleaner machines, one 18-inch hoppered-type unit per mill section.
29	Two Callow scavenger machines, 3-foot 7-pan units.
30	One middlings sump, tank capacity 2,000 gallons.
31	Three Krogh pumps, 3-inch.
32	Two Dorr concentrates thickeners, 12 by 25 foot.
33	One Dorr thickener, 11 feet 4½ inches by 46 feet.
34	One centrifugal pump, 3-inch.
35	Water storage tank, capacity 100,000 gallons.
36	One bucket elevator, 16-inch.
37	One Oliver filter, 12 by 8 foot.
38	One Oliver vacuum pump, 14 by 8-inch.
39	One Oliver compressor, 9½ by 8 inch.
40	One belt conveyor, 18-inch.
41	Concentrates storage bin, 290-ton capacity.
42	One Galigher automatic sampler for tailings.
43	One centrifugal pump, 1½-inch.

1 Refer to numbers of Figure 2.

Intermediate Crushing

Ore from the coarse-crushing unit is delivered onto an inclined grizzly having 1¼-inch spaces. The grizzly oversize is fed to two 8 by 20 inch Anaconda-type jaw crushers. The grizzly undersize joins the crushed material and the combined products are fed by a bucket elevator to one 40 by 72 inch trommel screen having 1¾-inch diameter round holes. The elevator is driven by a 20-hp. motor and is equipped with buckets 16 by 8 inches in size. The trommel operates in closed circuit with a pair of 55 by 24 inch Anaconda rolls set with a 1-inch spacing; the rolls product returns to the elevator which feeds the trommel. The trommel undersize is distributed to two 40 by 72 inch trommels having 1-inch round holes. These trommels operate in closed circuit with one pair of 55 by 24 inch Anaconda rolls, set at ⅜ inch, the rolls product being returned to the trommels by a 16-inch bucket elevator.

The trommel undersize product, minus 1-inch size, comprises the feed to the grinding units and is conveyed to the 2,400-ton capacity fine-ore bin by a 20-inch belt equipped with a tripper.

The coarse rolls are driven by a 100-hp. motor, the two Anaconda crushers and the fine rolls by a 150-hp. motor, and the three trommels by a 10-hp. motor.

Grinding and Classifying

As previously indicated the concentrator is divided into four units for grinding and flotation operations. The three original grinding units are each equipped with one No. 75 Marcy ball mill which operates in closed circuit with a Dorr duplex classifier 6 feet by 18 feet 4 inches in size. The fourth unit was, as previously mentioned added to increase the capacity of the original mill and is equipped with one No. 77 Marcy ball mill which operates in closed circuit with a Dorr Duplex classifier 6 feet by 23 feet 4 inches in size.

Each No. 75 Marcy mill is driven at a speed of 24 r.p.m. by a 200-hp., 900 r.p.m., induction motor through a Falk herringbone-gear speed reducer. The No. 77 mill is also driven at a speed of 24 r.p.m. by a 200-hp., 900 r p.m., synchronous motor through a Westinghouse-Nuttal speed reducer.

Ball charges carried in the Nos. 75 and 77 mills weigh 9 and 13 tons, respectively, and are maintained by the daily addition of 4-inch forged steel balls. Ball consumption is 2.074 pounds per ton of ore ground.

Shell and feed end liners are of manganese steel, the shell liners being of the ship-lap type. Grate sections are of rolled chrome steel and have ¼-inch openings. The tabulation which follows gives the life of liner parts and the consumption of liners per ton of ore ground.

Life of liner parts and consumption of liners per ton of ore ground

	Life of liner, hours	Liner consumption, pounds per ton of ore
Shell liners	3,200	0.273
Feed end liners	4,300	0.176
Grate bars	4,200	0.176
Total		0.563

The classifiers used with the No. 75 grinding mills are set at a slope of 3½ inches to the foot and are operated at a speed of 27 strokes per minute by 5-hp. motors. The classifier which serves the No. 77 mill is set at a slope of 3 inches per foot and is operated at a speed of 25 strokes per minute by a 5-hp. motor.

Ore from the fine-ore bins is delivered to the center of each drum and scoop type ball-mill feeder by an 18-inch conveyor belt. Each No. 75 mill receives feed at the rate of $16\frac{2}{3}$ tons per hour and the No. 77 mill at the rate of $23\frac{1}{3}$ tons per hour. The grinding mills operate with an average circulating load of 145 per cent and with pulps containing from 77 to 78 per cent of solids.

The degree of grinding is maintained at 12 per cent plus 48-mesh; classifier overflow pulps contain from 46 to 50 per cent of solids.

Table 1, page 9 presents screen analyses of ball-mill feed and of intermediate and final grinding-circuit products.

