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# MILLING PRACTICE AT THE ALASKA JUNEAU CONCENTRATOR

BY

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February, 1930.

To the reader:

This is one of a new series of papers that will present the details of milling practice and itemized costs at the principal ore-dressing plants in the United States. Officials and mill superintendents of the mining companies will prepare these papers, in cooperation with the mining division of the Bureau of Mines, and in accordance with a bureau outline designed to obtain uniform presentation.

The facts thus assembled have immediate value to the Bureau's research engineers working on ore-dressing problems and will be the basis for summarized reports by the bureau on methods and costs of separate steps in milling, such as crushing, grinding, screening, conveying, and concentrating by gravity, flotation, and leaching. Publication in mimeographed form allows these papers to be issued within a short time after receipt, and it is hoped they will be welcomed as cordially by the mining public as was the series on mining methods and costs.

Here again, we are counting on the hearty assistance of the industry, and the result should be another fine example of coordinated effort between industry and government, for the good of all concerned.

Scott Turner

SCOTT TURNER,
Director.

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DEPARTMENT OF COMMERCE--BUREAU OF MINES

# MILLING PRACTICE AT THE ALASKA JUNEAU CONCENTRATOR[1]

By P. R. Bradley[2]

This paper, describing the milling practices at the Alaska Juneau concentrator, Juneau, Alaska, is one of a series on milling practices being published by the Bureau of Mines.

## ACKNOWLEDGMENT

A large part of the paper was prepared by Walter P. Scott, mill superintendent, Alaska Juneau Gold Mining Co., Juneau, Alaska.

## GENERAL DESCRIPTION

The concentrator of the Alaska Juneau Gold Mining Co. is located on the steeply sloping shore of Gastineau Channel, near Juneau, Alaska. The Alaska Juneau mine is in Gold Creek Basin, about 2 miles from the mill. The ore is mined by a caving system, dropped through ore passes, and trammed in 10-ton cars through the haulage level to the tipple at the top of the mill.

The mill is an example of an extreme type of hillside construction, the difference in elevation between the tipple and the bottom floors being 263 feet. Very little elevating of material is required. The ore is free milling and does not require very fine grinding to free the values; the flow sheet is quite simple, consisting primarily of crushing, sorting, grinding, and table concentration. Approximately 11,000 tons of run of mine material is trammed to the mill daily, and 46 to 48 per cent of this is rejected as waste by hand-sorting.

Water for milling purposes is obtained from Gold Creek and delivered through a flume and a 20-inch wooden stave pipe line to a surge tank above the level of the ball-mill floor; 8,000 to 8,500 gallons per minute is required. No recovery of water is made, as it is all required to convey the fine tailings through the tailings flume to the beach. During very cold weather, when the supply of fresh water is inadequate, salt water is pumped from Gastineau Channel. Salt water is more satisfactory than fresh water during extreme cold weather, because it does not freeze so readily.

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 6236."

2 - One of the consulting engineers, U. S. Bureau of Mines.

Power, supplied by three hydroelectric plants owned by the company, is generated at 2,300 volts and stepped up to 22,000 volts for transmission to the central power plant. During shortages of water additional power is purchased from the Alaska Gold Mines Co. A stand-by oil-fired steam plant at the central power plant, equipped with one 2,000-kw. and one 6,000-kw. General Electric steam turbine, is used during interruptions on transmission lines and other emergencies. The average mill load is about 3,000 kw., and the total load for the entire operation 5,000 kw. All motors in the mill over 15 hp. are 2,300 volt, 3 phase, 60 cycle; all 15 hp. and under are 220 volts.

Gold, the principal economic metal, is mostly native and usually associated with small quantities of galena and sphalerite. The principal sulphide, by volume, is pyrrhotite with some pyrite. The gold is quite coarse, an occasional particle weighing over 1 gram.

The ore occurs in irregular stringers and gash veins of quartz distributed through black slate and brown metagabbro dikes. Coarse particles of native gold occur most commonly at the contact of the quartz and the gabbro, although coarse gold is found in the quartz. The metagabbro, the principal gangue material, is extremely hard and tough and very hard to crush. It tends to break into slabs, adding to the difficulty of handling. The ore as delivered to the mill varies from slime to slabs that will pass a 27-inch grizzly in the mine bulldozing chambers and has a moisture content varying from a few per cent to saturation. Most of the ore cars arrive at the mill partly full of water, and this water causes excessive wear on feeders and all coarse-crushing equipment.

The present plant was put into operation April 1, 1917, and was designed to treat 8,000 tons of run-of-mine ore per 24 hours; but owing to the failure of some experimental features the expected capacity could not be realized, and the cost of milling was several times greater than anticipated. Hand-sorting was introduced, and a vigorous campaign of alteration began which, together with sorting, has increased the capacity of the plant to such an extent that an average of approximately 13,000 tons per day was handled during part of 1927, 57 per cent of this material being rejected as waste by hand-sorting. The present fine-grinding capacity of the mill is about 6,000 tons per 24 hours. The following table gives the progress made in increase of capacity and reduction of costs since the plant went into operation.

