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MINING METHODS AND COSTS

ALASKA JUNEAU GOLD MINING COMPANY, JUNEAU, ALASKA

BY

P. R. BRADLEY

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ALASKA JUNEAU GOLD MINING CO.,

JUNEAU, ALASKA[1]

By P. R. Bradley[2]

INTRODUCTION

This paper is one of a series, dealing with mining methods and costs, sponsored and published by the U. S. Bureau of Mines. Papers of this series are written by engineers and executives of mining companies, at the solicitation of the Bureau, and in accordance with an outline prepared by Bureau engineers, for the purpose of securing uniform presentation and conformable data.

The property of the Alaska Juneau Gold Mining Co. is situated near the city of Juneau, Alaska, in what is known as the Harris mining district. Wholesale mining operations have been adopted on a large scale and 10,000 to 11,000 tons per day of gold-bearing ore are mined and sent to concentrators near Juneau. In addition to gold, the ore yields 0.6 ounce of silver and 13.0 pounds of lead to each ounce of gold recovered.

ACKNOWLEDGMENTS

This paper is a compilation and revision of an article by the author which was published in the Transactions of the American Institute of Mining and Metallurgical Engineers, volume 72, and of an article by Joseph A. Williams, engineer of the company, which was published in the Explosive Engineer for November, 1926.

HISTORY OF THE DISTRICT

Gold was first discovered in the district in 1880, and mining might be said to have been continuous since that date. During the late eighties there was a substantial production from placer work and from numerous small mills of various types.

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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 6186."

2 One of the consulting engineers, U. S. Bureau of Mines. Consulting engineer, Alaska Juneau Gold Mining Co.

Spencer shows that the early mills were:

Arrastres in the period to 1881 to 1888 inclusive.
A 5-stamp mill in 1882.
A "newly devised grinding mill" in 1884.
Two Huntington mills in 1886.
A 10-stamp mill in 1889.
A revolving Dodge mill in 1890.
A 5-stamp mill in 1891.
A 20-stamp mill in 1893.

In 1896 the owners of the Alaska Juneau property, having been encouraged by results obtained from their own 5-stamp mill, as well as by results of neighboring operations, built a 30-stamp mill. In 1898 the Ebner Co. built a 15-stamp mill, and in 1907-08 the Perseverance Co. built a 100-stamp mill. These mills, which had been pioneered by the smaller mills preceding them, in their turn pioneered the later expansions in the scale of operation that lead to present-day practice.

During the first twenty years of Alaska Juneau operations the small mills were operated both for commercial and for experimental purposes. At the same time a close study was made of all local conditions and problems, and valuable economic and technical data were gathered. The conclusions obtained therefrom may be summarized as follows:

1. The Juneau gold belt is an integral portion of the coast range formations, and is of great length, variable width, and of irregular and erratic mineralization.

2. The belt itself is composed of slate and similar sedimentaries with intrusions of metagabbro.

3. The belt is divided into bands of poor definition.

4. In the vicinity of Juneau the various bands converge to a limited width, become better defined, and constitute a broad lode.

5. The gold in the belt is due to the presence of quartz.

6. The broad lode in the Juneau vicinity contains an enormous tonnage of low-grade ore.

7. This grade of ore could be mined and milled at a commercial profit when operating on a large-scale all-year basis.

8. Large-scale all-year operations demand low-cost underground mining, sea-level mills, and a continuous supply of cheap power.

Climatic and other conditions rendered all-year operations impossible at the high altitudes where the various early mills were situated. Therefore the proposal to change from seasonal water-power operation to all-year operation involved the driving of low adit-level outlets from the mines to suitable mill sites on the beach, these adits serving at the same time to tap the ore at depths as much as 2,000 feet below the surface.

The first deep-level adit on the Alaska Juneau property was planned in 1898 and started in 1899, but it was not definitely arranged for until 1910. In that year F. W. Bradley entered into a contract with the Alaska Juneau Co. whereby he was to drive a tunnel 420 feet above sea level for a distance of 6,500 feet to a point beneath the surface workings, and then to raise 800 feet to the surface. This work started in 1911 and was completed in about two years. In 1913-14 the Alaska Juneau Co. built a 50-stamp pilot mill on the hillside near Juneau, and in 1916 a new mill was built, with a rated capacity of 8,000 tons per day; but, owing to the failure of some experimental features, the actual capacity of the mill proved to be less than 4,000 tons per day. The milling costs proved to be about four times higher than the average milling costs in the district.

GEOLOGY

The Juneau gold belt lies between the diorite core of the coast range mountains and the greenstone and chloritic schists on the northeastern shore of the Gastineau Channel. The rocks occupying this interval consist of sediments and their various derivatives, with irregular intrusions of metagabbro. The sediments have been folded, intensively plicated, and subjected to the compression that developed the slaty cleavage. This cleavage is generally coincident with the strike but not with the dip. The rocks making up the sedimentary series consist of phyllite gray slates, graphitic slates, laminated quartzites, and sericitic schists. The metagabbro intrusions are fairly abundant in the slates, and extend to a lesser degree into the schists and greenstones; they occur in the form of sills, small laccoliths, and dykes.

Gold occurs chiefly, if not wholly, in quartz stringers and gash veins in the slate and metagabbro. The quartz is irregular in form and disposition, following the strike of the slate cleavage in a general way, but has a slightly steeper angle of dip.

Stringer lodes usually near the slate and gabbro contacts are found in a zone from 1,000 to 2,000 feet wide. These lodes are made up of a network of quartz veinlets and isolated lenses varying in width from less than 1 inch to 3 or 4 feet. The higher-grade ore bands are not over 300 feet wide, while the lower-grade material between them varies from 25 to 100 feet.

Clean quartz will average $6 per ton within the areas of commercial ore while the rock outside of the quartz stringers is practically worthless. Outside the commercial ore zone there is an abundance of quartz carrying little or no gold.

The gold itself is erratically distributed and of wide variation in size. The size of gold ranges from nuggets with a maximum dimension of 0.75 inches, to the finest dust.

Associate minerals are galena, sphalerite, pyrrhotite, and pyrite. Galena and sphalerite are usually highly auriferous; the pyrrhotite will assay about $6 per ton and the pyrite less. The run-of-mine ore averages about 90 cents a ton in gold.

EXPLORATION, SAMPLING, AND ESTIMATION OF TONNAGES AND VALUES

Preliminary knowledge of the character, extent, and value of the ore deposits was gained by the early operations in the district, the gradual expansion of which had a most important bearing on present-day operations. This is true to the extent that each successive step in the progress was the result of the preceding step and the final operations of the Alaska Juneau Gold Mining Co. were based on an accumulated fund of information rather than on a systematically developed tonnage of which the assay value had been determined by any of the hand-sampling practices commonly in use.

Theoretically, it should be possible by hand-sampling to determine the average assay value of any gold ore, but on theJuneau gold belt the gold is unusually coarse for lode gold, its distribution in the quartz is erratic, and the quartz itself is irregularly disposed throughout the ore-bodies. Therefore, it is a difficult problem to determine in advance, by any system of hand-sampling, the average gold content of these ores. Furthermore, the development work done in any one of the mines on the belt, in advance of milling operations, was not sufficient to permit a reliable determination of average assay values by hand-sampling methods exclusively.

The average gold assay value of the ore milled during the history of the Alaska Juneau mine is 89 cents per ton, but many samples taken from within stoping areas exceed this average by several thousand per cent. Any practical method of hand-sampling this ore will produce such a great variation of values.

Systematic channel-sampling in the Alaska Juneau mine is considered an unnecessary expense and is not now practiced. The value of ground not already known through actual mining is gained by grab samples taken from the muck during the progress of development work. The assay results of such samples are interpreted in light of experience and knowledge of the ground. The chief purpose of sampling in the Alaska Juneau mine at all is to determine the grade of what is known to the miner's eye to be ore, and to make a permanent record of the information. The results obtained by this method of sampling, or any other method, determine the high or low value of what the experienced eye already knows to be ore.

Final knowledge as to the value of the ore in the Alaska Juneau mine has been derived from muck samples, moil samples, and mill returns; in addition to the mill returns from normal operations, many tests have been made, not only on ore from various parts of the mine, but also from bands interveining between ore bands, and from waste. The conclusions arrived at have been supported by actual returns.

