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POWER-SHOVEL AND DRAGLINE PLACER MINING

BY

E. D. GARDNER AND PAUL T. ALLSMAN

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By E. D. Gardner[2] and Paul T. Allsman[3]

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1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7013."

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ILLUSTRATIONS

INTRODUCTION

This is one of a series of papers being published by the Bureau of Mines on placer mining; it is written as a supplement to Information Circular 6788, "Placer Mining in the Western United States, Part III", by E. D. Gardner and C. H. Johnson, which was published in February 1935.

Since Information Circular 6788 was written (1933), considerable advance has been made in the technique of mining placer gravels with power shovels and draglines. Although new washing plants continue to be built in accordance with untried designs, the trend of new installations is toward proved equipment. A substantial number of plants are now being operated successfully (1937).

This paper describes various phases of placer mining where the gravels are excavated by draglines and power shovels. It is based principally upon original data collected by the authors in the summer of 1936 and spring of 1937 and in part upon available published information upon the subject.

ACKNOWLEDGMENTS

The operators in the field generously supplied information about their plants. Credit is given in the text to authors from whose published articles material has been abstracted.

HISTORY AND DEVELOPMENT

In the early days of placer mining, deposits of gold-bearing gravels were found that could not be hydraulicked or worked by hand. The principal result of efforts to work such deposits mechanically has been the development of the gold bucket-line dredge. The first efforts were mainly unsuccessful, but the modern gold dredge is an efficient machine and accounts for most of the placer gold produced.

During the past 45 years steam shovels and other mechanical excavators have been used for mining gravel deposits not susceptible to dredging. The technique of dragline and power-shovel mining, however, has not been developed to a comparable degree with dredging. Most of the operations have been spasmodic and, except in relatively few cases, unsuccessful up to about 1934.

Beginning in 1931 and 1932, general interest in placer mining increased greatly; fresh impetus was given to the industry by the increase in the price of gold to $35 per ounce in 1933. As a part of the expansion in placer mining, a large number of operations were begun in which mechanical equipment was used for mining the gravel, which was washed in separate plants. Most of the early plants were unsuccessful, but as experience has been gained in their design and selection of equipment, the proportion of failures has declined steadily; however, up to 1937 the majority (probably 80 percent) had not been profitable.

Placer gravels are excavated mechanically by (1) bucket line dredges, (2) tractors pulling scrapers, (3) bulldozers, (4) buckets or scrapers pulled by hoists, and (5) dragline excavators and power shovels. Dredging is a field in itself, and the second, third, and fourth methods up to the present are relatively unimportant; this paper is concerned only with dragline or power-shovel operations. The washing plants may be of three types - floating, movable on land, and stationary. All three are considered in this paper.

The following tabulation shows the relative yardages handled by the dredges, the separate floating washing plants, and the movable land and stationary plants in California in 1935, the last year for which figures are available.[4]

4/ Data supplied by Chas. W. Merrill, acting supervising engineer, Min. Prod. and Econ. Division, Bureau of Mines, San Francisco, Calif.

Kind of operation	Cubic yards	Average value of gold recovered per cubic yard of gravel
Dredges	77,282,173	$0.117
Floating washing plants	3,405,566	.212
Movable land and stationary plants	426,575	.559
Total and average	81,114,314	.123

More floating washing plants than any other type are used; most of these boats are in California. In March 1937, 20 California boats were visited by the authors. In addition, one at Hayfork, Trinity County, Calif., and another near Jacksonville, Jackson County, Oreg., were in operation but temporarily shut down because of bad weather; they were not visited. Three other plants were being moved in California at the time of the survey. A floating plant was visited in the spring of 1936 near Helena, Mont., and one near Prescott, Ariz., a third at Pinecliff, Colo., and a fourth at Fairplay, Colo., in the summer of 1937.

The Bodinson Manufacturing Co. of San Francisco, builders of most of the California floating plants, and Harry F. England of Oroville, Calif., are largely responsible for the development of the boats now in use. Kumle was using a homemade wooden floating plant, however, at Oregon House, Calif., and Hofford and Johnson a more elaborate plant at Sumpter, Oreg., in 1932.[5] The Hofford and Johnson washing plant was a dredge from which the excavating unit had been removed. The gravel was dug by a dragline on the bank. With the exception of being heavier and more expensive, this plant was quite similar to the boats now in use in California. A successful plant on Lynx Creek, near Prescott, Ariz., was developed independently and concurrently with the California boats.

Standard washing, screening, and gold-saving equipment similar to that used on bucket-line dredges is employed on the floating plants and permits continuous operation.

The first successful movable washing plant that has come to the authors' attention was installed by the E. T. Fisher Co. at Atlantic City, Wyo., in 1933;[6] it was equipped with a standard dredge trommel and dredge riffles. Since 1933, a number of other successful movable plants have been put in operation.

Relatively few stationary plants are used; the field for this type of plant is more limited than for the floating or movable land plant.

5/ Gardner, E. D., and Johnson, C. H., Placer Mining in the Western United States, Part III.: Inf. Circ. 6788, Bureau of Mines, 1935, p. 6.

6/ Ross, Charles L., and Gardner, E. D., Placer-Mining Methods of E. T. Fisher Co., Atlantic City, Wyo.: Inf. Circ. 6846, Bureau of Mines, 1935, p. 2.

Most of the unsuccessful ventures owe their failure to inadequate sampling of deposits; the gravel did not contain the anticipated amount of gold. Other factors contributing to failure have been poor washing-plant design, selection of a set-up not adapted to the deposit, and lack of experience. Although this type of mining is primarily a dirt-moving job, only a few of the excursions into the field by excavating contractors and sand and gravel men have proved successful. The majority of the unsuccessful ventures have been run by men without previous placer-mining experience; most of the successful ventures are run by men with this experience.

To be successful, gold must be recovered at low cost per cubic yard of gravel, and the success of most of the enterprises is determined by the number of cubic yards handled per man shift. A successful plant must be designed to fit existing conditions; proven equipment is used by virtually all of the successful operators.

The excavating machines are built by established responsible companies; mechanical "bugs" have been largely eliminated. On the other hand, washing and gold-saving equipment and plant practice have not been standardized, and nearly every new plant, except the floating plants in California, is built according to an original design; many contain untried innovations.

The most efficient screening and washing device for placer mining is the trommel of the type used on dredges. As far as is known to the authors, no installations using flat screens for washing and fine sizing of placer gravels have proved successful. Riffles, as used on dredges, are efficient in recovering gold, except fine or flaky rusty particles. Jigs have been used as an auxiliary to riffles to increase the over-all extraction in some places. There are numerous other gold-saving devices, but, with the exception of the Ainlay bowl, none of these have proven successful in practice, principally because of their limited capacity.

Although sufficient experience has been accumulated to ascertain the best type of equipment for any particular deposit, few inexperienced placer operators avail themselves of this knowledge. The manner in which otherwise successful businessmen will spend money in building untried placer plants is astonishing. A so-called movable placer machine, which was designed and built in the east at a cost of $30,000 and shipped to the southwest in late 1936, is an absurd example. Anyone with a fundamental knowledge of placer mining could have told at a glance that it was foredoomed to failure. Nearly everything about it appeared to be designed so it could not be successful. Power was supplied by an expensive Diesel-electric unit mounted on the plant in a position where it would get the most slop. The plant contained no scrubber. All the washing was to be done on a set of flat screens; most of the material to be handled was clayey and the gravel was largely flat and angular. The material was to be screen-sized down to minus 1/32 inch. The minus 1/2-inch plus 1/32 was to be treated in Ainlay bowls, and the minus 1/32-inch in a newly patented gold saver where the pulp was to be forced through a bath of quicksilver.

The tail sluice discharged 2 feet above the gravel at the front end of the machine; the discharge would be at the digging face if the machine was used in the pit, or at the brink of the bank if used on top. After moving the power unit to a stationary location and making other alterations, an attempt was made to run the plant. Seven cubic yards, which was put through the first day, occasioned a loss of 40 pounds of quicksilver. During the second and last day, the designer of the plant and inventor of the quicksilver gold saver ran the plant and only 15 pounds was lost in treating 10 cubic yards. The investment was then written off. A few coarse colors were saved in the Ainlay bowl. This could have been saved, however, by a few cross riffles in the sluice leading to the bowls. Not enough fines could be put through the quicksilver gold saver to ascertain whether any recovery was made in the device or not.

APPLICATION OF METHODS

Areas suitable for mining by methods discussed in this paper consist essentially of small, shallow deposits too small to amortize the cost of bucket-line dredges, too low-grade to be worked by hand methods, and unsuited to hydraulic mining. Each deposit is a problem in itself and the type of equipment must be selected and methods of treatment adapted to fit the particular conditions. In some cases a balance must be struck between lower operating costs attainable with dredges and lower first costs at plants using separate excavators. The operating costs per cubic yard at plants of the latter type usually are at least double that for dredges. Generally the costs at mines using floating washing plants are less than at those with movable land plants of similar capacities which in turn are less costly to operate than lay-outs with stationary plants. The latter involve an additional cost of transporting gravel.

The character and depth of the gravel and the character of bedrock is a determining factor in the selection of the floating type of washing plant. The gravel must be amenable to digging with draglines as these machines are used with floating plants. As the depth of gravel increases, larger equipment is needed on floating plants. Deep ponds must be maintained in working the higher banks to keep the boat from grounding on the sand tailing, or this material must be disposed of back of the pond. Moreover, long conveyors are needed for stacking the oversize rock. At one mine, difficulty was reported in digging the gravel in over 14 feet of water. The average depth of gravel washed in floating plants is 10 to 12 feet; the maximum is about 20 feet, although a few deposits are worked to a slightly greater depth.

Digging is under water, and under the best conditions more gold is lost than in dry pits. This additional loss of gold is balanced against higher costs with other types of plants. A rough, hard bedrock cannot be cleaned adequately under water by draglines; it would preclude the use of a floating plant. In addition to water for washing, the floating plant requires a pond to float the boat. The water flows from the pond through the loose gravel rapidly, and a steady inflow is necessary to replenish it.

The gravels treated in movable plants may be dug either with draglines or power shovels, depending upon the character of the deposit. With the former, the plant may be either on the bank or in the pit; with the latter, the plant must be in the pit, as a shovel cannot reach the hopper of a plant on the bank. Excavation can be carried to a greater depth in dry pits than under water. In mining deep deposits, the stacker on the treatment plant should be long enough to dispose of the tailing far enough back so that the active areas are not crowded; usually, this is not the case with new designs.

Stationary plants generally are used for treating gravels of unusual depths or in scattered deposits. They may also be used for treating gravels from pits that would be difficult to keep drained if a movable plant were employed. The gravel can be mined with the type of excavator best suited to the deposit and the pit laid out to the best advantage for digging.