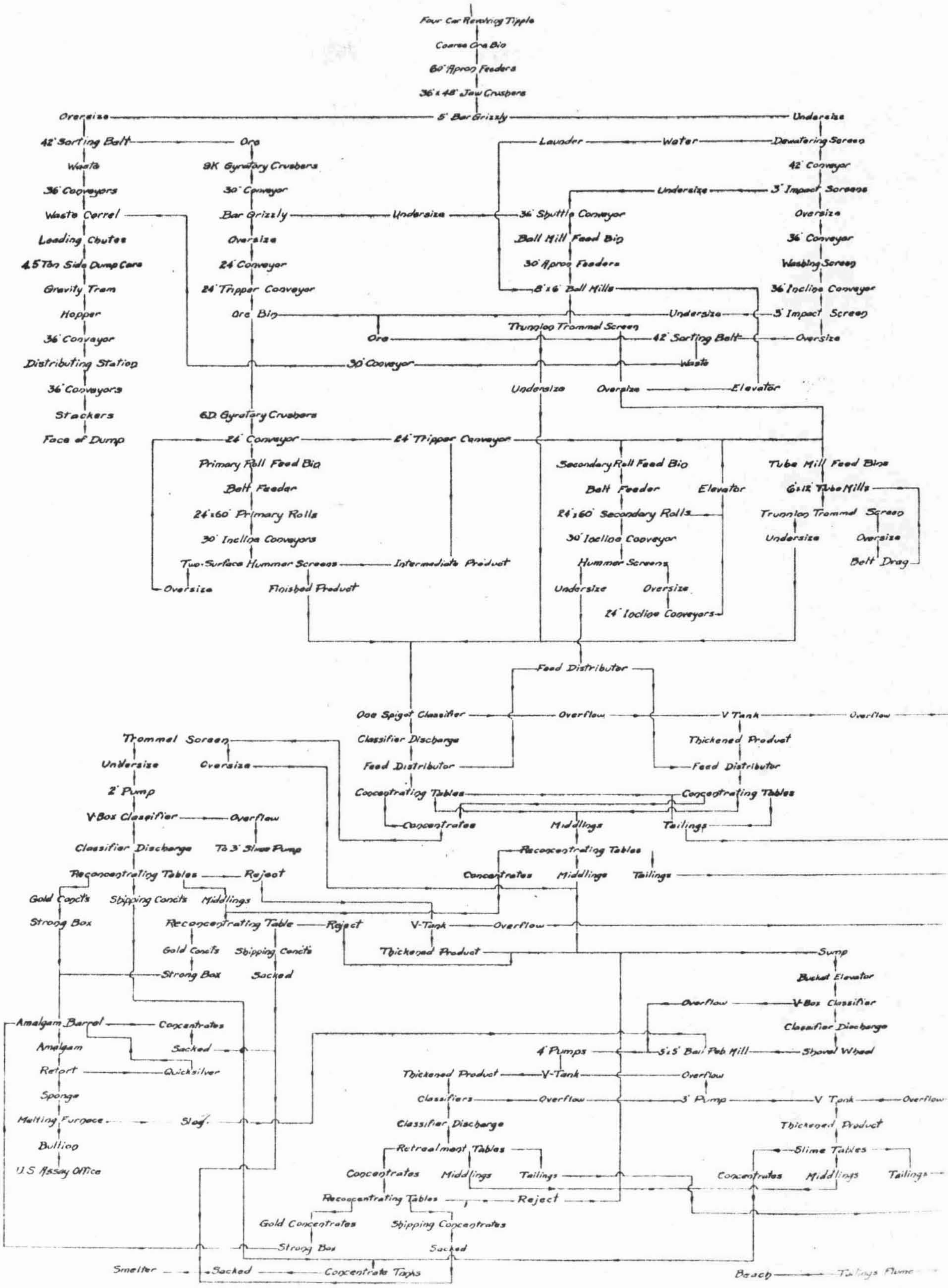


*Figure 2.- Flow sheet, Alaska Juneau Mill*

| Year | No. of days in operation | Tons mines per day | Tons fine milled per day | Tons coarse waste rejected per day | Cost of milling | Gold assay value | Gold recovered |
|---|---|---|---|---|---|---|---|
| 1917 | 274 | 2472 | 2472 | – | $0.7171 | $0.86 | $0.64 |
| 1918 | 363 | 1631 | 1582 | 49 | .6762 | .92 | .73 |
| 1919 | 363 | 1909 | 1698 | 211 | .5608 | .99 | .72 |
| 1920 | 364 | 2590 | 1751 | 839 | .4463 | 1.08 | .78 |
| 1921 | 363 | 4445 | 2491 | 1954 | .3554 | .86 | .60 |
| 1922 | 361 | 6400 | 3070 | 3330 | .2613 | .81 | .56 |
| 1923 | 361 | 6860 | 3144 | 3716 | .2662 | .81 | .58 |
| 1924 | 362 | 8476 | 3778 | 4698 | .2512 | .87 | .62 |
| 1925 | 362 | 9618 | 4248 | 5370 | .2504 | .85 | .58 |
| 1926 | 362 | 10579 | 4557 | 6022 | .2154 | .75 | .50 |
| 1927 | 362 | 11790 | 5083 | 6707 | .2257 | .77 | .55 |
| 1928 | 363 | 10243 | 4946 | 5297 | .2285 | 1.11 | .84 |
| 1 1929 | 271 | 10718 | 5640 | 5078 | .2363 | 1.10 | .86 |

1 First 9 months.

The percentage of coarse waste rejected since 1927 has decreased, due to a change in the character of the ore delivered to the mill. The flow sheets, Figures 1 and 2, show the arrangement of equipment in the plant and the flow of the material; the vertical arrangement of the mill is shown in end elevation, Figure 3.

## COARSE CRUSHING AND SORTING

Tramming continues throughout the 24 hours of the day, but the crushing plant is operated only two 8-hour shifts, with 3 hours between shifts. One hour is taken out during each shift for lunch. Four cars are dumped at a time by the revolving tipple into the coarse-ore bin, which has a live capacity of 1,500 tons, so there is little leeway for interruptions in either tramming or crushing. The rock is drawn from the bin by six 60 inch Stephens-Adamson apron feeders, two for each of the three 36 by 48 inch type C Buchanan jaw crushers, which are set at 8 inches. Only two crushing units are operated at one time, the third being held in reserve to allow necessary repair work. There is no screening of material ahead of the crushers. Occasional large slabs block the feeders or hang up in the crushers and have to be blasted in place. The crusher discharge falls upon a grizzly 5 feet in length with 4 inch openings.

The oversize of this grizzly is washed with a spray and drawn over a 42-inch sorting belt traveling 100 feet per minute. This sorting belt is placed directly over the bowl of a 9K Gates-type gyratory crusher set at about 2 inches. Four sorters work at each belt and pull off all quartz and any rocks with adhering quartz; the black slate and barren gabbro remain on the belt, are delivered to a chute leading to a 36-inch conveyor, and go thence to a waste bin on the hillside. The quartz from the sorting belt drops directly into the bowl of the gyratory crusher, and the crushed product is conveyed to a fine grizzly 7 feet in length with 1-1/2-inch openings. The undersize of this grizzly is distributed into the ball-mill feed bin, and the oversize is conveyed to the "sorted-ore" bin.