SELECTION OF STOPING METHOD

As previously stated, the Juneau gold belt is divided into ore bands of poor definition. The most easterly workings on the belt, those of the Alaska Gastineau Co., disclosed three separate bands: The footwall or Groundhog band, 70 feet wide; the Perseverance band on which the recent mining was done, also 70 feet wide; and the No. 2 band, 100 feet wide. These bands, aggregating 240 feet are found over a width of 2,000 feet. Going toward the west into the adjoining Alaska Juneau ground, four bands have been found which have a total right-angle thickness of 755 feet. These bands are convergent in their westerly trend and terminate on the plane of Silver Bow fault. The four bands have better definition at the fault plane than at the eastern boundary line where they enter the property. Along the property line, the width of the bands and intervening country is 1,600 feet, and at the Silver Bow fault this width is reduced to 1,300 feet. The distance from the eastern property line to Silver Bow fault is 2,400 feet. The bands are slate or slate with metagabbro intrusions, together with gold-bearing quartz masses, stringers, and gash veins. The bands themselves are not all ore, but all commercial ore is found within the bands. They have no uniform width either in horizontal or vertical section. The ore has no hard and fast boundary except where cut by faults, and profitable mining ceases on a vague and indefinite line where the auriferous stringers and gash veins become too few.

The throw of Silver Bow fault was downward and westerly, the components of motion being about equal, and the apparent horizontal displacement is about 2,000 feet. Being later than all the rocks and later than the ore, the fault has had the effect of dividing the mine into two parts. The occurrence of the ore bands on the eastern side of the fault has already been described. On the western side there apparently has been a coalescence of the bands without the identity of any one band being pronounced, unless it is the footwall or Nugget Gulch band.

For mining purposes a band can be considered as a definite channel of values, but actually this is not the case; the distribution of values throughout each channel or band is by no means uniform. There is an abundance of evidence to this effect in all the mines on the belt, and the irregularity of values extends both vertically and horizontally. No general law has made itself evident; that is to say, there is no system of repeated ore bodies within the bands, no arrangement of horizons of characteristic leanness or richness, and no marker of any kind that will indicate that a certain unknown part of a band will be good, bad, or indifferent. Some bands are known to be better than others, and parts of the same band are definitely known to vary greatly in gold content. The gold values may diminish and the amount of quartz remain the same; but, as a general rule, quartz that is gold-bearing contains sulphides of lead, zinc and iron, and conversely the absence of these sulphides denotes an absence of gold in the quartz, and marks it as low grade. Hence an intimate acquaintance will enable the eye to distinguish between payable areas and those not payable.

The selection of a mining method for the mines on the belt resolves itself immediately into consideration of (1) selective mining, and (2) wholesale mining.

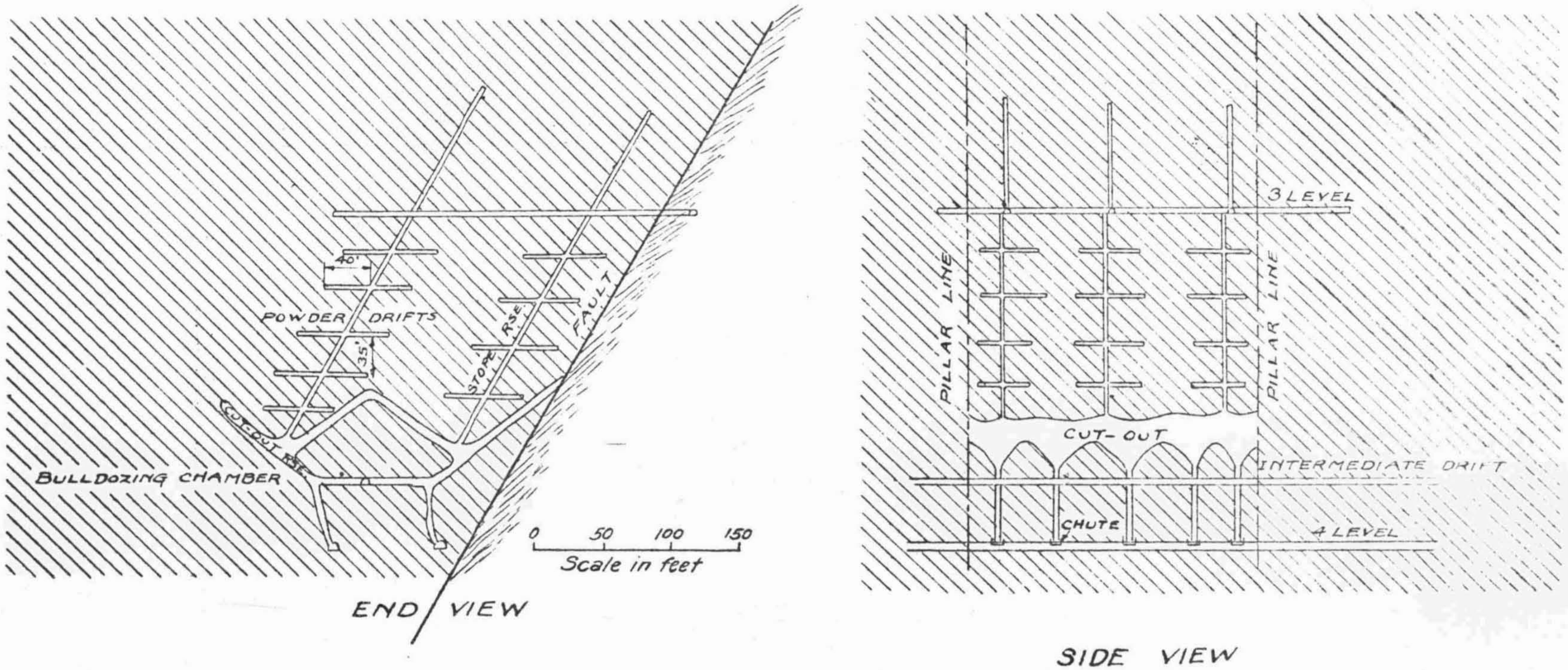
Selective Mining. - Small-scale selective mining on the Juneau gold belt has been tried in a number of instances, and whereas some of the enterprises have operated at a small profit, none has been a commercial success. Large-scale selective mining means a large number of small stopes or a smaller number of large stopes; in either case, stope control is necessary in order to avoid dilution. The result, however, will be and has been failure, for the reason that control means prohibitive mining costs.

Wholesale Mining. - Wholesale mining has to be viewed entirely in terms of the effects of dilution, for no low-cost system can be worked without this inevitable result. Due consideration must be given to the amount of dilution, its effect on the mill feed, and what means, if any, can be used to overcome this effect. In order to determine the effect of dilution on the value of the ore mined, it is necessary to know the value of the ore and the value and amount of dilution. Knowledge as to the value of the ore in the Alaska Juneau mine has been derived from muck samples, moil samples, and mill returns; in addition to the mill returns from normal operations, many tests have been made, not only on ore from various parts of the mine but also from bands intervening between ore bands, and from waste. All this accumulation of data is sufficient for the determination of ore values, and the conclusions arrived at are supported by actual returns; the mill feed and mill returns have confirmed absolutely what all data indicated.

In the neighboring Alaska Gastineau property the mine and mill operations were based on two assumptions: (1) That the ore bands were "continuous and uniform" and (2) that by a modified caving system of mining the stopes could be confined to a single ore band. Neither of these assumptions were correct, and the combined effect of irregularly distributed values and inclusions of low-grade material and waste reduced the mill feed so that the recovery instead of being $1.50 per ton, as estimated, was but 82 cents per ton, 7 cents of which was in silver and lead values.

The caving system adopted for mining the Alaska Juneau ore accepted dilution, and the new mill has been so rebuilt as to avoid having an excess of waste rock submitted to the process of fine grinding at an excessive ball mill cost of 40 cents per ton. The elimination of waste is accomplished by sorting the ore from the waste at advantageous points in the mill; 53 per cent of the rock trammed is rejected, and the remaining 47 per cent is fine-milled. The cost of sorting and disposing of waste is about 6 cents per ton trammed and the final mill feed has nearly twice the assay value of the ore trammed.