GENERAL

A dragline is always used with a floating plant. The excavating unit used with a movable land plant usually is a dragline, although occasionally a power shovel is used as the primary digging unit or as an auxiliary to the dragline. A dragline is always worked from the bank and a shovel in the pit. The washing plant may be placed either in the pit or on the bank when a dragline is used. The plant is placed in the pit behind the power shovel when that digging unit is used. The dragline working on the bank permits the plant to be kept near the working face, thereby shortening the pit and permitting a shorter swing. The hopper can be constructed at the top of the plant, permitting the gravel to flow entirely by gravity through the plant. The dragline has an advantage over the shovel, in that a much larger area can be dug from each position, due to the longer boom and throw of the bucket; therefore, less time is lost due to moving. The plant will not have to be moved as often for the same reasons.

Where the washing plant is placed on the bank, the capacity of a dragline is decreased because of the longer swing necessary from the digging face to the hopper of the plant. Other conditions, however, occasionally make it expedient to use the plant on the bank.

In easy-digging gravel, a dragline has a greater capacity than a shovel of like dipper capacity; a shovel makes a maximum swing with the dipper of 180° when discharging into a plant in a pit. A shovel is preferred in tight or bouldery ground. Because of its rigidity and the proximity of the operator to the working face, it has a more positive control than the dragline. Moreover, boulders can be more easily sorted out and set aside. It is usually necessary to take up from a few inches to 2 or 3 feet of bedrock to recover all of the gold. This can be done better with a shovel than a dragline. Occasionally, a deposit may have a rough hard bedrock that cannot be cleaned effectively with a dragline. Bedrock is more effectively cleaned by draglines in dry pits than under water. A shovel may be used in a pit as an auxiliary digging unit to dig out hard ribs, clean the bottom, and clean out corners that the dragline is unable to reach.

Although the power shovel and the dragline excavator each have a separate and distinct field of operation in the type of placer mining discussed here, intermediate types of deposits are found where conditions may warrant the use of either.

Most gravel deposits contain barren or low-grade overburden of varying thickness. Usually, it is found unprofitable to strip off this overburden and discard it, and it is dug and washed along with the enriched gravel. In order to strip the waste at most of the placers, washing operations would have to be suspended while this work was being done, or an extra digging unit provided; at others it may be impossible to find a suitable place to dispose of the waste. Occasionally, a tractor with a bulldozer blade is used to push aside a few feet of barren clay or soil from the surface; moveover, some operators have found it profitable, when the thickness of overburden is appreciable, to do stripping on one shift and digging and washing on the other two or some other combination, alternating the periods of stripping and digging. When the excavating unit has a capacity greatly in excess of the washing plant, some operators find it practicable to strip and keep the plant at capacity at the same time.

Areas in California suitable only for small mechanical placer operations generally occur along or near the foothills of mountain ranges. Most of them are in or near the beds of small streams and have been formed by the erosion and redeposition of older Tertiary gravel.

The California deposits discussed here are, roughly, in five groups: (1) Camanche, Calaveras County; (2) Lincoln, Placer County; (3) Oroville, Butte County; (4) Redding, Shasta County, and (5) McConnell bar on the Klamath River in Siskiyou County. With the exception of one operation near Camanche, one at La Grange, and those on the Klamath River, the gravel is shallow, fairly easy digging, and sufficient water is available to maintain operations of the floating-boat type. Near Lincoln, two movable land plants and one stationary plant were being used, owing chiefly to the availability of this type of equipment rather than to gravel or water conditions. The operator at Camanche, working bench gravel, was using a power shovel to dig and overcast gravel that was too tight to dig with a dragline. A pond was maintained a short distance back of the shovel, and the loosened gravel was dug and washed by a dredge with a light bucket line. At La Grange, bench gravels were deep and tight and required a shovel for excavation. At McConnell bar, although water is plentiful, the gravel ranges in depth to about 40 feet, is tight, and contains numerous large boulders; a shovel was used.

Other plants visited were at scattered localities. A considerable number (probably twice as many as listed in this paper) had been in operation between 1932 and 1936 but either had finished washing or were unsuccessful at the time the authors were in the field.

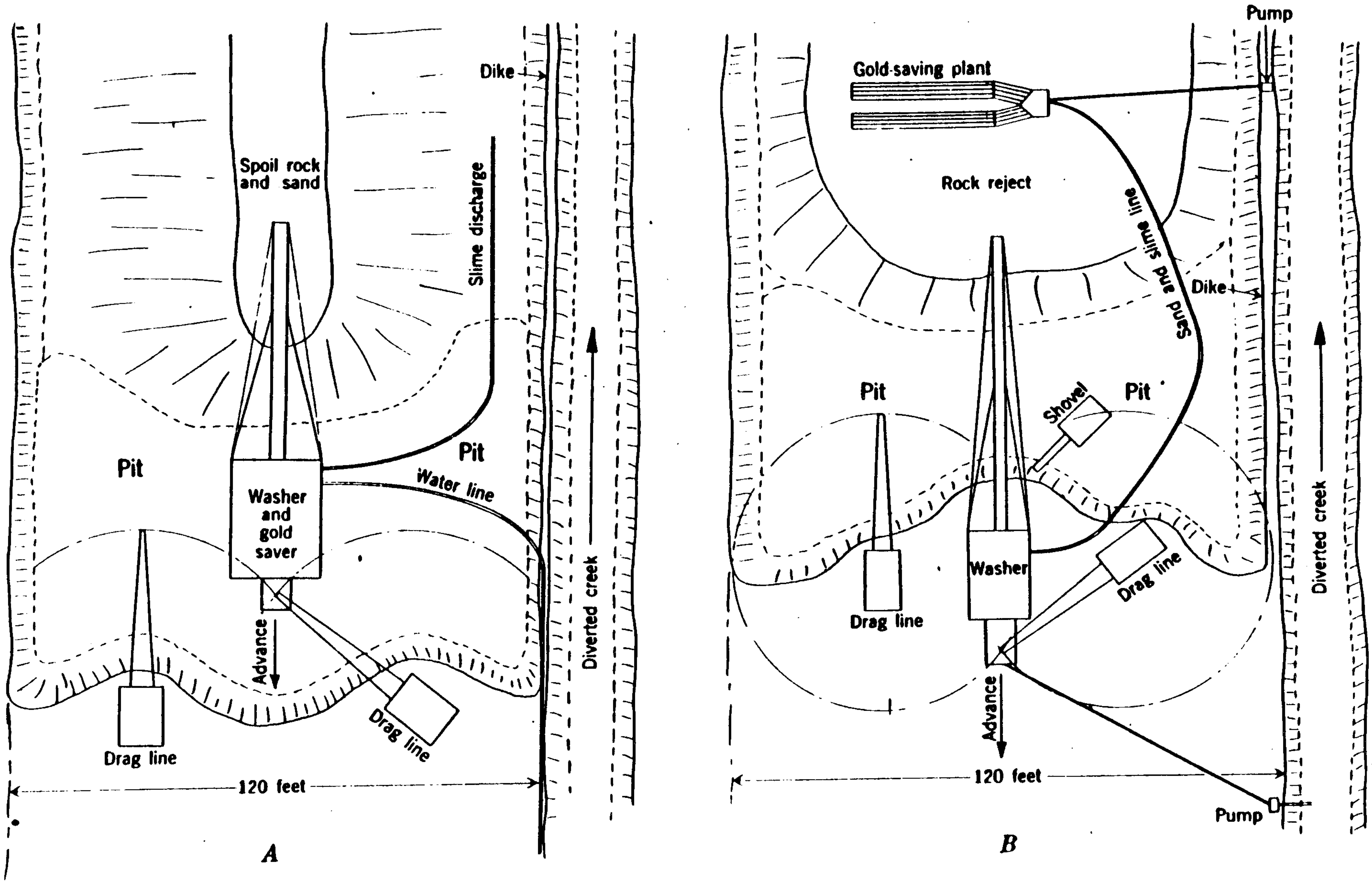


Figure 2.–Typical set-ups for movable dry land washers and excavators (not drawn to scale).

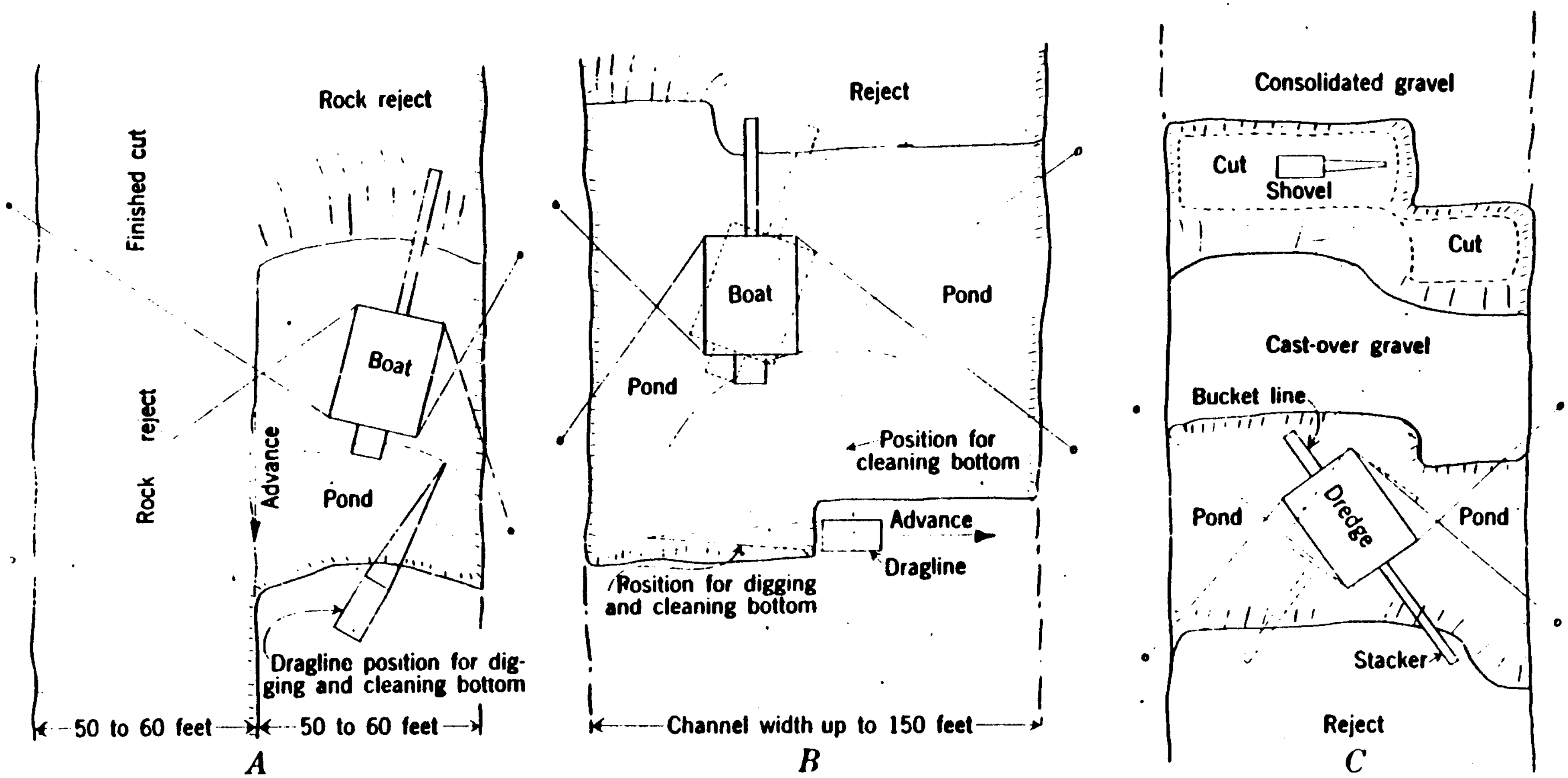


Figure 1.–Typical set-up for floating washer and excavator (not drawn to scale).