The undersize of the 4-inch grizzly is passed through a chute equipped with cast screen-bottom liners to remove as much water as possible and then to a 42-inch conveyor which delivers it to a 3 by 6 foot Niagara vibrating screen equipped with 3-inch square-mesh cast-manganese screens. The undersize of these screens is distributed by a 36-inch shuttle conveyor into the ball-mill feed bin, which has a live capacity of about 5,000 tons. The water screened from the ore is run in launders to the feed boxes of the ball mills.

The oversize of the Niagara screens is conveyed to a stationary washing screen, then elevated by an inclined conveyor to a second Niagara screen having the same size and type of screen as the first. The undersize of this second screen drops into the sorted-ore bin, and the oversize is passed over two 42-inch sorting belts traveling 150 feet per minute and located over the top of the sorted-ore bin. Four sorters at each belt pick off the ore, dropping it directly into the sorted-ore bin, and the remaining waste is conveyed to the waste bin. The last Niagara screen removes the undersize, which passes over the first coarse screens as a result of fluctuations in the rate of feed. The amount varies from 2 tons per minute to short surges of 8 to 10 tons per minute. Niagara screens have proved very satisfactory, even though they work under such severe conditions. The cost of their upkeep and maintenance is 0.2 per ton handled.

The proportion of oversize on the 4-inch grizzlies ranges between wide limits, depending upon mine and weather conditions. During very rainy weather an excess of fine material is washed down through the open stopes. At present the average amount of oversize will run from 40 to 45 per cent of the material trammed from the mine. Ore sorted from this material will average 1,000 to 1,200 tons per day. The average feed to the ball-mill bin is 4,200 tons per day and 500 to 700 tons screened and sorted into the sorted-ore bin. The maximum tonnage that has been put through the crushing plant in any 24-hour period was 15,600 tons.

An operating crew for each shift in the crushing and sorting department comprises a foreman and 32 laborers. All laborers on crushing and sorting are Indians and Filipinos. Maintenance and repair work is handled by a separate crew.

The crushers and gyratories are all belt-driven. The original installation had one 350-hp. synchronous motor direct-connected to a line shaft, equipped with Allis Chalmers friction clutches, driving both the crusher and gyratory in each unit. One unit is still operated in this way, but the other two units have individual 150-hp. motors for each machine. Crushers are driven at 166 r.p.m. and gyratories 300 r.p.m.

## DISPOSAL OF WASTE

The rejected waste is drawn from the bottom of the bin through chutes with underslung arc-type gates into 4-1/2-ton Granby-type cars. These cars are handled in two trains of nine cars each on a double-track balanced-gravity tram and deliver waste to the beach, about 1/2 mile away, where it is automatically dumped into a receiving bin. This bin feeds a 36-inch conveyor, which carries the material out over the waste dump to a distributing station. Three diverging

36-inch conveyors, terminating in stackers, lead out from this station and deliver the waste to the face of the dumps several hundred feet out into the waters of Gastineau Channel. The steeply sloping bottom of the channel has provided an excellent dumping site, and the resulting dike of waste rock has made a successful breakwater for the water front of Juneau.

All waste is trammed in two 8-hour shifts; an operating crew consists of a shift boss, hoistman, and nine men. Repair work, moving stackers, etc., are done by a separate crew.

All conveyors are belt-driven with gear and pinion. The three stacker conveyors have tandem drives a few feet ahead of the tail pulley. Each conveyor is driven by a 75-horsepower motor.

The cost for sorting and waste disposal per ton of material delivered to the waste dump for the past few years is as follows:

| | 1926 | 1927 | 1928 | 1929[1] |
|---|---|---|---|---|
| Total tonnage | 2,179,404 | 2,428,126 | 1,922,949 | 1,376,203 |
| Coarse crushing | $0.0304 | $0.0303 | $0.0333 | $0.0331 |
| Sorting | .0420 | .0388 | .0394 | .0334 |
| Screening | .0042 | .0039 | .0015 | .0007 |
| Waste disposal | .0414 | .0424 | .0432 | .0614 |
| General operation and maintenance | .0113 | .0134 | .0182 | .0190 |
| Total | $ .1293 | $ .1288 | $ .1356 | $ .1476 |

1 First nine months.

The increased cost in 1929 is due to charging to operating expense the entire cost of erecting a new distributing station during the year.

## FINE GRINDING

The material from the sorted-ore bin is drawn out through plain drop-lip chutes and fed into three types of crushers, that is, two 6-D Gates gyratories, one 6-inch Traylor Bulldog finishing gyratory, and two 4-foot Symons cone crushers. The 6-inch Bulldog finishing crusher has too small a feed opening for the size of feed handled and requires constant attention to avoid slabs bridging over. The Symons cone crushers have proven very satisfactory and are used exclusively, the others being used when repairs are being made to one of the cone crushers. These crushers handle about 125 tons per hour when set at 1 inch. A typical screen analysis of feed and product is:

| | Feed | | | Product | |
|---|---|---|---|---|---|
| Size | Per cent | Cumulative per cent | Size | Per cent | Cumulative per cent |
| Plus 5 inch | 7.4 | 7.4 | Plus 2 inch | 13.8 | 13.8 |
| 4 " | 19.1 | 26.5 | 1-1/2 " | 23.7 | 37.5 |
| 3 " | 30.8 | 57.3 | 1 " | 28.6 | 66.1 |
| 2-1/2 " | 17.1 | 74.4 | 1/2 " | 14.5 | 80.6 |
| 2 " | 10.9 | 85.3 | 3/8 " | 3.9 | 84.5 |
| 1-1/2 " | 7.1 | 92.4 | 1/4 " | 3.4 | 87.9 |
| 1 " | 7.6 | 100. | Minus 1/4" | 12.1 | 100.0 |

The plus 1-inch material in the product is slabs that are 1 inch or less in thickness.

The 6-D gyratories and Bulldog finishing crusher are belt-driven by 50-hp. motors and the cone crushers by 100-hp. ball-bearing motors with Tex-rope drives.