In developing the mining system finally adopted, due consideration was given to all physical conditions surrounding the ore bodies. Full advantage was taken of the fault system, consisting chiefly of Silver Bow fault, and Nugget Creek fault, and a number of subparallel sympathetic faults, all being post-mineral. Silver Bow fault cuts the ore at a horizontal angle of 53°, completely severs all the ore bands, and divides the mine into two parts, locally called the "north half" of the mine and the "south half" of the mine. Nugget Gulch is a strike fault and for all practical purposes is the marker for the footwall of the ore; its dip varies from 55 to 60°. On each fault plant there is a considerable amount of fault breccia which sloughs away readily when undercut. The system as finally worked out consists of:



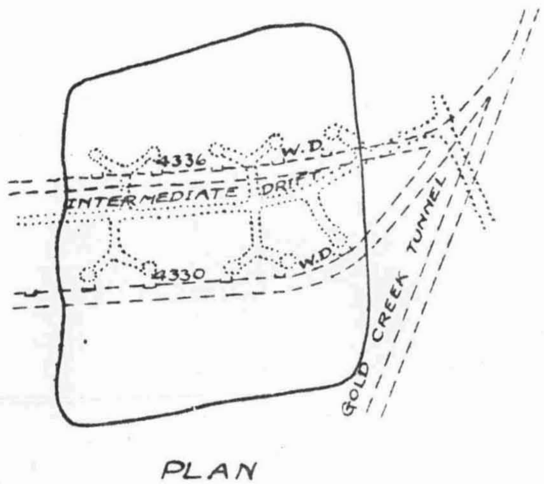


Figure 1. - A fully developed stope in the North Ore-body ready for powder drift blasting

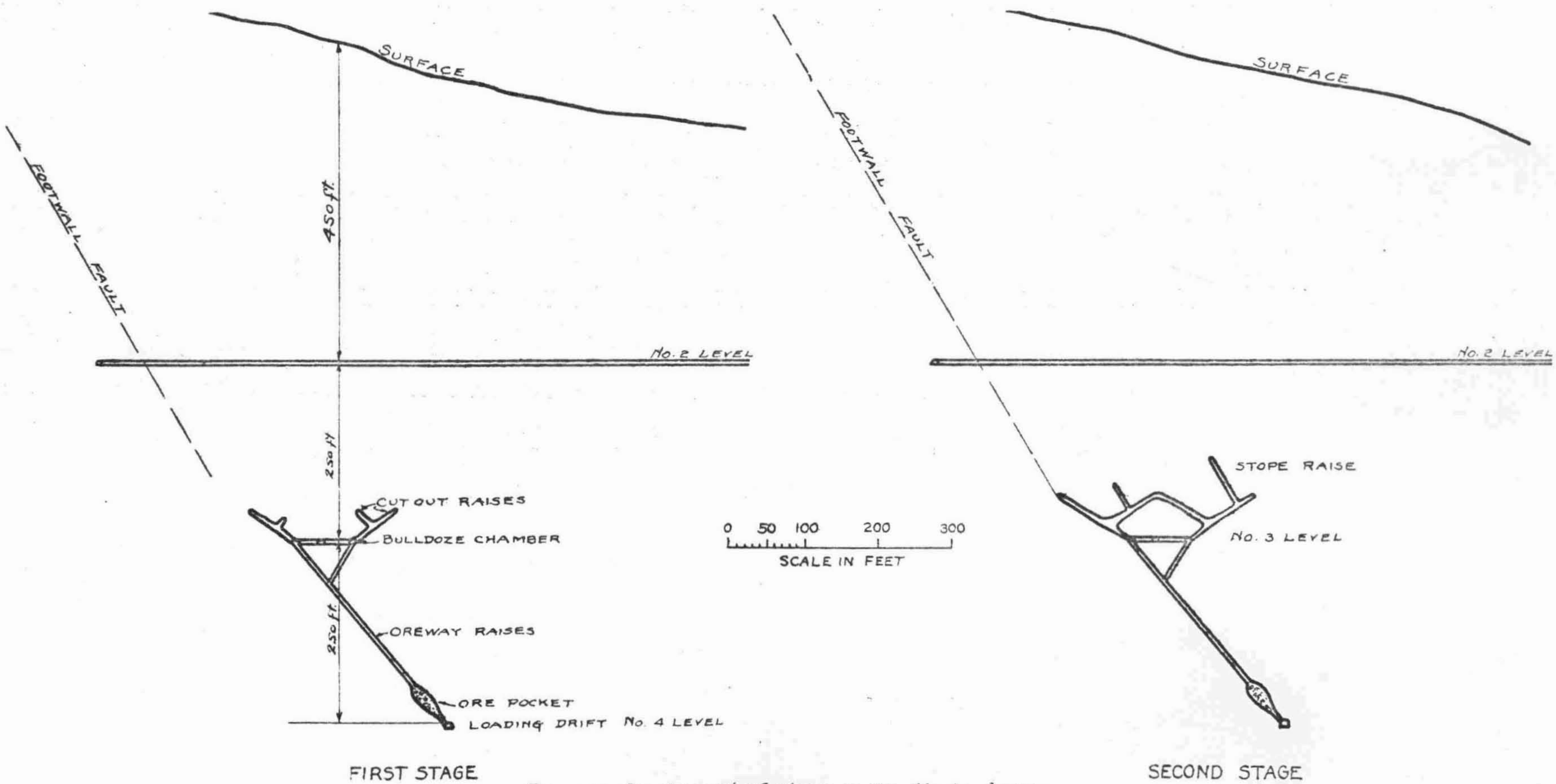


Figure 2a, Development of stopes at the Alaska Juneau

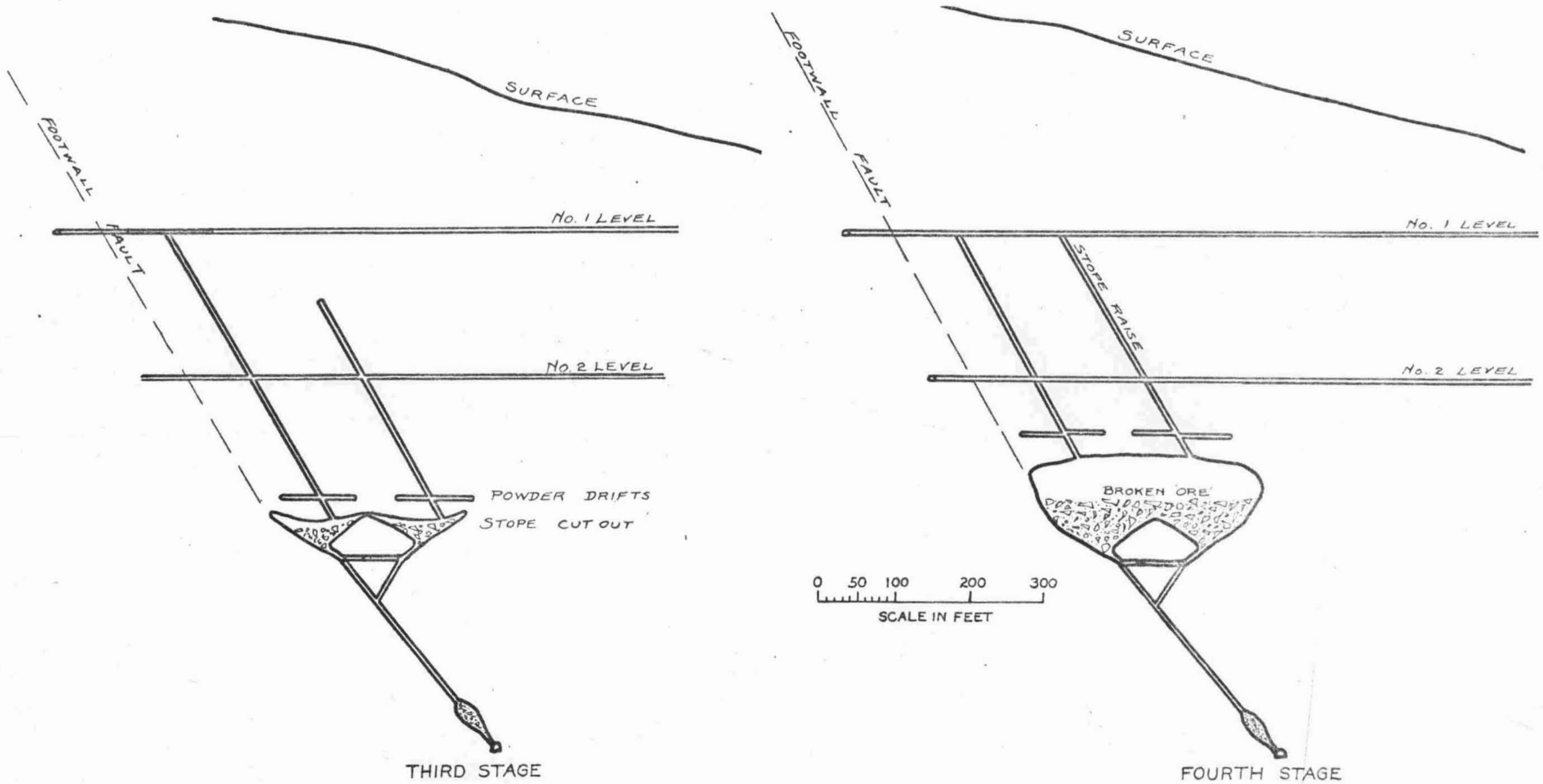
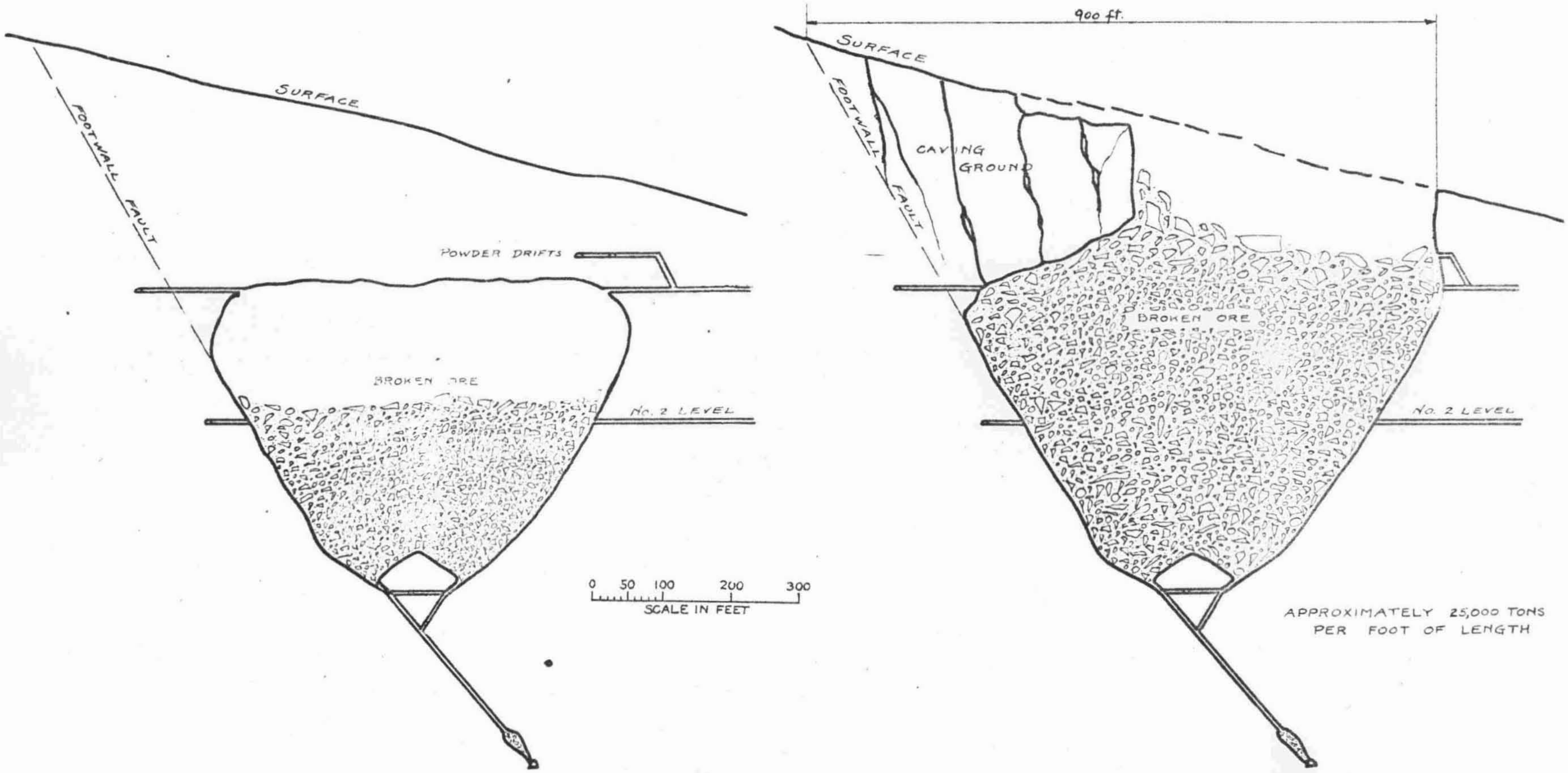