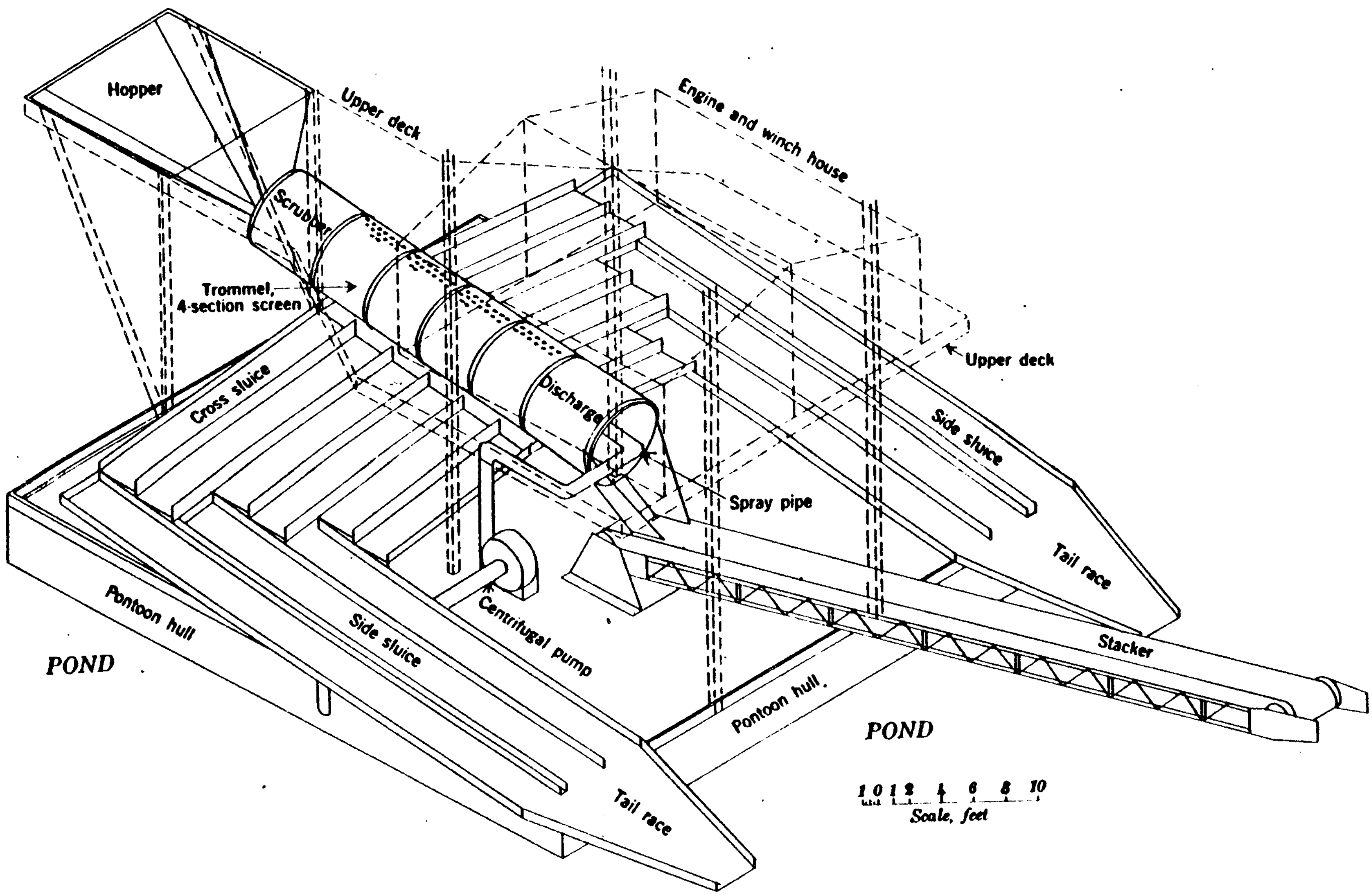


Figure 4.—Essential features of a floating washer and gold-saving plant.

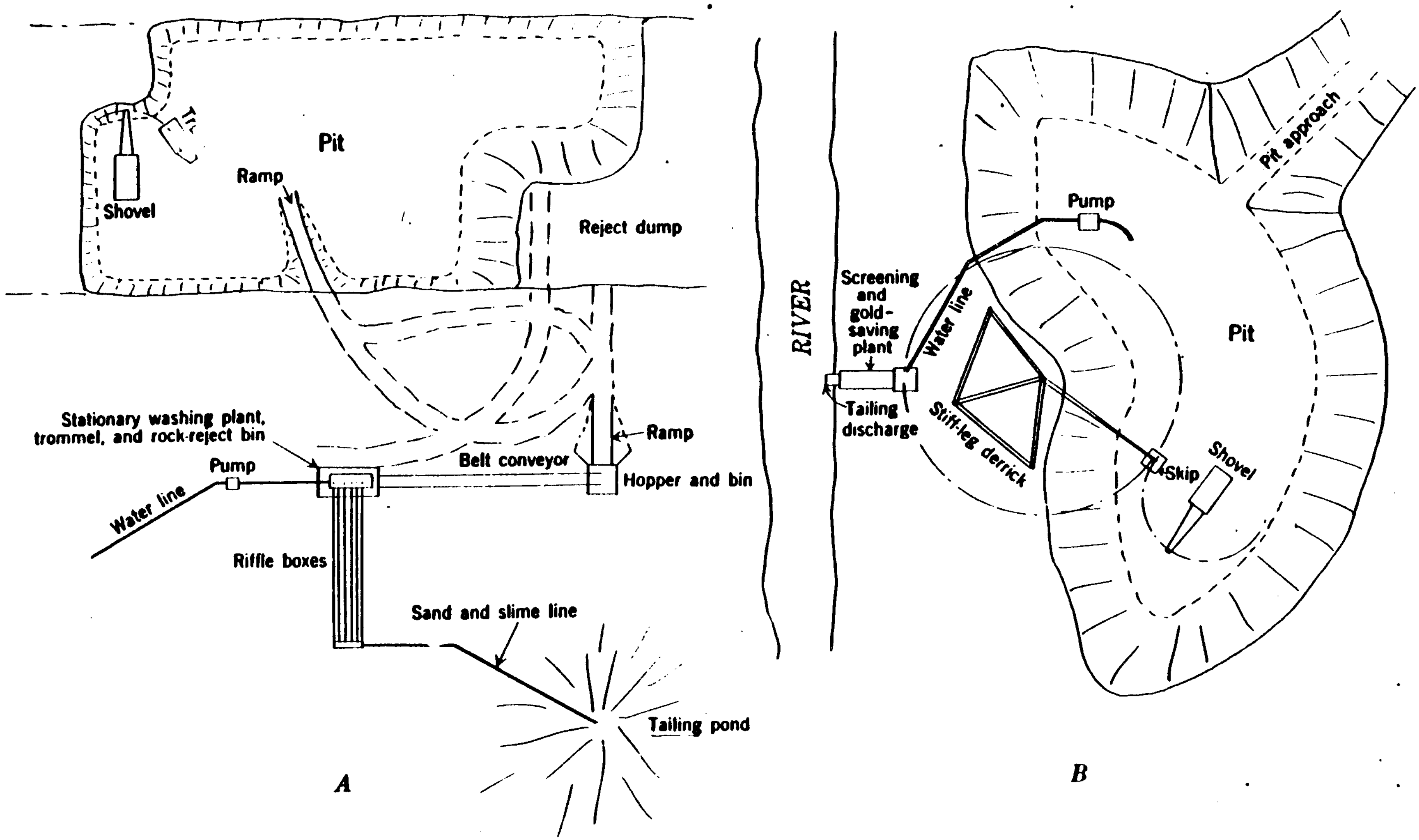


Figure 3.—Typical set-ups for stationary washing plants and excavators (not drawn to scale).

TABLE 1. - General data on placer operations using floating treatment plants.

Mine		Date	Operator	Stripping feet
Name	Situation			
Lynx Creek	Prescott, Ariz	1937	H. A. Savage.	2
Fay	Lincoln, Calif.	1937	Fay Placers.	0
Jasper-Stacey	do.	1937	Jasper and Stacey.	0
Clark	do.	1937	Lincoln Dredging Co.	0
Consuelo	Oroville, Calif.	1937	Max Hoffman.	0
Cotes	do.	1937	Butte Gold Dredging Co.	-
Richter	do.	1937	Wm. Richter & Sons.	0
Cinco Mineros	do.	1937	Cinco Mineros.	0
Penn	do.	1937	Penn Dredging Co.	1-1/2
England1/	do.	1935	Wyandotte Gold Dredging Co.	0
Midland	Cottonwood, Calif.	1937	Midland Co.	0
Gold Acres	do.	1937	Gold Acres Dredging Co.	-
Pioneer #1	Redding, Calif.	1937	Pioneer Gold Dredging Co.	0
Pioneer #2	do.	1937	do.	0
Pioneer #3	do.	1937	do.	0
Carlson Sandburg	do.	1937	Carlson & Sandburg Co.	0
Olson	do.	1937	R. S. Olson	0
Collins	do.	1937	A. C. Mining Co.	0
Folsom2/	Jenny Lind, Calif.	1937	A. R. Folsom Dredge	0
Lilly	Milton, Calif.	1937	E. L. Lilly	0
Schwegler	do.	1937	Milton Gold Dredging Enterprise	0
Cooley	Pinecliff, Colo.	1937	Cooley Gravel Co.	1-1/2
Fairplay	Fairplay, Colo.	1937	Beaver Creek Placer Corporation	0
Prickley Pear	Helena, Mont.	1936	Winston Bros. Co.	0

(See footnotes on page 11.)