The product of the cone crushers drops into a small receiving bin and is then conveyed without screening to the coarse-roll feed bin. The rolls are fed by small belt conveyors, one equipped with a Cutler-Hammer magnetic head pulley to protect the rolls from tramp steel. The product of the rolls is elevated by a series of inclined conveyors to the level of the ball-mill floor, where it is fed onto two double-deck Hummer screens. The upper screen has 7/8-inch square openings and the lower one is a Tyler No. 691 Ton-cap, which has rectangular openings 0.063 inch wide. The oversize of the 7/8 inch screen falls onto the same conveyor belt that carries the Symons cone-crusher product and returns with it to the feed bin. The product on the fine screen goes to the fine-roll feed bin, and the undersize is laundered to the concentrating floor. An average of 90 tons per hour is put through the 7/8 inch screen, and about 10 tons of this material passes through the fine screen. A circulating load of about 100 per cent is carried on this set of rolls.

The fine rolls are fed in the same manner as the coarse rolls, but there is no magnetic head pulley. The product of these rolls is carried on an incline conveyor to four 4 by 5 foot single-deck Hummer screens equipped with No. 691 Ton-cap screens. The undersize of these screens goes to the concentrating floor; and the oversize is returned by incline conveyors to the level of the roll feeder, where it can either be put in closed circuit through the rolls or all or any part put into a 14 by 7 inch bucket elevator and elevated to a conveyor over the tube-mill feed bins, where it is distributed by stationary trippers.

Two sets of rolls, Traylor AAA Ajo type, 24 by 60 inches, one for coarse crushing and one for fine, are in operation. Both sets of rolls are operated at 100 r.p.m., and each is driven by two 150-hp. motors with endless belts and idlers. Roll shells used are 8 inches thick; no grinding of shells is done, and only occasional burning off of the edges is required. The average life of a set of shells on the coarse rolls is 2,000 crushing hours, or a steel consumption of 0.102 pounds per ton, and on the fine rolls 2,800 crushing hours or 0.117 pounds per ton. A typical screen analysis of feed and finished product on the fine rolls is:

| Feed | | | Finished Product | | |
|---|---|---|---|---|---|
| Size | Per cent | Cumulative per cent | Size | Per cent | Cumulative per cent |
| Plus 1/2 inch | 20. | 20. | Plus 10 mesh | 1.7 | 1.7 |
| 3/8 " | 25. | 45. | 14 | 10.6 | 12.2 |
| 3 mesh | 16. | 61. | 28 | 25.9 | 38.1 |
| 4 | 12. | 73. | 35 | 11.3 | 49.5 |
| 7 | 14. | 87. | 48 | 6.3 | 55.8 |
| Minus 7 | 13. | 13. | 65 | 4.8 | 60.6 |
| | | | 100 | 6.5 | 67.1 |
| | | | 150 | 3.8 | 71.0 |
| | | | Minus 150 | 28.9 | 100.0 |

An average of 40 tons per hour is finished on these rolls; the circulating load is about 200 per cent.

The mill proper is divided into 11 sections. Each is equipped with an 8 by 6 foot ball mill, operating at 22 r.p.m. and driven by a 225-hp. motor with endless belt and idler. The mills are lined throughout with cast manganese-steel liners and grates and carry a load of approximately 20,000 pounds of 6-inch forged chrome-steel balls. Each mill is served by two 30-inch Stephens-Adamson apron feeders equipped with revolution counters for calculating the tonnage handled. These feeders deliver the ore to the scoop box of the mill. A dilute pulp, about 60 per cent moisture, and 1 inch slot grates are used to get a quick discharge from the mill.

The discharge trunnion liner has a special designed flange to which is bolted a double trommel screen. The inner screen is made of 3/8 inch plate with 7/8 inch round holes and the outer one of 7-mesh screen with 0.089-inch square openings. The purpose of the inner screen is to carry the weight of the whole screen, keep the coarse rock off fine screen surface, and act as a feed distributor.

The undersize of the fine screen is run in a launder to the concentrating floor. The oversize of both screens is combined and returned to the scoop box of the mill by a 14 by 7 inch bucket elevator, or in a section having a tube mill this oversize may, if desired, be dropped by gravity into the feed bin of the tube mill. The average circulating load when grinding is done in closed circuit is 135 to 150 per cent. The average tonnage finished through the 7-mesh screen for each mill is 15 tons per hour of grinding time. A typical screen analysis of the feed to the ball mills, oversize, and finished product is:

| Feed Size | Per cent | Cumulative per cent | Circulating Load Size | Per cent | Cumulative per cent | Finished Product Size | Per cent | Cumulative per cent |
|---|---|---|---|---|---|---|---|---|
| Plus 2-1/2 inch | 1.8 | 1.8 | Plus 3/4 inch | 15.9 | 15.9 | Plus 10 mesh | 4.3 | 4.3 |
| 2 " | 10.4 | 12.2 | 1/2 " | 7.9 | 23.8 | 14 | 9.5 | 13.8 |
| 1-1/2 " | 19.8 | 32.0 | 3/8 " | 8.8 | 32.6 | 20 | 10.7 | 24.5 |
| 1 " | 24.8 | 56.8 | 1/4 " | 9.2 | 41.8 | 28 | 10.0 | 34.5 |
| 3/4 " | 8.7 | 65.5 | 3/16 " | 29.2 | 71.0 | 35 | 9.3 | 43.8 |
| 1/2 " | 9.6 | 75.1 | 7 mesh | .7 | 71.7 | 48 | 7.0 | 50.8 |
| 3 mesh | 10.2 | 85.3 | 14 | 18.1 | 89.8 | 65 | 5.1 | 55.9 |
| 7 | 9.1 | 94.4 | Minus 14 | 10.2 | 10.2 | 100 | 7.0 | 62.9 |
| Minus 7 | 5.6 | 5.6 | | | | 150 | 5.6 | 68.5 |
| | | | | | | 200 | 4.0 | 72.5 |
| | | | | | | Minus 200 | 27.5 | 100.0 |

The average life of a set of manganese-steel grates and feed end liners is 5,200 grinding hours and that of the breast liners 6,200 hours. The steel consumption, based on the tons screened through the 7-mesh screens, is

| | | 1927 | 1928 |
|---|---|---|---|
| Manganese-steel breast liners---pounds | per ton | 0.186 | 0.159 |
| feed end | do. | .062 | .057 |
| grates | do. | .035 | .036 |
| Total liner consumption | do. | .283 | .252 |
| 6 inch chrome-steel balls | do. | .955 | .927 |
| Power consumption--Kw. h. per ton | | 9.462 | 9.302 |