Figure 2b, Development of stopes at the Alaska Juneau (continued)



FIFTH STAGE SIXTH STAGE

Figure 2c, Development of stopes at the Alaska Juneau (continued)

(1) Cutting out stopes of large area, so located that the footwall of the stope is one of the faults.

(2) Driving raises from the back of the cut-out stope area, through to the next two levels above.

(3) Driving numerous powder drifts from and radial to these raises.

(4) Provision of bulldozing chambers for drawing ore out of the stopes into the loading chute. Figure 1.

The system of mining is caving forced by firing charges in powder drifts located over the back of the stopes. In preparing a stope, two parallel drifts 40 feet apart are advanced under the ground to be caved. From these loading drifts chute raises are extended 50 feet above to an intermediate level, where the ore is to be drawn from the stope through bulldozing chambers. From the bulldozing chambers a cut-out raise at 38° is driven toward the hanging wall on one side and to the footwall on the other side; these two are then connected by a back cut-out raise from each. The undercutting then begins by working from these raises; one raise serves as a manway in cutting out the rest in a receding manner. Pillars, which between stopes are 80 feet wide, are left wherever needed, and in addition temporary pillars are frequently used to support a weak roof during cutting-out work; these temporary pillars are shot out just before the stope is brought into production. While the undercutting is being done, stope raises about 100 feet apart are driven to the level above. The upper level is then used as a supply level and for means of access to the powder drifts below. From these raises powder drifts are driven radially, usually being about 40 feet long with not over 50 feet of burden. When the area is completely undercut, blasting begins and the rock is drawn through the bulldozing chambers into the chutes below. It has been found by experience that to produce the best results from powder drift blasting and caving, the stope should have a horizontal cut-out area of not less than 50,000 square feet. Figures 2a, 2b, and 2c.

On the average, 12,000 feet of tunneling and raising and 46,000 square feet of undercutting are completed in one year. No timber is required, as the work is in either medium hard slates or dense gabbro.

STOPING

Powder Drift Blasting. - Powder drifts or coyote holes are driven from stope raises out over the back of the stope; they are 4 by 3 feet in section on a grade of about 10° to facilitate mucking operations. These drifts are seldom over 60 feet long; where they exceed this length, the first half is made big enough for a wheelbarrow. The muck from the last two rounds is left in the bottom as stemming for the powder charge. The nature of the ground, the distance the rock will have to fall, and the position of the powder piles in relation to the boundaries of the stope are the main factors in determining the burden and the charge of explosives. The average depth of ground placed on a powder drift is 35 feet; this would require an average charge of 4,000 pounds of 40 per cent dynamite placed in two piles 35 or 40 feet apart. Three or four or even five such piles make up an ordinary blast. As a rule only one series of powder drifts on the same level in anyone stope is blasted at a time.

The powder, a 1-1/4 by 8 inch 40 per cent ammonia dynamite, is taken from the cases at a convenient place, usually at the top of the stope raise, and transferred to canvas pack-sacks in which it is carried down the raise to the mouth of the powder drift. Here the sack is made fast to the middle of a long rope and hauled into the face on a wooden slide; the empty sacks are returned in the same manner. The cartridges are packed tightly against the solid rock, care being taken beforehand to remove all loose material. Prior to the completion of loading, double-countered Cordeau-Bickford detonating fuse is laid from pile to pile; each pile is then tamped for about 15 feet with fine rock stemming.

In some of the smaller blasts when the location is favorable, the loading, tamping, and blasting are finished in one shift, but for all large blasts these operations require two shifts.

The Bickford fuse is detonated by No. 8 blasting caps and two 30 foot lengths of single tape safety fuse. The fuse is spit in going off shift, and immediately after the shot the blast doors are closed. Enough broken ore is kept in the stopes to prevent any ill effects from air blasts due to caving; there has not yet been any trouble from this source.

Up to the end of 1928, 313 blasts have been made using 1,632,950 pounds of dynamite and averaging 20 tons of ore broken by each pound of explosive. In stopes and pits, where the blasting is not accompanied by caving, 5.56 tons are broken by a pound of explosive.

Bulldozing. - Bulldozing is the local name applied to the operation of delivering ore from the stope through the grizzly into the loading chute. The rock comes on to the grizzly through a raise called the draw, which slopes at 38° from the horizontal. Here the large pieces are blockholed with a Sullivan DP-33 drill using 7/8-inch hexagonal hollow steel. The holes are loaded with 1-1/4 by 8 inch 40 per cent ammonia dynamite and blasted with No. 6 caps, on 3-foot fuse; no stemming is provided. Mudcapping is resorted to only when the boulder can not be drilled with safety and then the charge is limited to three cartridges of explosive. Before firing, the "bulldozer" warns his neighbors and turns on an air jet which acts as a warning to those at the loading chute below if the chute is empty. When a big rock hangs up in the raise above the grizzly so that it can not be barred down it is left for the "bulldoze boss" to handle. If he considers it safe, the rock is drilled with a CC-11 Ingersoll Stoper; otherwise it is brought down with powder charges on long blasting poles.