PLANT LAY-OUTS

Figure 1 (A and B) shows the usual lay-outs with draglines and floating treatment plants. Figure 1C shows an unusual lay-out (at the Folsom plant, Jenny Lind, Calif.) where the gravel is first dug by a shovel and then handled in a dredge with a light bucket line.

Two general methods of attack are common where the gravel is dug under water - (1) following the channel with one or more cuts (fig. 1A) the excavator advances in a straight line, (2) advancing by taking successive 15- to 20-foot cuts back and forth across the channel (fig. 1B).

When the channel is 50 or 60 feet wide, it may be taken in a single straight-line cut. Under the plan shown in figure 1B, the channel usually is taken in one section when 150 feet or less in width; if wider, two or more sections may be mined.

The dragline that travels along the bank has an advantage over the one that travels forward in a straight line, as bedrock may be scraped from one or more angles (fig. 1B). Gold recovery under water is undoubtedly improved in any method that permits the bedrock to be cleaned and dug in two or more directions. Neither set-up has an advantage in the length of the swing of the loaded bucket to the hopper as the boat may be arranged to make either distance a minimum.

Digging may progress either up or down stream; advancing upstream has the advantage since the muddy waste water has a chance to clarify by settling behind dams and by filtering through the loose gravel.

Figures 2A and 2B show typical combinations of draglines and movable dry land washing plants.

Figure 3A is a typical set-up used at pits where placer gravel is transported to a stationary washing plant and rock reject is dumped back into the pit. Figure 3B is an unusual small layout with a shovel in the pit, a stiff-leg derrick, hoist, and a stationary washing plant.

FLOATING PLANTS

Tables 1 to 4 give information on the gravels, excavators, and treatment plants, and operating data on placer mines where the gravel is excavated by draglines and the gold is recovered in floating plants.

All the mines with floating plants visited, except the Prickly Pear in Montana, the Lynx Creek in Arizona, and the Cooley and Fairplay in Colorado, are in California. All except the Jasper-Stacey dredge use essentially the same flow sheet. Most of the plants were built by the same manufacturer. Gravel is washed in a revolving screen; the undersize is distributed to a bank of cross tables on each side of the trommel, from which it discharges into banks of longitudinal sluices on each side, and finally flows to the pond at the rear of the boat. Gold is collected in Hungarian-type riffles installed in the sluices. The oversize is discharged from the trommel to a stacker belt and piled at the rear. Figure 4 shows the essential features of a typical floating plant.

TABLE 2. - Draglines at placer operations using floating treatment plants.

	Capacity of bucket, cubic yards	Length of boom, feet	Horse-power of engine	Type of engine	Cables					
					Hoist			Drag		
					Diameter, inches	Length, feet	Length of service, hours	Diameter, inches	Length, feet	Length of service, hours
Lynx Creek	1-3/4, 1-1/2	61, 60	75, 175	Electric gasoline	-	-	-	-	-	-
Fay	1-1/2	50	135	Diesel	7/8	240	800	7/8	120	200
Jasper-Stacey	1-3/4	50	75	Electric	7/8	107	800	1	64	188
Clark	1-1/2	60	135	Diesel	-	-	-	-	-	1/ 200
Consuelo	1-1/4	55	130	do.	3/4	113	700	3/4	58	-
Cotes	1-1/2	50	135	do.	7/8	-	-	7/8	-	-
Richter	1-1/4	40	75	do.	7/8	100	-	1	55	-
Cinco Mineros	1-1/2	50	130	do.	1	-	-	1	-	1/ 180
Penn	2-1/4	80	125	do.	1-1/2	190	Up to 3,000	1-1/8	100	Up to 300
England	1-1/4	60	102	do.	-	-	-	-	-	-
Midland	1-1/4	45	-	do.	3/4	95	165	7/8	52	115
Gold Acres	1-1/2	50	-	do.	3/4	-	160	7/8	-	115
Pioneer 1	1-1/2	50	75	do.	-	-	-	-	-	-
Pioneer 2	1-1/2	45	85	do.	-	-	-	-	-	-
Pioneer 3	3	65	125	Electric	-	-	-	-	-	-
Carlson-Sandburg	1-1/4	50	130	Diesel	7/8	-	400	1	-	175
Olson	1-1/2	50	95	do.	7/8	-	450	1	-	220
Collins	1-1/2	50	120	do.	7/8	-	150	1	-	150
Folsom	1	-	85	Gasoline	7/8	-	900	0	0	0
Lilly	2 and 2-1/2	50	123	Diesel	7/8	-	400	1	-	250
Schwegler	1-1/2	50	121	Electric	7/8	60	-	7/8	112	-
Cooley	1-1/2	45	80	Diesel	3/4	60	-	7/8	110	-
Fairplay	2-1/2	70	215	Gasoline	7/8	-	600	7/8	85	200
Prickly Pear	2-1/2	70	120	Diesel	-	-	600	-	-	400

1/ Hoist cables in service are cut in two and used as drags as the drags wear out; only new hoist cables are purchased.

TABLE 1. - General data on placer operations using floating treatment plants. - Continued

Name	Gravel: Average depth, feet	Gravel: Physical character	Gravel: Boulders over 12 inches	Gravel: Clay, percent	Bedrock: Kind	Bedrock: Character	Bedrock: Depth mined, inches
Lynx Creek	16	Easy digging.	2%	None	Caliche	Flat, even	6 to 18
Fay	10 to 12	do.	0	Small	Granite	Flat, uneven	18 to 24
Jasper-Stacey	8	do.	0	do.	do.	-	do.
Clark	8	do.	0	10	do.	-	12
Consuelo	3-1/2 to 8	Easy digging.	0	Small	Soft sandstone	-	None.
Cotes	-	-	-	-	-	-	-
Richter	12	Easy digging.	0	25	Soft clay	Rolling	Variable.
Cinco Mineros	12	do.	0	15	Soft porphyry	do.	12 to 14
Penn	10 to 20	Medium hard.	0	10	Greenstone	do.	-
England1/	-	Easy digging.	-	-	Lava ash	-	-
Midland	7-1/2	do	0	Small	Sandy hard pan	-	6 to 8
Gold Acres	-	-	-	-	-	-	-
Pioneer #1	6 to 8	Easy digging.	0	-	Clay	-	6
Pioneer #2	6 to 8	do.	0	-	do.	-	6
Pioneer #3	7	do.	0	-	do.	-	6
Carlson Sandburg	13	Medium digging.	0	Small	Clay, gravel	-	-
Olson	6-1/2	Easy digging.	0	10	Clay	Rolling	6
Collins	11	do.	0	High	Porphyry	-	18
Folsom2/	9	Hard digging.	0	2	-	-	-
Lilly	8	Medium tight.	Few	10	Soft clay	Rolling	12
Schwegler	4-1/2 to 12	do.	0	10	Tuff	-	6
Cooley	16		0	-	Decomposed granite		6 to 18
Fairplay	3/21	Easy digging.	Few	-	Granite	-	0
Prickley Pear	8 to 9	Easy digging.	Up to 10 tons	-	Granite	Rough	-

1/ Data extracted from publication by James F. Magee, A Successful Dragline Dredge, A.I.M.E. Tech. Pub. No. 757, 1936.
2/ Gravel is dug and cast aside with a gasoline power shovel; it is picked up and washed in a light bucket-line floating dredge.
3/ Twelve feet of gravel left unmined on bedrock as too deep for plant to handle.

TABLE 3. - Floating treatment plants; general data and gold-washing and gold-saving equipment - Continued.

	Trommel									
				Screen						
	Length, feet	Diameter, inches	Scrubber length, feet	Number of sections	Length of section, feet	Diameter of holes, inches	Bridge, inches	Blank section at lower end, feet	Slope, inches per foot	R.p.m.
Lynx Creek	24	60	5	3	6	all 7/16	7/16	1	1-1/2	11
Fay	28	54	8	3	5	all 3/8	1-1/2, 1-1/2, 3/4	5	1-1/4	18 to 19
Jasper-Stacey	32	60	10	3	6	all 3/8	1-1/2, 3/4, 1/2	4	1-1/2	14
Clark	24	54	4	3	5	3/8,3/8,1/2	1, 1, -	5	-	-
Consuelo	20-1/2	54	4	3	5	1/4,3/8,1/2	- - -	1-1/2	1-1/2	-
Cotes	25-1/2	48	4	4	4	all 3/8	- - -	5-1/2	1-1/2	-
Richter	25	48	4	4	4	1/4, 1/4, 1/2, 1/2	- - -	4	1-1/4	15
Cinco Mineros	32	54	10	4	4	3/8, 3/8, 3/8, 1/2	All 3/4	6	-	-
Penn	27	54	5	3	5	3/8,3/8,1/2	-	6	-	-
England	25	48	4	4	4	all 3/8	All 3/4	5	1-1/2	14
Midland	24	48	4	6	4	all 3/8	1-1/4,1-1/4,7/8, 7/8,7/8,7/8	3	-	-
Gold Acres	30	54	-	4	-	all 3/8	1-3/4,1-3/4,1, 1	-	-	18
Pioneer 1	26	48	-	4	4	all 3/8	-	-	1-1/2	15
Pioneer 2	26	48	-	4	4	all 3/8	-	-	1-1/2	15
Pioneer 3	30	60	-	-	-	all 3/8	3/4 to 5/8	-	1-1/2	15
Carlson-Sandburg	30-1/2	54	10	4	4	all 3/8	1-1/2, 7/8, 1/2, 1/2	4-1/2	1-1/2	13
Olson	25	54	4	4	4	3/8, 3/8, 1/2, 1/2	All 3/4	5	1-1/2	14 to 1
Collins	30	60	12	3	4	3/8, 1/2, 1-1/4	-, 1-1/2, 1	5	1-1/4	9
Folsom	18	60	8	1	6	1/2	-	4	1-3/4	16
Lilly	34	54	8	5	4	3/8,3/8,3/8,3/8,1/2	1-1/2,3/4,1/2,1/2,1/2	6	1-1/2	-
Schwegler	30	54	8	6	3	all 3/8	-	4	1-1/2	14
Cooley	26	60	5	4	4	all 3/8		5	1-1/2	-
Fairplay	28-1/2	54	6	4	4	1/2,1/2,3/4, slot 1-1/8 by 3/4	1/2,1/2,3/4, -	1/	1-1/2	12 to 1
Prickly Pear	27-1/2	54	-	4	-	slot 7/16 by 9/16	1-1/4	-	1-1/4	17

1/ Last 6-1/2 feet contain half 8- by 8-inch holes and half 10- by 10-inch holes; undersize discharges to stacker; oversize passes to pond by rock chute.