Originally there was one 6 by 12 foot tube mill in each section of the mill, but six of these have been removed, three to provide space for the two sets of rolls and three to make room for a boiler shop. The five mills in operation have been converted to operate as ball mills. These are operated at 25 r.p.m. and driven by a 150-hp. motor with endless belt and idler. Cast manganese-steel breast liners are used, but the grates and feed end liners are cast steel made locally in the company's own foundry. The usual ball load is 20,000 pounds. Balls used are the worn balls from the ball mills and some new 5-inch cast-steel balls. The general practice when a ball mill is stripped for relining is to send part of the old ball load to the tube-mill floor. Balls are fed to the mills daily in proportion to the running time of each mill. The material handled by these mills consists of fine-roll oversize, ball-mill oversize, or a combination of the two. It is fed into the scoop box of the mill by a gravity chute so arranged that the material feeds in as fast as it is taken out by the scoop. A dilute pulp, about 60 per cent moisture, carries the material rapidly through the mill. The grates have 1/2 inch slot openings. Trunnion trommel screens, similar in design to the ball mills, are used. The undersize of the fine screen goes to the concentrating floor, and the oversize of both screens is returned to the scoop box by an 8-inch belt drag. A circulating load of 75 to 100 per cent is maintained. The average life of manganese-steel breast liners is 2,700 grinding hours, of cast-steel grates 1,700 hours, and of feed-end liners 1,800 hours. The consumption of steel per ton finished is:

| | | |
|---|---|---|
| Manganese-steel breast liners---pounds per ton | | 0.856 |
| Local cast-steel feed end liners---pounds per ton | | .060 |
| Local cast-steel grates | do. | .091 |
| Total liner consumption | do. | 1.007 |
| Ball consumption | do. | 1.354 |
| Power---Kw.h., per ton | | 7.640 |

An average of about 11 tons per hour is finished through the 7-mesh screens. A typical screen analysis of feed and product is:

| Feed | | | Product | | |
|---|---|---|---|---|---|
| Size | Per cent | Cumulative per cent | Size | Per cent | Cumulative per cent |
| Plus 3/4 inch | 8.0 | 8.0 | Plus 10 mesh | 3.8 | 3.8 |
| 1/2 " | 5.5 | 13.5 | 14 | 8.7 | 12.5 |
| 3/8 | 7.8 | 21.3 | 28 | 19.8 | 32.3 |
| 1/4 | 10.9 | 32.2 | 35 | 11.7 | 44.0 |
| 3/16 | 36.6 | 68.8 | 48 | 6.9 | 50.9 |
| 7 mesh | 1.9 | 70.7 | 65 | 5.7 | 56.6 |
| 14 | 20.7 | 91.4 | 100 | 10.5 | 67.1 |
| Minus 14 | 8.6 | 8.6 | 150 | 2.7 | 69.8 |
| | | | Minus 150 | 30.2 | 100.0 |

## CONCENTRATING

Each of the 11 sections in the concentrating department has the following equipment: One classifier, two V-tanks, two feed distributors, and eight Deister Simplex sand tables. The classifier is a 1- spigot Deister cone remodeled to suit local conditions. The feed distributors are of local design and consist essentially of two concentric cast-iron pots. The pulp drops through a pipe into the center of the inner and shallower pot, which overflows into the outer one, having a series of holes uniformly spaced. These feeders give fairly uniform distribution and require very little attention or upkeep. The Deister tables, as originally installed, had the old open type of head motion and "drum-stick" underconstruction. These were very unsatisfactory and have all been replaced with Deister Plat-O self-oiling head motion and slipper-bearing underconstruction and have proved quite satisfactory. Covering for the deck under the riffles is 1/16-inch rubber sheeting with one ply of fabric in the center; linoleum is used for the apron. The rubber lasts several times as long as the linoleum, especially with the coarse feed. Spruce riffles 1 inch wide and 3/8 inch high are spaced 1 inch apart. The tables are belt-driven and operate at 267 r.p.m. with a stroke of 3/4 to 7/8 inch.

The undersize of the 7-mesh screens from all sources in each section passes through the classifier, which is placed in the launder leading to the V-tanks. This classifier makes a rough separation of the coarser material. The discharge of the classifier is laundered to a distributor, which feeds the first four Deister tables of the section. The overflow passes on to the V-tanks, where it is thickened. The overflow of the tanks goes to the tailings flume and the thickened product to the second distributor, which feeds the last four Deister tables of the section. Approximately 52 per cent of the material goes to the first four tables and 48 per cent to the last four. These tables all make three products, rough concentrates, dirty middlings, and tailings to waste. Their primary function is to produce clean tailings, without regard to the grade of the concentrates or middlings--the reverse of ordinary table work. The middlings are taken from between two definite points on the table, regardless of the character of material that may lie between these points; concentrates constitute all the remaining material produced, regardless of appearance or condition. Virtually the same amount of concentrates and middlings is cut, whether the tables are working at normal maximum or normal minimum loads. Each Deister table produces approximately 0.75 ton of concentrates and 6 tons of middlings per 24 hours. The concentrates consist of nearly all the freed gold and sulphides, plus coarse sands and true middlings. The middlings consist of a small amount of freed sulphides and a large amount of pulp containing some true middlings. This material is run in launders directly to the Wilfley floor and becomes the feed for two No. 6 Wilfley tables in each section. The functions of these tables are not only to recover the freed sulphides in this material but also to recover relatively high-grade coarse sands in large enough quantity to supplement the pulp in the re-treatment circuit up to the capacity limit of the fine-grinding equipment in that department and to produce tailings to waste. A minute cut of the freed sulphides is made from each table and run in launders to the reconcentrating tables on the re-treatment floor, and the middlings cut--about 1 ton from each table per 24 hours--goes to the sump.