The grizzly bars formerly were 12 by 14 inch fir timbers strengthened with 100-pound rails. For the last three years, however, a standard 15-inch 104-pound H beam 16 feet long has been satisfactorily used. The wide flange is stiffened by cast-iron fillers spaced 4 feet on each of the center grizzlies and on the inside of the side beams. A 13-inch channel inverted is riveted to the top; besides adding strength, this channel also makes the spacing between beams less at the top than at the bottom, which is desirable. The opening between the girders is 25 inches. Figures 3 and 4.

The beams slope 1-1/4 inches a foot (about 6°) and are set on concrete foundations with the lower ends butting against solid rock. Wooden blocking, to maintain the spacing, is wedged in between beams at both ends. Usually the center girder, which gets most of the wear, will handle 47,000 tons of rock

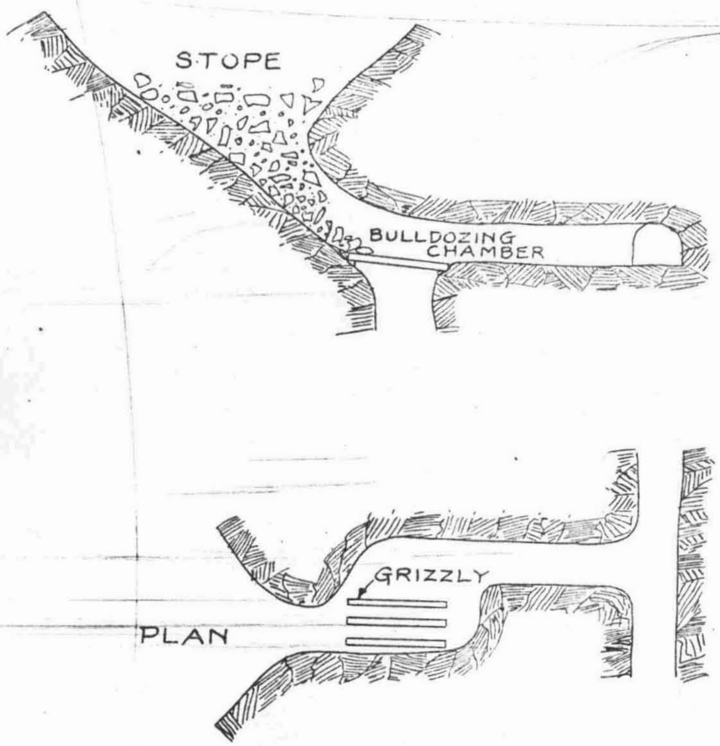


Figure 3.- Standard Bulldozing Chamber

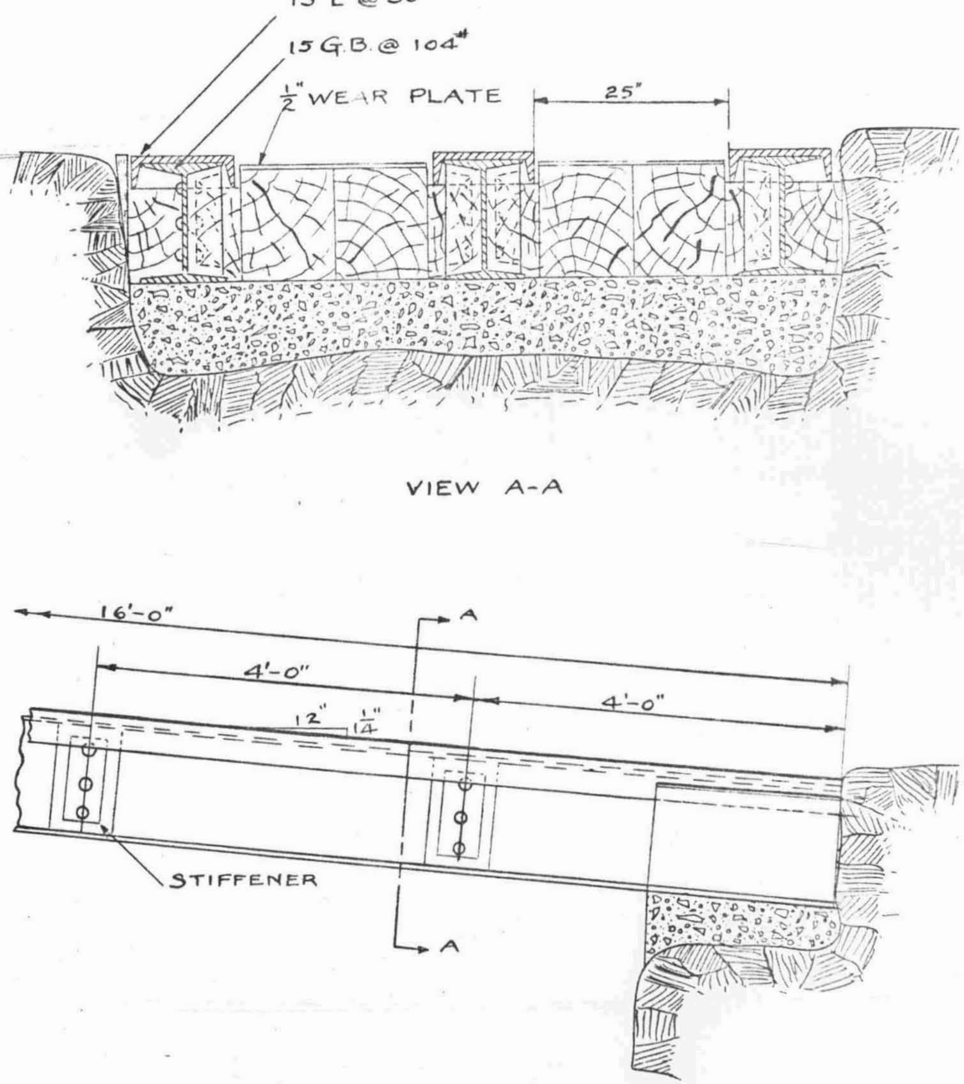


Figure 4.-Details of Grizzly

before it needs replacing. Often a worn center beam will still do for a side, or if bent too badly it can be cut into wearing plates for the loading chutes.

When the back of the drawhole from the stope wears so that rock drops vertically onto the grizzly, the beams are reset in a position which is relatively higher and farther away from the opening. The bottom of the draw then fills in with fine material up to the angle of repose and the drawhole becomes as good as new. The nature of the ground has a great deal to do with how soon this grizzly charge is necessary; experience shows that over 250,000 tons are handled before the change is needed.

The amount of powder for secondary breaking varies with the age of the stope and the nature of the ground. During the first year of operation of a new stope in hard, tough rock, 2.85 tons of rock per pound of powder is not unusual, while in the older slate stopes 5.26 tons per pound is ordinary. The average is 4.54 tons a pound of explosive consumed.

EXPLOSIVES

Two days supply of powder is kept in the underground magazine. On the surface two miles from the mine, 3,000 cases are always stored in a non-heated, bullet, weather, and fire proof magazine. This magazine, located in compliance with the American Table of Distances, is constructed of weak cement mortar according to the recommendations of the Institute of Makers of Explosives.

Of the total powder consumption 13 per cent is used in development headings and stope preparatory work; 16 per cent in stoping (the blasting of powder drifts), and 71 per cent in secondary breaking or block holing, commonly called bulldozing. All drilling and blasting operations fall into one of these three large groups.

UNDERGROUND TRANSPORTATION

After passing the grizzly, the ore falls into chute raises which hold 200 tons of ore each. From these raises it is drawn through the chutes, which are equipped with an underslung arc-type gates, into the cars. The chute opening is 6 feet long by 3 feet high. The bulldozing chambers and chutes are spaced on 42-foot centers so that when a train is in the loading drift, every third car is under a chute. Figures 5 and 6.

A 10-ton flat-bottomed box car is used in main haulage levels, and a 30-inch gauge track of 50-pound steel rail is used throughout the mine, except where a 40-pound rail is used for sidings.

The overhead trolley system is used in the haulage level and the ore is trammed to mill 2 miles distant in trains of 44 cars each by 18-ton articulated Baldwin Westinghouse locomotives.

Storage-battery locomotives are used for development in advance of main haulage work and also on the upper levels.

No mechanical mucking machines are used in the mine and there is practically no hand-tramming except in the small coyote drifts where wheelbarrows are sometimes required for drifts which are longer than the average.

Power is obtained from the Alaska Juneau Co.'s hydroelectric plant. There is also a standby steam unit which is used only in cases of emergency or water shortage. The cost per kw.h. for 1928 was .00439.

PERCENTAGE OF EXTRACTION

It is yet too early to estimate the percentage of extraction, but a total extraction is expected in the northern half of the ore body plus a slight dilution from the lower-grade wall rock. A small loss is expected on the southern ore body because of the pyramidal sections between the cone-shaped stopes which it may not be economical to undercut and cave. This loss, plus the dilution, was calculated before commencement of operations.