Flotation

For simplicity of control and metallurgical accounting the classifier overflow pulps of the four grinding sections are combined, sampled and then distributed equally to four flotation units. The equipment of each flotation section comprises two 3-foot, 11-pan, standard Callow rougher machines, one 3-foot, 4-pan, standard primary Callow cleaner, and one 18-inch, hoppered-type, secondary Callow cleaner.

The two rougher machines operate in parallel; rougher concentrates are removed from the first three pans and middlings froths from the remaining eight pans. The rougher concentrates, which have an average content of 15 per cent of copper, are cleaned in two stages, the final stage producing finished concentrates. The middlings froths of the rougher machines join the tailings of the two cleaner cells and flow by gravity to a common pump sump, and from there are returned to the head of the rougher cells by three 3-inch Krogh sand pumps, each of which is driven by a 15-hp. motor.

The tailings from the rougher cells of the four flotation sections are combined and distributed to two 3-foot, 7-pan, Callow scavenger units which produce middlings froths and final waste tailings. The middlings froths join the middlings of the rougher and cleaner units in the common sump and are returned to the heads of the roughers.

Cell blankets of 4-ply, quilted, 18-ounce canvas are used and have a life of from 60 to 90 days.

Air for flotation operations is furnished at 4.15 pounds per square inch pressure by two No. $6\frac{1}{2}$ Roots bloweres and one Connersville blower. The Roots blowers are each link-belt driven at a speed of 172 r.p.m. by a 150-hp. motor. The Connersville blower is also link-belt driven at a speed of 240 r.p.m. by a 75-hp. motor.

The reagents used in flotation comprise lime, potassium ethyl xanthate (Z-3), and steam-distilled pine oil. Sodium aerofloat was used for a short period, but recently its use has been discontinued.

Dry hydrated lime is fed to the ball mills from small hoppered feeders at the rate of 1.2 to 1.6 pounds per ton of ore milled. These amounts produce a protective alkalinity of about 1.09 pounds of CaO per ton of mill water which is sufficient to insure the desired metallurgical results. Operators are required to make hourly titrations for protective alkalinity and to make immediately any changes in the rate of adding lime as indicated by these titrations.

Xanthate is added as a 25 per cent solution to the classifier overflow pulps by a scraper feeder at the rate of 0.18 pound per ton of ore treated.

Steam-distilled pine oil is added to the ball mills by a scraper feeder at the rate of 0.16 to 0.22 pound per ton of ore. A rather large amount of this reagent is necessary on account of the coarseness of the flotation feed and also due to the fact that flotation operations are conducted in a circuit which is essentially a fresh-water circuit.

DEWATERING AND HANDLING OF CONCENTRATES

The concentrates pulps which contain from 20 to 25 per cent of solids, flow by gravity to two 25 by 12 foot Dorr thickeners. The thickened pulps containing 75 per cent of solids are delivered to one 8 by 12 foot Oliver drum-type filter by a 16-inch bucket elevator. The filter is chain driven by a 3-hp. motor. The concentrates produced are handled by operating the filter on two of the three daily shifts, one operator being required on each shift.

A vacuum amounting to 22 inches of mercury is maintained at the filter by one 14 by 8 inch Oliver vacuum pump which is driven by belt from a 15-hp. motor. Blowing air is furnished at 5 pounds pressure by a 9½ by 8 inch Oliver compressor, driven by belt from a 15-hp. motor. The filtrate is handled by a 1½-inch centrifugal pump in place of the usual barometric leg. A filter cover gives approximately six months of service before replacement is necessary.

The overflows from the two Dorr thickeners are conveyed to a spare 45 by 12 foot thickener, where a small additional recovery of fine concentrates is made. These concentrates are allowed to accumulate and are dewatered in the filter about once each month.

The filter cake, which averages 1 to ½ inch in thickness and which contains from 8 to 10 per cent of moisture, is discharged onto a 14-inch conveyor belt and delivered by this belt to a 290-ton capacity storage bin. The concentrates are loaded from this storage bin into 800-pound capacity tramway buckets; the latter are trammed to Spring Garden where the concentrates are dumped into railroad cars for shipment to the Tooele plant of the International Smelting Co.

The tramway is of the double rope type and is 9 miles long. The loaded side is equipped with 1½-inch locked-coil track cable and the light side with 1-inch cable of the same construction. The buckets are equipped with automatic grips which engage a ¾-inch Lang Lay traction rope which is driven by a 50-hp. motor.

Labor employed on the tramway includes 1 foreman, 3 loaders, 3 unloaders, 2 line riders, and 1 agent, who is located at Spring Garden.

Since the completion of the aerial tramway in 1922, it has been an important factor in plant operation as it is the only means of transporting passengers, mine and mill supplies and camp provisions during the months of heavy snowfall.