(o429)

TABLE 3. - Floating treatment plants; general data and gold-washing and gold-saving equipment.

		Hull			Hopper	
	Type of plant	Kind of pontoon	Dimensions, feet	Draft, inches	Dimensions, feet	Spacing of grizzly bars, inches
Lynx Creek	Grizzly, trommel, sluice	Wooden	50 by 46 by 5	40	10 by 10	10
Fay	do.	do.	40 by 30 by 2-2/3	24	10 by 12	8
Jasper-Stacey	Grizzly, trommel, sluice, jigs, plates	Steel	50 by 50-1/2 by 2-1/4	-	-	-
Clark	Grizzly, trommel, sluice,	-	30 by 28 by 3-5/12	36	9 by 10	14
Consuelo	do.	Wooden	17 by 35 by 3	28	8 by 5	10
Cotes	do.	Steel	25 by 38 by 2-1/2	-	11 by 11	12
Richter	do.	Wooden	30 by 30 by 4-1/2	42	10 by 10-1/2	12
Cinco Mineros	do.	do.	32 by 42 by 3-1/2	32	-	24
Penn	do.	do.	30 by 40 by 3-1/6	24	-	24
England	Grizzly, trommel, sluice,	-	-	28	10 by 10-1/2	14
Midland	do.	Wooden	25 by 40 by 3	24	10 by 10	16
Gold Acres	do.	do.	30 by 40 by 4	36	-	18
Pioneer 1	do.	do.	26 by 38 by 3-1/2	30	-	-
Pioneer 2	do.	do.	26 by 38 by 3-1/2	30	-	-
Pioneer 3	do.	Steel	32 by 35 by 3-1/2	30	-	-
Carlson-Sandburg	do.	Wooden	34 by 42 by 3-1/2	22	-	14
Olson	do.	-	30 by 40 by 3-1/2	40	-	13
Collins	do.	-	30 by 40 by 3-1/2	26	10 by 12	18
Folsom	Bucket line, trommel, sluice	-	28 by 38 by 3	20	0	0
Lilly	Grizzly, trommel, sluice	Steel	40 by 36 by 3	30	10 by 10	14
Schwegler	do.	Wooden	40 by 35 by 3	26	12 by 14	12
Cooley	do.	-	40 by 34 by -	-	10 by 10	16
Fairplay	Trommel, sluice	Wooden	28 by 43 by 2-1/2	18	-	0
Prickly Pear	Trommel, sluice	Wooden	28 by 40 by -	40	-	-

TABLE 3. - Floating treatment plants; general data and gold-washing and gold-saving equipment - Continued

	Length of stacker, feet	Width of stacker belt, inches	Size of pump discharge, inches	Horse-power of plant	Type of engine	Clean-up period		Quick-silver charged, pounds
						Cross sluices, days	Entire plant, days	
Lynx Creek	2/ 80	26	8 6	135	Electric.	4	12	700
Fay	45	24	8	64	Diesel.	3	6	152
Jasper-Stacey	60	34	8	142	Electric.	-	-	57
Clark	40	24	7	50	Diesel.	-	-	-
Consuelo	20	17	8	90	Diesel.	7	21	-
Cotes	40	28	8	50	do.	-	-	-
Richter	50	22	8	60	do.	7	14	152
Cinco Mineros	50	30	7, 4	85	do.	10	20	114
Penn	60	24	7, 5	65	do.	6	18	150
England	45	24	7	50	do.	-	-	-
Midland	45	24	10	80	do.	5	14	60
Gold Acres	50	30	6	88	do.	2	6	100
Pioneer 1	40	30	-	50	do.	-	-	-
Pioneer 2	40	24	-	50	do.	-	-	-
Pioneer 3	50	36	10	223	Electric.	-	-	-
Carlson-Sandburg	50	30	8	57-1/2	do.	3-1/3	7	266
Olson	45	30	8	50	Diesel.			-
Collins	36	36	8	100	do.	3/ 4	3/ 4	60
Folsom	40	18	-	51-1/2	Electric.	0	10	50
Lilly	50	30	8	102-1/2	do.	-	14	150
Schwegler	50	24	12	185	do.	-	15	-
Cooley	60	36	8	95	Diesel.	3	14	0
Fairplay	70	24	8, 4	144	Gasoline.	-	-	0
Prickly Pear	32	30	8, 8	150	do.	-	7	61

2/ Also a rock conveyor, 65 feet by 36 inches.

3/ Half of cross sluices cleaned every 150 hours. Last half cleaned every 300 hours, and the side sluices are cleaned every 450 hours.

TABLE 3. - Floating treatment plants; general data and gold-washing and gold-saving equipment - Continued.

	Sluices			Riffles		
	Transverse, square feet	Longitudinal, square feet	Grade, inches per foot	Type	Size, inches	Spacing, inches
Lynx Creek	1/	1,000	1-1/2	Wooden, iron-clad, angle iron.	1-1/4 by 1-1/4 7/8 by 7/8	1 2
Fay	1/	750	1-1/4 to 1-1/2	Wooden, iron-clad, angle iron, expanded metal on carpet.	1-1/4 by 1-1/4	1
Jasper-Stacey	165	675	-	Wooden, iron-clad.	1-1/4 by 1	1
Clark	300	320	-	Wooden, iron-clad, expanded metal on matting.	1-1/4 by 1-1/4	1
Consuelo	230	280	1-1/2	Wooden, iron-clad.	1-1/4 by 1	1 to 1-1/4
Cotes	390	420	-	do.	1-1/4 by 1	1
Richter	320	300	1-1/2	do.	1-1/4 by 1	1
Cinco Mineros	480	300	-	Wooden, iron-clad, expanded metal on carpet.	1-1/4 by 1	1
Penn	350	320	-	Wooden, iron-clad, expanded metal on matting.	1-1/4 by 1	1
England	1/	537	1-1/2	Wooden, iron-clad.	1-1/4 by 1	1
Midland	324	180	1-1/4	Wooden, iron-clad, expanded metal on burlap.	1-1/4 by 7/8	1
Gold Acres	200	210	1-1/2	Wooden, iron-clad.	1-1/4 by 1	1
Pioneer 1	270	210	-	do.	1-1/4 by 1	1
Pioneer 2	270	210	-	do.	1-1/4 by 1	1
Pioneer 3	504	320	1-1/2	Wooden, iron-clad, wire screen on matting.	1-1/4 by 1	1
Carlson-Sandburg	328	224	1-1/2	Wooden, iron-clad.	1-1/8 by 1	1
Olson	352	288	1-1/2	do.	1-1/2 by 1	1-1/4
Collins	460	250	-	Wooden, iron-clad, wire screen on matting.	1-1/2 by 5/8	1-1/4
Folsom	0	120	1-1/4	Wooden, iron-clad, screen on matting.	-	-
Lilly	545	180	1-1/2	Wooden, iron-clad	1-1/4 by 1-1/4	1
Schwegler	432	420	1-1/2	Angle iron.	1-1/4 by 1-1/4	1
Cooley	1/	1,000	1-1/4	do.	1 by 1	1
Fairplay	276	208	3/4	Screen over matting and "T" iron.	-	-
Prickly Pear	330	130	1+	Angle iron.	1-1/2 by 1-1/4	1-1/4

1/ Included in longitudinal.

TABLE 4. – Operating data at placer mines using floating treatment plants. – Continued.

	Labor										
	Washing and gold saving		Miscellaneous								
	Operators		Welders		Foremen		Roustabout		Extras, number	Total number of employees
	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour		
Lynx Creek	9	$0.60	2	$0.60	1	–	3	$0.60	3	30
Fay	2	.625	0	–	1	–	0	–	0	7
Jasper-Stacey	–	–	–	–	–	–	–	–	–	–
Clark	3	–	1	–	1	–	1	–	0	12
Consuelo	3	.625	1	.625	1	.75	0	–	0	11
Richter	3	.625	1	.75	0	–	1	.50	1	12
Cinco Mineros	3	.5625	1	–	1	1.25	1	.5625	0	13
Penn	3	.625	1	.875	0	–	3	.625	1	14
England	3	–	1	–	1	–	1	–	0	12
Midland	2	.70	1	.70	0	–	5	.60	1	11
Gold Acres	3	–	1	–	0	–	1	–	1	13
Pioneer 1	6	.625					1	.625		
Pioneer 2	6	.625	2	.625	1	–	1	.625	2	47
Pioneer 3	6	.625					1	.625		
Carlson-Sandburg	3	.625	2	.625	0	–	2	.625	1	15
Olson	3	.625	1	.75	0	–	1	.625	1	13
Collins	2	.85	1	–	1	–	4	.50	1	16
Folsom	4	.50	0	–	1	–	0	–	0	7
Lilly	3	.625	1	.625	1	–	0	–	0	12
Schwegler	3	–	1	–	1	–	1	–	0	12
Cooley	3	–	1	–	1	–	0	–	1	12
Fairplay	4	–	0	–	1	–	0	–	0	7
Prickly Pear	6	–	1	–	3	–	0	–	1	17

TABLE 4. - Operating data at placer mines using floating treatment plants.

	Shifts				Labor					
					Excavation					
					Operators		Oilers		Bulldozer operators	
	Number per 24 hours	Hours per shift	Operating time, hours per day	Gravel washed per hour of operating time, cubic yards	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour
Lynx Creek	3	8	18	125	6	$1.00 1.25	6	$0.60	0	-
Fay	2	8	15-1/4	90	2	1.00	0	-	2	$ .625
Jasper-Stacey	3	8	21	67	-	-	-	-	-	-
Clark	3	8	20	90	3	-	3	-	0	-
Consuelo	3	8	20-1/2	50	3	1.00	3	.5625	0	-
Richter	3	8	19	79	3	.875	3	.50	0	-
Cinco Mineros	3	8	19-1/2	82	3	1.00	3	.5625	1	.5625
Penn	3	8	-	104	3	1.00	3	.625	0	-
England	3	8	15-7/10	127	3	-	3	-	0	-
Midland	2	9	15-1/3	122	2	1.00	0	-	0	-
Gold Acres	3	8	21	100	3	0	3	-	1	-
Pioneer 1	3	8	19	100	3	1.00	3	.625	1	.625
Pioneer 2	3	8	19	100	3	1.00	3	.625	1	.625
Pioneer 3	3	8	16-1/2	180	3	1.00	3	.625	1	.625
Carlson-Sandburg	3	8	19	130	3	1.00	3	.625	1	.625
Olson	3	8	18	167	3	1.00	3	.625	1	.875
Collins	2	10	19	100	2	1.25	1/ 4	.65	1	1.00
Folsom	2	8	15	90	2	.85	0	-	0	-
Lilly	3	8	21-1/2	125	3	1.00	3	.625	1	.625
Schwegler	3	8	19	100	3	-	3	-	0	-
Cooley	2/ 3	8	20	60	3	-	3	-	0	-
Fairplay	2	10	12	50	2	-	0	0	0	-
Prickly Pear	3	8	20	100	3	1.50	3	.50	0	-

1/ Includes two oilers for washing plant.
2/ Strip one shift every 4 days.