No sorting or selective mining is attempted underground. Approximately 53 per cent of all ore is discarded in the mill by hand and mechanical devices before it is sent to the fine-grinding department.

DETAILS OF DEVELOPMENT

The various sizes of openings are: haulage tunnels, 9 by 9 feet, main levels, 7 by 7 feet; intermediate levels, 7 by 5 feet; powder drifts, 4 by 3 feet; oreway raises, 7 by 9 feet; cut out raises, 6 by 6 feet; stope raises, 5 by 5 feet; and stope cut out, 7 feet high.

Machines in use on this work are the medium weight wet leyner type drifters, using the anvil block, and medium weight, hand-rotated stopers. The Leyner drill is used for all work except that in small, steep raises. The steel used is 1-1/8-inch hexagonal, hollow for drifters and 1-1/4-inch cruciform and 1-inch quarter octagon for stopers. The standard cross bit with single 14-1/2° taper is employed with 1/4-inch change in gauge for each 20-inch change in length.

Rounds are drilled with from 8 to 24 holes, usually not over 6-1/2 feet long. The center pyramid cut is customary and is blasted first, then the rest of the round is loaded and blasted. A 40 per cent ammonia dynamite in a 1-1/4 by 8 inch cartridge has been adopted for all work; no stemming is provided. No. 8 blasting caps and single tape safety fuse constitute the detonating agents. The average advance on all headings is 2.64 feet a machine a shift. In stope cut out work the average area covered during each machine shift is 38.54 square feet; this area is taken out to a height of 7 feet.

WAGE, CONTRACT AND BONUS SYSTEMS EMPLOYED

Bulldozing, loading, and tramming, and all mine development as well as preparatory mining work, is done by contract. The wages paid out to the contractor and his laborers amounts to 75 per cent of the total underground payroll. Briefly mentioned, some of the features that have made the contract system successful, are:

The guarantee of a reasonable base wage for contractor and men.

The division of all excess earnings or bonus after a certain stipulated amount among contractor and contractor's employees, share and share alike, in accordance with the number of shifts worked.

The close supervision of work and the prompt adjustment of price when justified by changed conditions.

The careful selection of men for contractors, and the prompt elimination of such contractors as are unable to earn more than base wages at a reasonable contract price.

The withholding of a small amount of earnings as retained pay. This is usually retained when contractors' earnings are good. This retained pay may be forfeited by the contractors for unsatisfactory work or failure to complete the contract satisfactorily. It has seldom been necessary to forfeit the contractors' retained pay on account of poor work.

The furnishing of good equipment and its maintenance in good condition, with plenty of steel and good air pressure.

Maintaining the same price for explosives regardless of market change.

The inclusion of two or more working faces in the same contract whenever practicable to obtain more nearly average drilling and breaking conditions.

The bulldozing and tramming contract as handled at present guarantees a good base wage to contractor and men, with a graduated bonus to all when tonnage exceeds a certain amount. This contract is really more of a bonus system than a contract, but the working conditions are such, and so many men working in different parts of the mine are included in this contract, that it is not practicable to make it as firm a contract as in the case of development work.

In connection with and on account of the other contract and bonus work, the company pays a bonus to all employees who are not in the development or bulldozing and tramming contracts. This bonus is based on tons per man per day and payable on the twentieth of the month to employees who worked 26 days in the preceding month. It has been necessary to adjust the bonue rate from time to time owing to changed conditions. This bonus is based on the theory that at those times of the year when help is scarce and the plant may be somewhat undermanned, the employees who do stay will automatically receive an increase in pay.

OUTLINE OF EARLY MINE-DEVELOPMENT CONTRACTS

Gold Creek tunnel was started in August, 1911, and finished in August, 1913, during which time it was driven 6,538 feet. The tunnel was driven 9 feet high and 7 feet wide at a total cost of $20.49 per foot.

For the first few months, straight daily wages were paid the men. However, in January, 1912, a bonus was added which for several months amounted to $3.50 per shift per man.

The bonus system was as follows: The month was divided into three periods on which bonus was paid; only those men who worked during a complete period were entitled to the bonus earned during that period. The bonus started at 180 feet at the rate of $5 for every foot over 180 up to and including 240 feet. For every foot over 240 feet made during the month, the bonus was $10 per foot. The bonus was prorated among all the men according to the number of shifts worked. The base rates paid in 1912 are as follows:

	Per shift
Foremen	$5.00
Machine men	3.50
Machine men helpers	3.25
Muckers	3.00
Blacksmith	4.50
B. S. Helper	3.00
Trammers	3.00

The driving of 450 Oreway Raise in 1915 was probably the next contract job in the mine. The first set of contractors made 17 feet and then gave it up. The second group finished the raise for a slightly higher price per foot but made less than wages for themselves. The prices were as follows:

First set (cancelled)		Second set	
First 200 ft.	$6.00 per ft.	First 100 ft.	$8.50 per ft.
200 - 300 ft.	6.50 " "	100 - 200 ft.	9.00 " "
300 - 400 ft.	7.00 " "	200 - 300 ft.	9.50 " "
400 - 580 ft.	7.50 " "	300 - 400 ft.	10.00 " "
		400 - 580 ft.	10.50 " "

Labor was $4.50 per day, powder $6 per case, and primers 8 cents each.

Two stope raises in 402 Stope were contracted for in August, 1915, for a price of $6 per foot. Then in April, 1916, the south portal of No. 3 Tunnel was driven 9 by 9 feet for a contract price of $9.50 per foot. Up to this time no provisions were made regarding maximum or minimum earnings. In a contract October, 1916, let for the widening of No. 3 Tunnel for $5.50 per foot a maximum earning of $250 per month and a guaranteed minimum of $5 per day was agreed upon. The surplus over $250 remained with the company. Labor at that time was $3.50 per day and powder $7 per case.

From 1918 to date nearly every heading has been advanced by contract work. Up until June, 1922, no maximum rate was provided for, but at this time it was agreed that anything over $11 per day remained with the company. In November, 1922, it was provided that the surplus over $11 per day be divided among the contractor and his men according to the number of shifts worked. Up to this time it was customary to deduct 25 per cent of the contractors' earnings each month. This was later changed so that the whole amount retained rarely exceeds $150 per contractor, depending on the length of the job.

A wage scale without bonus for the various years follows:

	1915	1918	1920	1922	1924	1926	1928
Shift boss - - - -	$ 5.00	$ 5.50	$ 5.50	$ 5.50	$ 6.00	$ 6.50	$ 7.00
Blacksmith - - - -	5.00	6.00	5.00	5.00	5.50	5.50	5.50
Steel sharpener - -	4.00	4.50	5.00	5.00	5.00	5.00	5.00
Timberman - - - - -	4.00	4.50	4.50	5.00	5.25	5.25	5.50
Trackmen - - - - -	3.50	4.00	4.50	4.50	4.50	4.50	4.50
Pipemen - - - - - -	3.50	4.50	4.50	4.50	4.50	5.00	5.50
Hoistmen - - - - -	3.50	4.00	4.00	4.00	4.00	4.50	4.50
Machinemen - - - -	3.50	4.50	5.00	5.00	5.00	5.50	5.50
Contr. mucker - - -	3.00	4.50	4.50	4.50	5.00	5.00	5.00
Laborer - - - - - -	3.00	3.50	4.00	4.25	4.00-4.50	4.00-4.50	4.00-4.75
Bulldozer - - - - -		4.50	5.00	5.00	5.25	5.25	6.00
Loader - - - - - - -		4.00	4.25	4.50	4.75	4.75	5.00

PRESENT MINE-DEVELOPMENT CONTRACTS

Contract work in mine development such as driving a 500-foot drift is handled in the following manner: A call for bids on the work may be posted, the company reserving the right to reject any or all bids. When a bid is finally accepted, a contract is drawn up and signed by both parties. The price per foot may be the same for the whole distance, or it may increase every so often as the distance from the face to the dump increases. The general nature of the ground is usually known. For short pieces of work bids are not always called for, but a certain miner is chosen and a price is set.

The contract price is so much a linear foot; out of this amount the contractor pays for his direct labor, including liability insurance, and for his explosives. The explosives are bought from the company at the rate of $9 a case for powder and 8 cents each for primers.

The contractors' labor consists of machinemen, muckers, and a steel-nipper. Aside from direct labor and explosives, the company supplies everything, including tools, compressed air, steel, pipe, track, etc. On the average the contract price for explosives and direct labor amounts to 60 per cent of the total cost of driving headings.