## RE-TREATMENT

The rough concentrates from all the Deister tables are run in launders to a pair of small trommel screens on the re-treatment floor which screen out any tramp oversize and send it to the sump. The undersize of the trommels is handled by a 2-inch Krogh centrifugal pump and is delivered to a dewatering and distributing tank, which feeds three Deister reconcentrating tables on the Wilfley floor. These tables produce a finished concentrate. Two concentrates are made, one a high-grade gold cut containing as much of the freed gold as possible and the other a shipping concentrate which is run in launders to the tanks containing concentrates. A middlings cut consisting mostly of freed sulphides, pyrrhotite, and pyrite with some galena and freed gold, is sent to two Deister reconcentrating tables on the re-treatment floor, while the reject from the tables is sent to the sump. The purpose of retabling the middlings cut a second time before regrinding is to remove as much freed gold and galena as possible from this material before it is reground. These tables make high-grade gold concentrates and shipping concentrates, and the reject is sent to the sump.

The material from the sump is the feed for the re-treatment department proper. It is elevated by 14 by 7 inch bucket elevators to a dewatering box, which feeds the partly thickened material to one of two 5 by 5 foot Allis-Chalmers ball mills equipped with shovel-wheel feeders. The overflow of the dewatering box and shovel wheel, together with the product from the mill, is pumped by a 4-inch Krogh centrifugal sand pump to a V-tank on the concentrating floor. The partly thickened product from this tank is run in launders to two 4-spigot Deister cone classifiers. The product from each spigot is tabled on one of eight Deister re-treatment tables. The functions of these tables are to recover as much freed gold and galena as possible from this material in a low-grade product and to produce a low-grade reject. Three products are made on these tables, low-grade concentrates, middlings which are returned to the sump, and a reject which formerly went to waste but is now sent to the flotation circuit. The low-grade concentrates from the re-treatment tables are laundered to a Deister reconcentrating table on the re-treatment floor. This table makes high-grade gold concentrates, shipping concentrates, and a reject, which is sent to the sump.

The overflow from the V-tank and classifiers is pumped by a 3-inch Byron-Jackson slime pump to a second V-tank. The thickened product of this tank goes to two Deister slime tables and the overflow to waste. The slime tables produce shipping concentrates, middlings to the sump, and a reject which formerly went to waste but now goes to the flotation circuit.

The feed for the flotation circuit is pumped by a 3-inch Byron-Jackson slime pump to a double V-tank, the overflow of which goes to waste and the product to a 2- cell 18-inch Minerals Separation Sub-A flotation machine. This machine produces a shipping concentrate from the first cell and tailings to waste. The flotation plant is still in the experimental stage, and more cells may be added. At present about 1 ton of concentrates, assaying $75.00 in gold, 10 to 14 per cent lead, 4 per cent zinc, and 40 to 45 per cent iron, is being produced per 24 hours from 80 to 100 tons of feed assaying $1.50 to $2.00 in gold, 0.1 to 0.2 per cent lead, 0.5 per cent zinc, and 20 per cent iron. Potassium amyl xanthate and cresylic acid are the flotation reagents used.

The above description has pointed out that the table work in the Alaska Juneau mill is quite distinct from that in the ordinary concentration mill. The concentrates and middlings cuts are both enormously large in proportion to the mineral content in the feed, which is extremely small. An average of 1.15 pounds of lead is recovered per ton of ore fine ground. It will be noted that all these tables making clean tailings do not make a finished product, and those tables making a finished product do not make tailings.

Numerous experiments have been made with finer grinding and better classification of table feed, but the additional recovery has not been found to be great enough to cover the increased cost of operation. The typical distribution of values in the Deister and Wilfley table tailings is given in the following table:

| Size | Deister | Wilfley |
|---|---|---|
| Plus 28 mesh | $0.2766 | $0.3063 |
| 35 | .2747 | .3370 |
| 48 | .2734 | .3504 |
| 65 | .2575 | .3335 |
| 100 | .2351 | .2928 |
| 150 | .2170 | .2861 |
| 200 | .2265 | .2714 |
| Minus 200 | .2493 | .3161 |

All fine tailings to waste are discharged into one of two 42 inch tailings flumes and carried to the beach, a distance of about 3,000 feet. The grade of the old flume is 4 per cent and the new one 2-1/2 per cent. A dilute pulp, 10 per cent solids, is required on account of the high percentage of coarse sand in the tailings. A typical screen analysis of tailings is

| Size | Per cent | Cumulative per cent |
|---|---|---|
| Plus 10 mesh | 4.3 | 4.3 |
| 14 | 9.9 | 14.2 |
| 20 | 16.8 | 31.0 |
| 28 | 13.6 | 44.6 |
| 35 | 13.8 | 58.4 |
| 48 | 9.5 | 67.9 |
| 65 | 5.7 | 73.6 |
| 100 | 6.0 | 79.6 |
| 150 | 3.4 | 83.0 |
| 200 | 6.3 | 89.3 |
| Minus 200 | 10.7 | 100.0 |

The old flume is lined with concrete. The new flume has 2-inch cast-iron liners cemented in place and a few hundred feet of rubber lining. These have not been in use long enough to allow comparisons of their relative wearing value.

Shipping concentrates produced on the re-treatment floor are caught in boxes at the end of the tables and packed in double burlap sacks. Concentrates produced on the Wilfley floor are run in launders to the concentrates tanks with filter bottoms. The concentrates, after draining in the tanks, are shoveled onto the floor, allowed to dry for 2 or 3 days, and then packed in paper-lined burlap sacks. The average moisture content is about 5 per cent. These concentrates average about $350.00 per ton in gold, 35 ounces silver, 60 per cent lead, and 20 per cent iron. The high gold content of these concentrates is due to very thin flat particles of gold, which tend to ride on the galena. The ratio of concentration after fine grinding has been about 1000 to 1, but since flotation concentrates are being made this has dropped to 750 to 800 into 1.

The high-grade gold concentrates, assaying $20,000 to $30,000 a ton in gold, are collected in an amalgam barrel for treatment. Six hundred ounces of quicksilver, which has been cleaned with a 10 per cent nitric acid solution and about 3 pounds of freshly slaked lime, is added to the charge and all ground for 5 or 6 hours. The amalgam barrel is of cast iron, is 2 by 4 feet in size, revolves at 30 r.p.m., and has one piece of 6-inch shafting as a grinding medium; the shafting keeps the inside of the barrel smooth and makes it easier to clean out all the amalgam after each run. The barrel is discharged while running through a 1/2-inch hole into a 4-foot diameter mechanical batea which removes most of the galena. The residue in the batea is carefully cleaned by hand, and the cleaned amalgam is squeezed in an air-operated press. The value of the concentrates discharged from the batea averages about $75.00 in gold.