Hulls are constructed of wood or steel; the smallest one visited was 17 by 35 feet and 3-1/2 feet in depth; the largest was 50 by 50-1/2 feet and 2-1/4 feet in depth; the customary size is 30 by 40 by 3-1/2 feet for boats with a capacity of 100 to 130 cubic yards per hour. The size is very important; in addition to being able to carry the load, the hull should be large enough to give as much stability to the plant as practicable in order to minimize swaying and tipping caused by the intermittent dumping of gravel into the hopper. Swaying interferes with the efficiency of the sluices, and sudden tipping causes sand to bank in places and upset the even flow over the riffles. The latest practice is to use steel pontoons about 8 by 30 by 3 feet in size, fastened together by bolting them to steel members laid across the deck. The first cost of the steel pontoon hull is greater than that of wood; the steel hull, however, has a much longer life. When the plant is dismantled and moved to a new site, the pontoon sections are separated and moved along with it. An ultimate saving of steel over wood hulls is claimed by manufacturers. Hulls made of wood are constructed on the site and abandoned when the operation is finished.

—The superstructure is made of wood or steel. The engine and winch room on the upper deck usually is covered with corrugated iron. Occasionally the entire plant is enclosed, particularly in colder climates.

A hopper, usually about 15 to 15-1/2 feet above the surface of the pond, is constructed at the front of the boat. This is made of metal supported by steel or wood underpinning; it slopes downward, terminating in a metal chute that conveys the gravel to the feed end of the trommel. Manufacturers recommend that the hopper be lined with 2 to 4 inches of wooden plank, over which is laid a wearing sheet of steel plate shaped to the hopper. The wearing sheet may be renewed economically without renewing the entire hopper; the wood serves as a cushion.

A grizzly, usually level, with from 8-to 18-inch spacing between the bars is mounted above the hopper. The usual spacing is 12 inches. Railroad rails up to 90 pounds per yard are used for bars. They are inverted to prevent blinding of the grizzly. Oversize boulders and trash usually are thrown by hand into the pond.

The trommels in use on the boats listed are 48, 54, and 60 inches in diameter and from 18 to 32 feet in length. About 4 feet on each end is blank to protect the trunion rollers and drive mechanism. An additional 4 to 8 feet is blank on the feed end of the trommel, on about half the boats visited, to provide a scrubber for the gravel. The blank upper ends in the more modern trommels are provided with a lining of high carbon or other abrasive resisting steel to protect the shell. Considerable saving is made by this procedure, as the lining may be burned out and replaced more cheaply than the outer shell.

Most of the screens of the trommels are 16 to 20 feet long, made up of 4- or 5-foot sections. Usually, each section is made up of four rolled-steel plates forming the periphery of the shell. The blank sections are tied

TABLE 4. - Operating data at placer mines using floating treatment plants - Continued.

	Fuel consumed					Water for pond and washing				Recovery 3/		
	Excavator		Washing and gold saving			Washing						
	Per hour, gallons	Per cubic yard, gallons	Per hour, gallons	Per cubic yard, gallons	Cost per gallon of fuel	g.p.m.	Gallons per cubic yard	Miner's inches bought or used	Cost per miner's inch	Loss in digging percent	Loss in washing, percent	Total recovery, percent
Lynx Creek	-	-	-	-	-	2,500	-	-	-	Small	15 - 25	80
Fay	5.90	.07	5.90	.07	$0.055	-	-	35	$0.10	-	10 - 15	-
Jasper-Stacey	0	0	0	0	0	3,000	2,500	40	.10	-	-	95
Consuelo	2.68	.05	5.86	.12	.06	-	-	40	-	25	-	75
Richter	4.74	.06	3.16	.04	.06	-	-	-	-	-	-	100
Cinco Mineros	4.61	.06	3.59	.04	.06	-	-	50	.125	Small	Small	100
Penn	4.38	.04	2.91	.03	.06	-	-	-	-	20	do.	80
England	-	-	-	-	-	1,200	570	-	-	-	-	100
Midland	-	-	-	-	-	2,800	1,400	-	0	-	-	100
Gold Acres	3.00	.03	3.00	.03	-	-	-	-	-	12.5	12.5	75
Pioneer 1												
Pioneer 2	17.5	.09	4/	4/	.065	-	-	-	-	Small	13	87
Pioneer 3	0	0	0	0	0	-	-	-	-			
Carlson-Sandburg	4.73	.04	0	0	.06	1,800	830	100	-	10	Small	90
Olson	7.78	.05	4/	4/	-	2,000	720	40	.10	-	-	-
Collins	3.00	.03	10.00	.10	.065	1,800	1,080	100	-	-	-	95
Folsom	6.67	.07	0	0	.15	1,200	800	20	-	-	-	-
Lilly	5/9.30	5/.07	0	0	.06	-	-	-	-	-	-	-
Schwegler	0	0	0	0	0	2,500	1,500	50	.12	-	-	105
Cooley	2.5	.04	3.75	.06	.09	-	-	55	-	-	-	-
Fairplay	5.50	.11	20.0	.4	.20	-	-	-	-	-	-	-
Prickly Pear	5.50	.06	0	0	.11	3,000	1,800	150	-	-	-	-

3/ Based on method of testing ground.
4/ Included with excavator.
5/ Includes small amount for bulldozer.

The slope of the trommels usually is 1-1/2 inches to a foot. Speed of rotation ranges from 14 to 19 r.p.m., with 15 r.p.m. the most common.

Sluice boxes with riffles (called riffle tables on dredges) are used on all the boats for recovering the gold; at one plant, however, (Jasper-Stacey) jigs are employed in the flow sheet in addition to riffle tables. Sluice boxes usually are made of about No. 12-gage steel; those in use generally range from 24 to 48 inches in width and 6 to 9 inches in depth. A typical arrangement is shown in figure 4. The slope is between 1-1/4 to 1-1/2 inches per foot; the latter grade is favored. The width, area, and slope of the sluices have an important bearing on the gold-saving efficiency of the plant. An even distribution of sand across the width of the sluice is necessary for good work. The side sway of the boat has a tendency to pile the sand up at the edges; this tendency increases with the width. The 48-inch width is undoubtedly too great; 30 inches is probably a better maximum.

The character of the deposit and its contained gold determines the table area required per cubic yard of material handled hourly. In average ground in which about 50 percent of the material passes through the screen, manufacturers recommend at least 500 and preferably 600 square feet for plants with a capacity of 150 cubic yards per hour. The table areas of all the plants visited are well in excess of this requirement.

The slope of the tables should be adjusted to the character of the material handled. The slope is increased when fines tend to pack in the riffles or when the gravels contain an undue proportion of sand.

Wooden riffles are used in the sluices on most of the boats; these consist of 1- by 1-inch slats topped with 1/8- or 1/4-inch by 1-1/8- or 1-1/4-inch strap iron. The overhang of the strap iron is on the downstream side. The top of the wooden member of the riffle is usually cut on a bias to make the strap iron lie flat; this has a tendency to cause cascading as the pulp passes down the sluice. Usually, the riffles are made up in sections of 10 each; they are held together by header slats at each end. Generally the width of the riffle is 1/8 inch less than the width of the box, to facilitate its removal. Riffles made of 1-1/4- by 1-1/4-inch angle are favored by many. The top of the riffle may be placed parallel to the bottom of the box, but usually it is horizontal. The overhang is downstream. The iron riffles are made up into sections by being welded onto strap headers on each end or by being fitted into notches in wooden strips. Riffles are spaced 1 to 1-1/2 inches apart. One or the other of these types of riffles is used in all the plants. They are supplemented by expanded metal or wire screen laid on burlap, carpet, or matting. Usually, these auxiliary riffles follow the main type for the purpose of catching fine and rusty gold not caught by the standard riffles.

together endwise across the screen area with four heavy railroad rails, the base flanges of which act as the longitudinal butt straps and to which the replaceable screen section plates are bolted. Peripheral butt straps about 4 inches wide and 1/2 inch thick cover the joints between abutting sections of screens to which they are bolted.

Some operators prefer welded joints; these are cheaper to construct but are more costly to maintain. The worn section must be burned out and new parts welded in.

Screens usually are perforated with holes with a minimum diameter of 3/8 inch along most of their length. Depending on the maximum size of gold nuggets found during testing, the last section of screen may be perforated with holes 1/2, 5/8, or 3/4 inch in diameter. When flat or elongated nuggets are found, one or more of the last sections sometimes are perforated with slots. These are formed by punching or drilling two holes, 3/8 inch in diameter or larger, near each other and cutting out the intervening metal.

The bridge between holes in the screen commonly is diminished gradually for each succeeding section, to give an equal distribution of the undersize to the sluices. A less common method is to start with smaller holes in the first section and increase the size in succeeding sections, keeping the bridging the same.

The intermittent loads dumped into the hopper cause surges of gravel through the screen and sluices. To equalize the flow, some trommels have been equipped with an Archimedean or spiral type of retarding ring that acts as a feeder. The spiral ring makes one or more turns along the length of the blank scrubber section. Considerable success is claimed by the operators in regulating the flow by this method.

The degree of cementation found in various gravel deposits varies over a wide range. Some are entirely unconsolidated, and a strong stream of water introduced by a spray pipe within the trommel is sufficient entirely to disintegrate the masses and free the gold. Other gravels may be cemented or may contain layers of clay; when this condition exists, it is often found necessary to increase the scrubbing section up to half the length of the trommel. Lifter bars, comprising short pieces of angle iron, usually are bolted to the inside of the trommel to increase cascading and to aid in the disintegration of the gravel. Retarding rings are also commonly used in addition to lifter bars to give the water more time to act on clayey masses. The capacity of a screen decreases as the time required to disintegrate the gravel increases.

Best practice indicates that all clay should be entirely broken down into a pulp, regardless of whether it contains gold. Obviously, if gold is entrapped in clay balls, it will be lost with the rock oversize. Clay passing through the screen has been noted to have collected flecks of gold and carried them off with the tailings.