The contract price of headings of the same cross section varies with the hardness of the ground, length, accessibility, ventilation, etc. No timber is required, as all work is done in gabbro or medium-hard slates. The present prices run as follows:

Main haulageways - - - - - - - -	9 x 9 ft. - - -	$12.50 to $14.50
Drifts and crosscuts - - - -	7 x 5 ft. - - -	7.00 to 8.50
Powder drifts - - - - - - - -	4 x 3 ft. - - -	5.50 to 6.50
Stope raises - - - - - - - - -	5 x 5 ft. - - -	6.50 to 8.50
Oreway raises - - - - - - - -	7 x 7 ft. - - -	10.00 to 12.00

Stope cut-outs which are 7 feet high are also done on contract. The price varies from 35 to 40 cents per square foot slope measurement. Liability insurance is figured at 3 per cent of the total labor paid, including the contractor himself, who is rated at $5.50 per day.

It is customary to bring the contractors' earnings up to $6 per day by advancing the necessary amount which may be deducted from future earnings. Whenever his earnings per shift exceed $11 the surplus amount is divided between contractors and laborers alike according to the number of shifts worked.

BULLDOZING, LOADING, AND HAULING CONTRACT

The essential work of ore production, which includes bulldozing, loading, and hauling, is done by contract. The early contracts were short lived, but in 1919 a new contract was agreed upon which, by modifications made from time to time, has developed into the existing arrangement. The 1919 contract provided for a payment of 13 cents per ton of ore bulldozed, loaded, and hauled to the mill. The contractors provided all labor and explosives, and liability insurance; the company provided all else. Hauling was then, and is yet, handled as a subcontract under the main contract. Contractors on bulldozing and loading were limited to $8 per shift, and all their earnings in excess were prorated among the men and contractors according to the number of shifts worked; all earnings over $10 per shift for contractors, $7 per shift for bulldozers, $7 per shift for chute punchers, $5.50 for loaders, and $4.75 for cleanup men were to be held as retained pay to be distributed in future months when the earnings fell below the schedule. The subcontractors on tramming were guaranteed $7 per shift, and earnings in excess of this amount were to be divided between the contractors and their men on the basis of shifts worked. It was further provided that men quitting during the month were to be paid at the base rate of $6 for contractors, $5.25 for bulldozers, and $4.75 for loaders. This provision was incorporated into the contract as an inducement for men to stay on the job, as at that time there was a shortage of labor. In 1923 it was agreed that if at the end of six months there was any retained pay that had not been absorbed in making up deficiencies as provided for, it would be distributed among all men in the mine working on straight day's pay and prorated among them on the basis of shifts worked; however, to participate in this distribution or bonus a man must have worked an average of 26 shifts per month for four months previous to the time of payment. In 1924 the distribution of the bonus was put on a monthly basis, with the same 26 days work, not including overtime, as a qualification. However, any man incapacitated by accident received the bonus for the time he did work even though that time was less than 26 days. Men paid by the day were given the benefit of the bonus on the theory that they, the timbermen, trackmen, pipemen, etc., by efficient work contributed to the efficiency of the contractors. Later the timbermen's wages were charged directly to the contract because their work consists chiefly of chute repairs, the amount of which depends on the loader's care in handling chutes.

In 1928 the rate for bulldozing, loading, and hauling was increased from 13 to 14 cents per ton; and the base wage increased as follows:

$7.50	for	contractors
6.25	"	chute punchers
6.00	"	bulldozers
5.00	"	loaders
5.00	"	motormen
4.75	"	cleanup men

This list gives an outline of the alterations in the original contracts made necessary by changing conditions. It also shows how the first contract, all the earnings of which were paid to a few, grew into a base-rate-plus-bonus system for all men employed on the contract.

A great many factors operate to change conditions so that it is necessary to alter the contract from time to time. Some of these factors follow:

The weather affects the flow of rock in the South ore body. Too much rain causes loading troubles, whereas a continued dry spell slows up bulldozing. Occasionally a cold winter will cause muck in low-drawn pits to freeze. North ore body muck generally runs more freely above the grizzly than that from the South due to its more slaty nature. Rock in 400 Stope, for instance, could be handled much more cheaply than South ore. Old stopes are generally more productive than new ones. Gabbro ore does not run as freely as slate ore. In the South ore body with its long oreways below the grizzly the rock becomes well broken so that the cars can be loaded to capacity. In the North frequently a car must be loaded light on account of large slabs.

At the end of each month the contract is credited with 14 cents per ton trammed out of the mine. From this amount is taken the cost of explosives and all direct labor, including the contractors, all at base rates. The balance, if any, is available for bonus and is divided among the contractor's entire crew in proportion to a certain maximum bonus rate per shift. If after this first bonus has been declared there is still a surplus, it is divided so that everyone, including the contractor, receives the same amount per shift. If the contract fails to make wages at base rates, the amount advanced to enable it to do so may be deducted from future earnings. The men who leave during the month are paid at their base rates.

Explosives are sold and delivered by the company as follows: 40 per cent Red Cross powder at $9 per case; 3-foot primers with No. 6 Cap at 80 cents each.

Contract 58-A, which is a subcontract for the transportation of ore from the mine to the mill, is charged to contract 100. The trainmen are paid $5 per day and receive a bonus of 50 cents per day whenever contract 100 earns a bonus.

Liability insurance on contract 100 amounts to 3 per cent of the total labor at base rates, including contract 58-A. It is charged to the contract whenever there is a surplus available for bonus, exceeding the insurance by $1,000.

Bulldoze contractors average earnings per day, 1923 - 1928, inclusive.

Year	Earnings	Tons mined per day	Percentage from North ore body
1923	$9.10	6,860	79.5
1924	9.88	8,476	63.4
1925	9.16	9,618	53.2
1926	8.17	10,579	45.4
1927	8.34	11,790	22.2
1928	7.29	10,243	6.4

The contract system has proved highly satisfactory. The men make better wages and the unit costs are less than they would be under straight day's pay. Supervision is reduced to a minimum, and the inclusion of day's-pay employees into the contracts indirectly, through a share of the earnings, swings them into the contractors' stride. The general result is an esprit de corps and a genuine interest in the work on the part of the underground crew.

VENTILATION

The mine is ventilated by natural draft stimulated in two places by Ventura fans of 60-inch diameter. Raises and crosscuts are driven solely for ventilation as required.

By means of ventilation and blast doors, gasses from blasting find a ready exit to the surface without polluting other portions of the mine. The ventilation is so good that after a shot of 200 cases of powder, one can safely venture to that locality within eight hours.

FIRE HAZARDS

There are practically no fire hazards in the mine. Timber is used only in the ore chutes and No. 4 main haulage level and in places where ground is heavy because of the promimity of fault plane. As timbers on this level fail they are being replaced by steel sections.

SAFETY METHODS AND FIRST-AID ORGANIZATION

First-aid training is considered important by the management, and a first-class safety engineer is employed. Local instruction is given to the men in both first-aid and helmet work, and as far as possible the first-aid spirit is instilled into the organization, with the result that the accident rate is exceptionally low.

FORM OF ADMINISTRATIVE ORGANIZATION

An organization chart is maintained to define the authority and duties of every one in the organization; this chart shows not only lines of authority, but lines of cooperation as well.

Instructions from the management to superintendents and foremen or to other members of the staff are usually preceded by a discussion or conference. At such a conference the highest in authority should be a leader in thought.

As most of the work is done by contractors, the number of foremen and shift bosses is reduced to a minimum. During 1928 the total number was five per day, or an average of 55-1/2 men underground to one boss.