The amalgam is retorted at regular intervals in an oil-fired cast-iron horizontal retort. The sponge-gold recovery is 60 to 65 per cent of the weight of the amalgam and the mercury loss about 1 per cent. The sponge gold is melted in an oil-fired tilting furnace with a No. 10 graphite retort for a crucible. Soda and borax glass are used for flux, and the molds are heated and oiled with boiled linseed oil. The bullion is sampled while molten and before pouring by a graphite mold made from an old retort. One bar, 1200 to 1600 ounces in weight, is melted at a time. The average grade of the bullion is gold, 850 fine; silver, 130 to 135 fine. Approximately 80 per cent of the total gold recovery is in the form of bullion. One man takes care of amalgamating, retorting, and melting.

The operating crew for the mill, outside of the coarse crushing and sorting plant, is 1 shift boss and 11 men for each shift. A clean-up and repair crew takes care of general cleaning up, handling of concentrates, maintenance and repairs, etc.

The company has a large dock and warehouses where ocean-going steamers land all supplies and load concentrates for shipment to the smelter. Supplies are delivered to the mill by an inclined tram. The ball and tube mill floors are each equipped with a 50-ton Shaw electric traveling crane, and the crushing plant has a 20-ton crane of the same make. Supplies on other floors are handled on monorail tracks.

## Table of Assays and Recoveries

| Year 1927 | Weight | | Gold | |
|---|---|---|---|---|
| | Tons | Per cent | Assay, dollars per ton | Per cent of total |
| Rock trammed .............. | 4,267,810 | 100.00 | $0.7743 | 100.00 |
| Coarse table tailings ..... | 2,428,115 | 56.89 | .1900 | 13.96 |
| Coarse table middlings reground ............... | 1,839,695 | 43.11 | 1.5455 | 86.04 |
| Bullion ................. | - - - | - - - | .9659 | 53.77 |
| Lead concentrates ......... | 1,420 | .03 | .2937 | 16.69 |
| Fine tailings ............. | 1,838,275 | 43.08 | .2801 | 15.58 |
| Total tailings ............ | 4,266,390 | 99.97 | .2288 | 29.54 |
| Total recovery ............ | - - - | - - - | 1.2656 | 70.46 |
| **Year 1928** | | | | |
| Rock trammed .............. | 3,718,140 | 100.00 | 1.1062 | 100.00 |
| Coarse table tailings ..... | 1,922,949 | 51.72 | .2097 | 9.8 |
| Coarse table middlings .... reground ............... | 1,795,191 | 48.28 | 2.0666 | 90.20 |
| Bullion ................. | - - - | - - - | 1.3424 | 58.59 |
| Lead concentrates ......... | 1,947 | .05 | .4071 | 17.17 |
| Fine tailings ............. | 1,793,244 | 48.23 | .3174 | 13.84 |
| Total tailings ............ | 3,716,193 | 99.95 | .2617 | 23.64 |
| Total recovery ............ | - - - | - - - | 1.7496 | 76.36 |
| **Year 1929[1]** | | | | |
| Rock trammed .............. | 2,904,560 | 100.00 | 1.1007 | 100.00 |
| Coarse table tailings ..... | 1,376,203 | 47.38 | .1919 | 8.26 |
| Coarse table middlings reground ............... | 1,528,357 | 52.62 | 1.9190 | 91.74 |
| Bullion ................. | - - - | - - - | 1.2724 | 60.82 |
| Lead concentrates ......... | 1,627 | .06 | .3699 | 17.69 |
| Fine tailings ............. | 1,526,[illegible] | 52.56 | .2770 | 13.23 |
| Total tailings ............ | 2,902,[illegible] | 99.94 | .2367 | 21.49 |
| Total recovery ............ | - - - | - - - | 1.6423 | 78.51 |

1 First 9 months.

### Summary of All Production per Ton

| | Milled | Mined | Milled | Mined | Milled | Mined |
|---|---|---|---|---|---|---|
| Gold ....... | $1.2656 | $0.5456 | $1.7496 | $0.8447 | $1.6423 | $0.8642 |
| Silver ..... | .0187 | .0081 | .0252 | .0122 | .0233 | .0123 |
| Lead ....... | .0542 | .0233 | .0709 | .0342 | .0841 | .0442 |
| | 1.3385 | .5770 | 1.8457 | .8911 | 1.7497 | .9207 |

The company maintains a foundry at Treadwell, the site of the famous Treadwell mine, just across the channel on Douglas Island. The foundry is equipped with a Heroult 2-ton electric furnace and makes most of the necessary castings, pulleys, gears, liners, etc.; an annealing furnace has been put into operation, and alloy-steel liners will be made. Scrap from the mill and from the old Treadwell plants is utilized by the foundry. A machine shop and a boiler shop are located in the mill building and are equipped to make any necessary repairs.

## MILLING COSTS

The costs for the various stages of fine milling for the last few years, based on the total tonnage of fine milled, are:

| | 1926 | 1927 | 1928 | 1 1929 |
|---|---|---|---|---|
| Tons milled | 1,659,791 | 1,839,686 | 1,790,491 | 1,528,357 |
| Coarse crushing | $0.0304 | $0.0303 | $0.0333 | $0.0331 |
| Sorting | .0094 | .0087 | .0122 | .0122 |
| Screening | .0063 | .0077 | .0025 | .0025 |
| Intermediate crushing | .0206 | .0143 | .0190 | .0194 |
| Fine grinding | .1830 | .1976 | .1606 | .1604 |
| Concentrating | .0165 | .0226 | .0221 | .0225 |
| Re-treatment | .0178 | .0175 | .0179 | .0147 |
| General operation and maintenance | .0449 | .0530 | .0588 | .0514 |
| Total | .3289 | .3517 | .3264 | .3162 |