Special riffles or traps are installed at the heads of the cross sluices on the boats into which the quicksilver is charged. A common type comprises a number of 1- by 1-inch cross slats nailed together. Alternate slats have a series of 1/2- by 2-inch notches; the slat sections are placed with their length across the sluice. Other types comprise boards with holes partly bored through them and moulded rubber mats with round or irregular depressions. The better constructed side sluices usually have a strap iron 1 to 1-1/4 inches high, welded on edge at the lower ends; this prevents live quicksilver from penetrating beyond this point. Traps consisting of rectangular depressions in the bottoms are used at the lower ends of the side sluices; occasionally extra traps are installed farther up in the boxes.

Jasper and Stacey

The operators of the Jasper and Stacey mine at Lincoln, Calif., have done considerable pioneering in metallurgy as applicable to the type of treatment plants under discussion. Standard practice is followed in digging and washing; an innovation has been applied in saving the gold. Figure 5 is the flow sheet of the plant.

The gravel is washed in a 60-inch by 32-foot trommel, comprising a 10-foot scrubber section, three 6-foot screen sections, and a 4-foot blank discharge section. Perforations are all 3/8-inch diameter; the bridging is 1-1/2, 3/4, and 1/2 inches, respectively, for each screen section.

The undersize from the trommel distributing boxes goes to a bank of three 30-inch-wide by 3-foot-long double-deck riffle tables on each side, and thence to two 42- by 42-inch Bendelari jigs on a side. The jigs have 5-foot head room, a 1-3/8-inch stroke, and pulsate at the rate of 124 per minute. A bed of 250 pounds of No. 10 shot is used in each jig. The overflow from each pair of jigs passes over two 5-foot sluices and thence through 30-inch by 45-foot longitudinal sluices to a dewatering tank. The sand is raised by a bucket elevator to a steel sluice, from which it is discharged onto the rock pile at the edge of the pond.

The hutch product from the primary jigs is pumped to a cleaner jig. The bed of the cleaner consists of 350 pounds of No. 13 and 250 pounds of No. 10 shot. The pulsations are 136 per minute.

The overflow from the cleaner jig flows by gravity back to one of the rougher jigs. The hutch product flows by gravity to a 36-inch by 7-foot rod mill divided midway by a partition. Six 3-inch rods are used on one side and five 4-inch rods on the other. The mill turns at 19 r.p.m.

The pulp from the mill is distributed over two sets of 12- by 36-inch amalgam plates in series. The pulp from the plates goes through a 17-inch by 10-foot sluice, with 3 feet of quicksilver traps and 7 feet of wooden Hungarian riffles, and thence to one of the tail sluices.

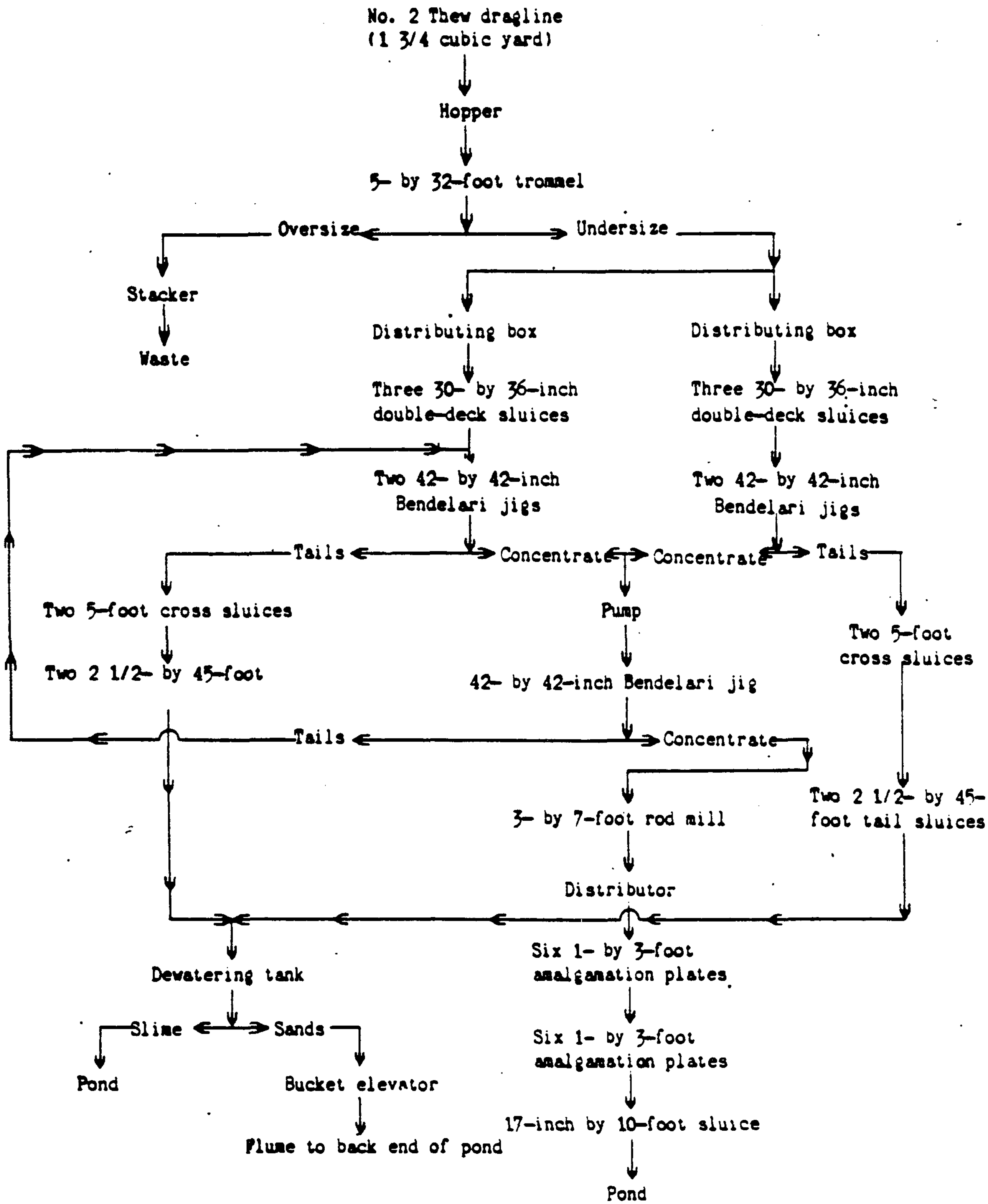


Figure 5.- Flow sheet, Jasper and Stacey boat.

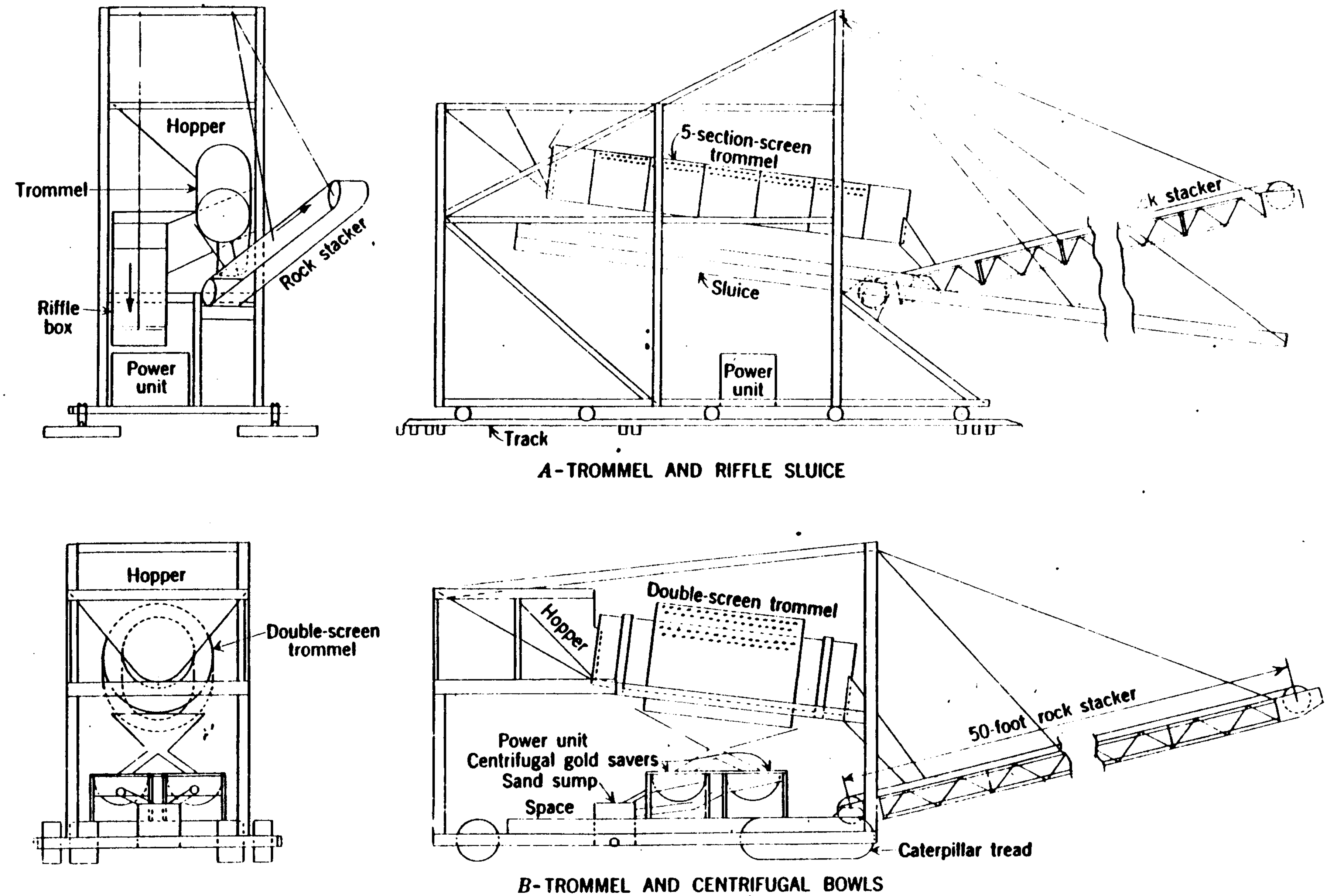


Figure 6.—Essential features of movable washing and gold-saving land plants (not drawn to scale).

The operators state that most of the gold is recovered in the double-deck cross riffles and distributors under the trommel. About 25 percent of the recovered gold is saved in the jigs. Recovery is said to have been raised about 25 percent by use of the jigs.

MOVABLE LAND PLANTS

The placer mines visited, at which movable land plants are used, are scattered widely over six Western States. Two of the plants are in California, 5 in Colorado, 1 in Idaho, 3 in Montana, 1 in New Mexico, and 2 in Wyoming.