SUMMARY OF COSTS

Tons of ore trammed during period: 3,670,910 Period covered: 1928

Mining method: Sublevel caving

Underground costs per ton of ore trammed

	Labor	Power Costs	Explosives	Other Supplies	Total
Development:					
In ore - - - -	.0375	.0035	.0095	.0106	.0611
In rock - - - -	-	-	-	-	-
Mining - - - - - - - - - -	.0016	.0000	.0069	.0005	.0090
Bulldozing - - - - - - - -	.0601	.0019	.0430	.0079	.1129
Transportation - - - - - (underground)	.0811	.0035	-	.0290	.1136
Total - - - - - - - - - -	.1803	.0089	.0594	.0480	.2966

SUMMARY OF MINING COSTS IN UNITS OF LABOR, POWER AND SUPPLIES

Tons trammed: 3,670,910

A. Labor (man hours per ton):	Underground crew	All labor charged to mining
Development - - - - - - - - - - -	.030	.048
Stoping - - - - - - - - - - - -	.001	.003
Bulldozing - - - - - - - - - - -	.064	.083
Tramming - - - - - - - - - - - -	.064	.132
Total - - - - - - - - - - - -	.159	.266
Tons per man per shift - - - - -	50.10	30.10
Tons per man per shift on surface chargeable to underground - - -		75.4

B. Power and supplies:	
Explosives, pounds per ton:	
Development - - - - - - - - - - -	.06
Stoping - - - - - - - - - - - -	.05
Bulldozing - - - - - - - - - - -	.29
	.40
Power, kw.h. per ton - - - - - -	1.61
Other supplies in percentage of total supplies and power	48.9%
Supplies and power, percentage of total cost - - -	19.17%

C. Percentage of Total Cost:	
Development - - - - - - - - - - -	20.59%
Mining - - - - - - - - - - - - -	79.41%
	100.00%

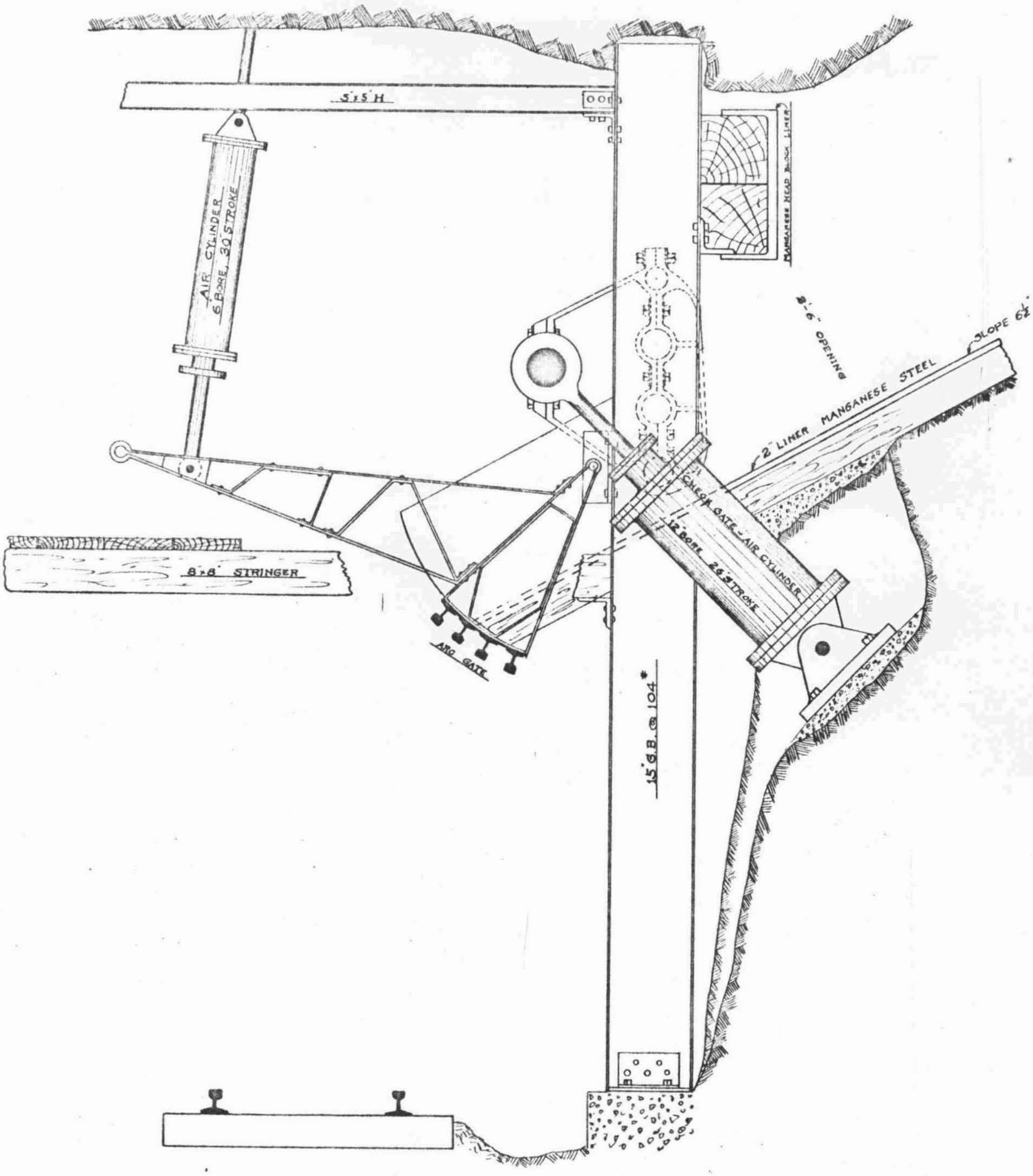


FIGURE 5

AIR OPERATED LOADING CHUTE

ALASKA JUNEAU GOLD MINING CO. JUNEAU ALASKA

SCALE 0 3 6 9 12 INCHES SEPT. 11, 1929

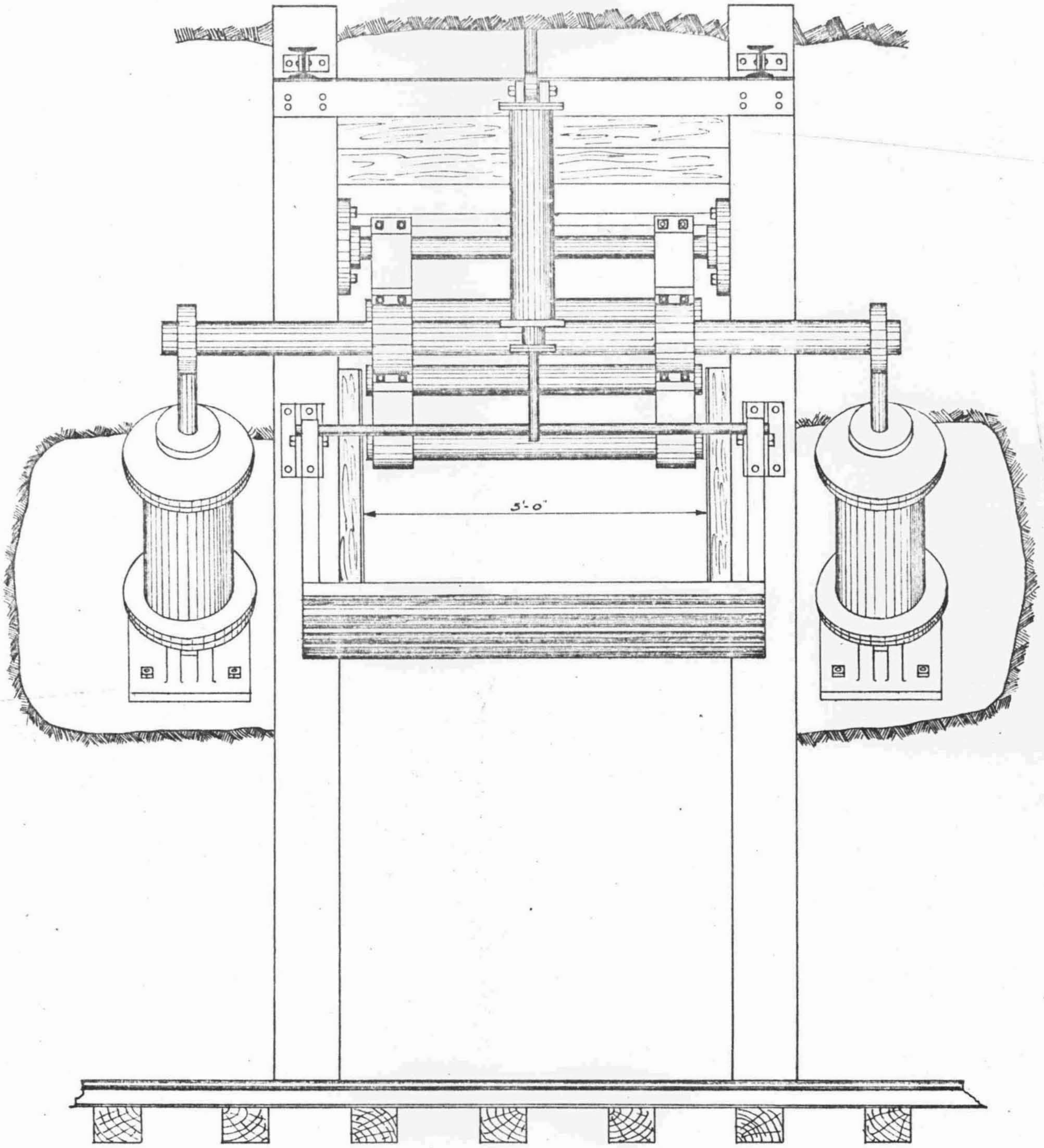


FIGURE 6

AIR OPERATED LOADING CHUTE

ALASKA JUNEAU GOLD MINING CO. JUNEAU ALASKA

SCALE 0 3 6 9 12 INCHES SEPT. 11, 1929.