DISPOSAL OF TAILINGS

The tailings of the scavenger flotation cells contain from 33 to 36 per cent of solids and are conveyed by a wooden launder for a distance of about ¾ mile to a large impounding pond. Proper precautions are taken to prevent tailings from entering near-by streams.

MILL SAMPLING

Samples of the heads as represented by the combined classifier overflow pulps, the concentrates, and the final tailings are taken during each shift by Galigher automatic samplers. The samples are dewatered in a small pressure filter and after being dried are split to convenient-size assay pulps.

An analysis for copper content is made on each shift sample for mill guidance and control. A composite sample is made from shift samples for metallurgical accounting. These composite samples are assayed for copper, gold, silver, and insoluble contents.

Cars of concentrates are sampled by pipe samplers at Spring Garden before being shipped to the smelter.

METALLURGICAL AND OPERATING DATA

Screen analyses of concentrator intermediate and final products are presented in Table 1. Table 2 gives chemical analyses of mill heads, final concentrates, and tailings; and Table 3 shows the percentage distributions of copper, silver, gold, iron, and insoluble in final concentrates and tailings. Metallurgical data for the period June to November, 1930, are presented in Table 4, and the distribution of labor is shown in Table 5.

Table 1.- Screen analyses of concentrates intermediate and final products

Screen size	Weight, per cent									
	No. 75 Marcy mill units				No.77 Marcy mill unit			Flotation products		
	Ball-mill feed	Ball-mill dis-charge	Clas-sifier sands	Clas-sifier overflow	Ball-mill dis-charge	Clas-sifier sands	Clas-sifier over-flow	Concen-trates	Middlings	Tail-ings
Plus 1-inch	5.4	-	-	-	-	-	-	-	-	-
Plus ½-inch	41.3	-	1.4	-	-	0.9	-	-	-	-
Plus 4-mesh	23.0	2.6	8.1	-	1.2	4.7	-	-	-	-
Plus 8-mesh	9.5	4.7	8.5	-	2.5	6.0	-	-	-	-
Plus 30-mesh	9.0	30.0	43.5	2.5	23.8	46.5	2.2	-	-	3.2
Plus 48-mesh	1.8	14.0	14.8	11.2	14.3	15.4	10.5	4.8	3.0	15.7
Plus 65-mesh	2.9	8.1	6.4	22.4	11.4	8.4	14.6	6.8	1.5	5.5
Plus 100-mesh	0.5	6.8	3.3	2.5	7.0	3.3	6.2	18.1	4.5	13.8
Plus 150-mesh	2.4	6.0	3.8	15.5	10.5	4.2	9.0	14.5	4.4	10.0
Plus 200-mesh	2.9	6.1	3.7	2.3	6.5	3.3	12.2	6.8	6.0	10.7
Minus 200-mesh	1.3	21.7	6.5	43.6	22.8	7.3	45.3	49.0	80.6	41.1
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2.- Chemical analyses of mill products, June to November, 1930

	Weight, per cent	Analyses				
		Copper, per cent	Silver, ounces per ton	Gold, ounces per ton	Insoluble, per cent	Iron, per cent
Heads	100.0	1.687	0.833	0.05	79.0	9.0
Concentrates	6.41	24.00	9.920	0.49	14.5	22.1
Tailings	93.59	0.163	0.200	0.02	83.5	8.1

Table 3.- Mill recoveries and losses, June to November, 1930

	Weight, per cent	Distributions, per cent				
		Copper	Silver	Gold	Insoluble	Iron
Concentrates	6.41	91.2	73.3	62.7	1.2	15.8
Tailings	93.59	8.8	23.7	37.3	98.8	84.2

Table 4.- Metallurgical data, June to November, 1930

Ore treated, total	tons	268,255
Days operated	number	169.67
Operating time per day	hours	24
Amount of ore treated per 24 hours, average	tons	1,580.62
Ore treated per man-shift per 24 hours, average	do	38.51
Sections operated, average	number	3.84
Ore treated per section per 24 hours, average:		
No. 75 Marcy mill units	tons	400
No. 77 Marcy mill unit	do	500
Concentrates produced, total	do	17,290.54
Copper produced, total	pounds	84,027,948
Concentrates produced per 24 hours, average	tons	101.90
Recoveries:		
Copper	per cent	91.21
Silver	do	76.32
Gold	do	62.73
Ratio of concentration	tons into 1	15.57
Pressure of flotation air, per square inch	pounds	4.15
Alkalinity of mill water, CaO per ton of water	do	1.09
Plus 48-mesh material in flotation tailings	per cent	11.10
Consumptions of water, reagents, and supplies per ton of ore milled:		
Net water used	gallons	325 to 350
Lime	pounds	1.40
Pine oil	do	0.321
Potassium ethyl xanthate (Z-3)	do	0.084
Sodium aerofloat (use discontinued)	do	0.075
Balls	do	2.074
Liners	do	0.563