1 First 9 months.

The cost per ton handled in each operation, based on the tonnage actually handled in that operation, is:

| | 1927 | 1928 | 1 1929 |
|---|---|---|---|
| Coarse crushing | $0.0303 | $0.0333 | $0.0331 |
| Sorting | .0388 | .0394 | .0334 |
| Coarse waste disposal | .0424 | .0432 | .0614 |
| Screening, coarse | .0080 | .0030 | .0024 |
| Intermediate crushing | .0551 | .0739 | .0686 |
| Screening, hummer | .0063 | .0089 | .0130 |
| Ball mills | .1988 | .1613 | .1609 |
| Rolls | .1100 | .0738 | .0806 |
| Tube mills | .2017 | .1773 | .1593 |
| Concentrating | .0226 | .0221 | .0225 |
| Re-treatment | .1972 | .1974 | .1732 |
| General mill, operating maintenance, etc. | .0305 | .0378 | .0361 |
| Total | .2257 | .2285 | .2363 |

1 First 9 months.

Milling costs for power, labor, and supplies based on tonnage trammed are distributed as follows:

| | 1927 | 1928 | 1929 |
|---|---|---|---|
| Power | $0.0321 | $0.0272 | $0.0288 |
| Labor | .0984 | .1085 | .1081 |
| Supplies | .0952 | .0928 | .0994 |
| Total | $ .2257 | $ .2285 | $ .2363 |

The cost and tonnage handled per man per day for sorting and milling are:

| | 1927 | 1928 | 1929 |
|---|---|---|---|
| Sorting: | | | |
| Crew (direct) | 79.47 | 71.61 | 72.35 |
| Cost per man per day | $ 8.53 | $ 8.26 | $ 8.91 |
| Tons rejected per man per day | 83.71 | 73.37 | 69.67 |
| Milling: | | | |
| Crew (direct) | 110.46 | 106.53 | 110.34 |
| Cost per man per day | $17.75 | $16.24 | $16.94 |
| Tons milled per man per day | 46.04 | 46.04 | 50.74 |

The outstanding features of the operations of the Alaska Juneau are: An ore body of such size and character as to permit a caving system of mining whereby ore is mined and delivered to the mill at a cost of $0.26 to $0.29 per ton; rejection by screening and hand-sorting of approximately 50 per cent of the material mined at a cost of $0.13 to $0.15 per ton rejected; and milling of the sorted ore at a cost of $0.31 to $0.33 per ton milled, giving a total operating cost of $0.51 to $0.57 per ton trammed from the mine.

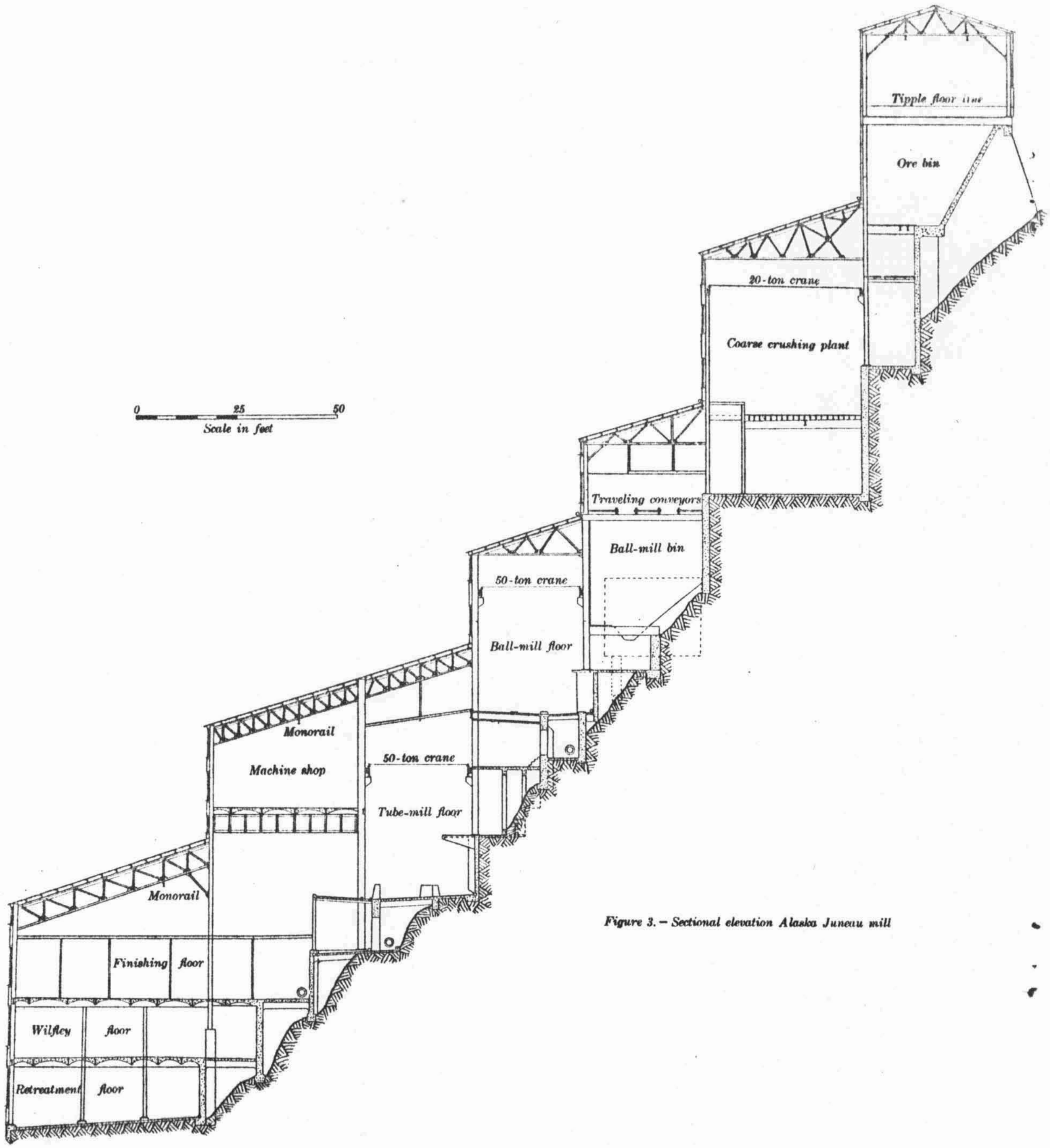


Figure 3. – Sectional elevation Alaska Juneau mill