Table 5.- Distribution of labor

	Number per 24 hours
Mill superintendence:	
Mill superintendent	1
Shift foremen	3
Coarse and intermediate crushing departments:	
Crusher operators	2
Crusher helpers	2
Rolls	2
Screens	2
Electromagnet	2
Grinding and flotation departments:	
Ball mills	3
Flotation operators	3
Flotation helpers	3
Filter department:	
Operators	2
Repair and shop crews:	
One repair foreman and 20 men	21

Distribution of electric power,
May, 1931

Department	Kilowatt-hours	Per cent
Primary crushing	42,804	7.22
Secondary crushing	42,804	7.23
Grinding	348,631	58.83
Flotation	149,765	25.27
Filtration	8,561	1.45
Totals	592,565	100.00

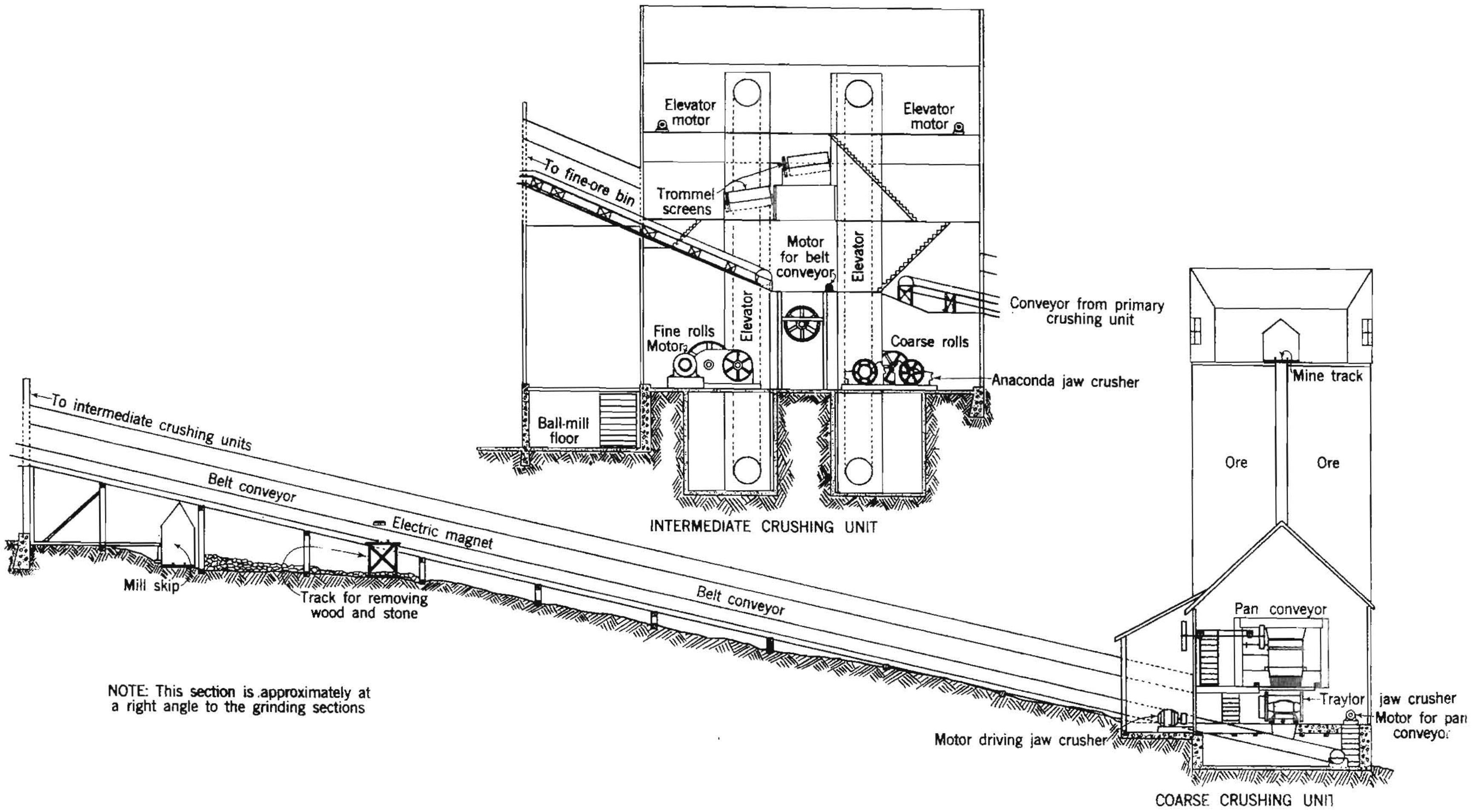

Figure 3.—Longitudinal sections of the coarse and intermediate crushing units