Tables 5 to 8 give information on the gravels, excavators, and treatment plants, and operating data on placer mines where the gravel is excavated by draglines or power shovels and the gold is recovered in movable and stationary plants.

Figure 6a shows the essential details of a small movable plant, comprising a trommel and riffle sluice; figure 6b shows one comprising a trommel and Ainlay centrifugal bowls.

At three properties, the gravels were washed and screened in plants in the pits and the screen undersize is pumped to separate gold-saving units back on the tailings piles.

All the plants, except the Jett-Ross, wash and screen the gravel in trommels; all use sluices or Ainlay bowls for recovering the gold. A few plants employing Ainlay bowls are built along the same general lines, but the construction of the majority of the plants differs greatly at individual mines. Few mines use the same lay-out, even under similar conditions. The lack of standardization of practices at the mines using both movable and stationary plants probably is partly due to the isolation of the plants making it difficult for the operators to exchange information. Moreover, enough plants have not been constructed by any one manufacturer to eliminate all the mechanical difficulties. The principal drawback to this type of plant has been time lost because of breakdowns. The most fruitful cause of lost time has been failure of power units. Many of the plants have been designed by men without previous experience in this line of work; most of them, in part at least, are built of salvaged material. Long periods of adjustment generally are necessary to get reasonably continuous operation. Next to engines, mountings and drives of trommels appear to give the most mechanical trouble.

Frames of movable plants usually are built of structural steel. The plants may be mounted on tractor chassis, railroad-car trucks or locally made trucks; caterpillar treads running on the ground or timber mats, and wheels running on rails or timber generally are used. Some plants are moved on skids. The plants may be self-propelled, usually by tractor units, on which they are mounted, or they may be towed by the excavating unit.

TABLE 5. - General data on placer operations using movable and stationary land plants - Continued

Name	Gravel					Bedrock		
	Depth of stripping, feet	Average depth, feet	Physical character	Boulders over 1 foot	Clay, percent	Kind	Depth mined, inches	Character
Movable land plants:								
Skeels	0	8 to 12	Easy digging.	0	--	Granite	8	--
Pantle	10 to 12	18 to 20	do.	0	0	do.	24	--
Pan-Due	0	20	do.	0	--	do.	24	--
Peerless	3 to 12	9	do.	0	--	do.	4	--
Fairplay	3	--	do.	Few.	--	--	--	--
Blackhawk	0	26	do.	--	--	Decomposed granite schist	12 to 15	--
Humphreys	--	15	do.	Numerous.	Small	Granite, schist	Over 1	--
Dixie	10	13	do.	do.	--	Decomposed granite schist	6 to 12	Rough
Humphreys 1/	0	17	do.	0	--	Volcanic ash	6	--
Eldorado	12 to 13	15	do.	0	Considerable	Shale, clay	--	--
Pikes Peak	9	12	do.	0	Small	Clay	2/	--
Hallett 3/	2 to 6	10	--	--	do.	--	--	--
Jett-Ross	2 to 12	2 to 8	Loose to tight.	2%	0	Schist, diorite	24 to 60	Rough
Fisher	3	10	Easy digging.	Few.	--	Diorite, schist	18 to 24	--
Stationary plants:								
Ash Canyon	8	10	Hard digging.	do.	Small	Cemented conglomerate	2 to 3	--
Chittendon	0	15	do.	0	do.	Granite	6 to 10	Uneven
Von der Hellen	Up to 12	40	do.	5%	0	Serpentine	18 to 24	do.
Guerin	0	27	do.	10%	0	4/	4/	4/
Wallace 5/	--	--	--	--	--	--	--	--
La Grange	0	25	Hard digging.	Few.	0	Volcanic tuff	Few	Hard
Rhyolite	10	4	Easy digging.	--	--	Gravel	--	Soft

1/ Corry, Arthur V., Dragline Installation For Recovering Gold at Virginia City, Mont.: Mining and Metallurgy, Oct. 1936. 2/ Enriched clay is stripped by hand. 3/ Metzger, O. H., Gold Mining in New Mexico: Inf. Circ. 6987, Bureau of Mines, 1938. 4/ The operations had not reached bedrock. 5/ The original operations of Gold Gravel Products Co. were described by Gardner and Johnson in Placer Mining in the Western United States, Part III: Inf. Circ. 6788, February 1935, p. 31.

TABLE 5. - General data on placer operations using movable and stationary land plants.

Name	Situation	Operator	Date
Movable land plants:			
Skeels	Rocklin, Calif.	E. B. Skeels.	1937
Pantle	Lincoln, Calif.	Pantle Bros.	do.
Pan-Due	Leadville, Colo.	Pan-Due Placer Co.	1936
Peerless	Como, Colo.	Peerless Mining Co.	do.
Fairplay	Fairplay, Colo.	H. H. Reiber.	do.
Blackhawk	Blackhawk, Colo.	Edward Manion.	1937
Humphreys	Clear Creek, Colo.	Humphreys Gold Corporation.	1936
Dixie	Dixie, Idaho	Dixie Placers.	1937
Humphreys[1]	Virginia City, Mont.	Humphreys Gold Corporation.	1936
Eldorado	Finn, Mont.	Eldorado Gold Placer Mining Co.	do.
Pikes Peak	Finn, Mont.	Pikes Peak Mining Co.	do.
Hallett[3]	Hillsboro, N. Mex.	John V. Hallet.	do.
Jett-Ross	Atlantic City, Wyo.	Jett-Ross Mines Inc.	do.
Fisher	do.	E. T. Fisher Co.	do.
Stationary plants:			
Ash Canyon	Cochise County, Ariz.	R. R. Meier.	1937
Chittendon	Lincoln, Calif.	Charles N. Chittendon.	do.
Von der Hellen	Siskiyou County, Calif.	Wm. Von der Hellen, grading contractor.	do.
Guerin	do.	Guerin Bros.	do.
Wallace[5]	Wallace, Calif.	Gold Gravel Products Co.	1936
La Grange	La Grange, Calif.	La Grange Placer Mines.	1937
Rhyolite	Oreana, Nev.	C. E. Swartz and three partners.	do.

(See following page for footnotes.)

TABLE 6. - Excavating and transportation equipment at placer operations using movable and stationary land plants - Continued.

	Cables						Transportation			
	Hoist			Drag						
	Diameter, inches	Length, feet	Length of service, hours	Diameter, inches	Length, feet	Length of service, hours	Type	Capacity, cubic yards	Kind of power or fuel	Length of haul, feet
Movable land plants:										
Skeels	--	--	--	0	0	0				
Pantle	3/8	180	600	7/8	70	300				
Pan-Due	3/4	--	900	0	0	0				
Peerless	--	--	--	0	0	0				
Fairplay	--	--	--	--	--	--				
Blackhawk	7/8	--	700	0	0	0				
Humphreys, Clear Creek	1	130	800	1-1/8	65	150				
	1	130	800	1-1/8	65	150				
	7/8	--	--	0	0	0				
Dixie	--	--	--	--	--	--				
Humphreys, Virginia City	--	--	--	--	--	--				
	--	--	--	--	--	--				
	--	--	--	0	0	0				
Eldorado	--	--	--	--	--	--				
Pikes Peak	--	--	--	--	--	--				
Hallett	--	--	--	--	--	--				
Jett-Ross	3/4	110	500	7/8	66	100				
Fisher	7/8	134	700	7/8	70	350				
Stationary plants:										
Ash Canyon	--	--	--	0	0	0	Truck	1-1/2	Gasoline	1,500
Chittenden	1/2	70	600	0	0	0	Trucks 2/	3	do.	400
Von der Hellen	7/8	--	300	0	0	0	do. 3/	2-1/2, 5	do.	900
Guerin	1/2	68	400	0	0	0	Derrick	3/4	do.	4/ 35
Wallace	--	--	--	0	0	0	Train	5/	6/	2,600
La Grange	9/16	96	400	0	0	0	Trucks	3	Gasoline	600
Rhyolite	--	--	--	--	--	--	Trucks	2-1/2	do.	5,000

2/ Two 3-cubic-yard trucks. 3/ The company has three 2-1/2-cubic-yard trucks and two 5-cubic-yard trucks; three trucks each shift haul gravel to the washing plant, one truck hauls away the oversize a distance of 150 feet and one truck is on general service. 4/ Vertical lift. 5/ A train was comprised of four 4-cubic-yard and four 6-cubic-yard dump cars. 6/ Two 8-ton and one 5-ton Plymouth gasoline locomotives and two 17-ton steam locomotives.

TABLE 7. - Movable and stationary treatment plants; general data and gold washing and gold saving equipment.

	Type of plant	Type of construction and mountings	Feeder unit
Movable land plants:			
Skeels................	Trommel, sluice, and centrifugal bowls.	Steel frame on caterpillar treads and wheels.	Hopper and plate feeder.
Pantle................	Trommel and centrifugal bowls.	do.	3-cubic-yard hopper.
Pan-Duo..............	do.	Steel frame on four railroad car trucks.	Hopper.
Peerless..............	do.	Steel frame on four wheels.	Hopper and belt.
Fairplay..............	Trommel and sluice.	Steel frame on wheels.	1-1/4-cubic-yard hopper.
Blackhawk............	do.	Steel on chassis of old dragline.	Hopper.
Humphreys, Clear Creek.........	do.	Steel frame on caterpillar tractor chassis.	10-cubic-yard hopper and pan-belt, feeder
Dixie................	do.	Eight double-flanged wheels running on timber track.	Hopper.
Humphreys, Virginia City................	do.	Steel frame on three tractor chassis and caterpillar treads.	20-cubic-yard hopper and pan feeder.
Eldorado..............	do.	Steel frame on eight wheels.	Hopper.
Pikes Peak...........	do.	Steel frame on two 2-wheel trucks and two caterpillar treads.	do.
Hallett..............	Trommel and centrifugal bowls.	Steel frame, four wheels on wooden stringers.	2-cubic-yard hopper.
Jett-Ross............	Grizzly and sluices.	Wooden frame on skids.	Hopper.
Fisher................	Trommel and sluice.	Seven double-flanged wheels on each side running on rails.	4-cubic-yard hopper.

TABLE 7. - Movable and stationary treatment plants; general data and gold washing and gold saving equipment - Continued

	Trommel									
				Screen						
	Length, feet	Diameter, inches	Scrubber length, feet	Number of sections	Length of section, feet	Size of holes inches	Bridge, inches	Discharge length, feet	Slope inches per ft.	r.p.m.
Stationary plants:										
Ash Canyon......	8	36	0	1	8	1/2	-	0	-	15
Chittendon......	12	52	8	8/2	4	8/	2	0	1	14
Von der Hellen..	20	60	0	4	5	1-1/2, 3/4, 3/4, 1/2	-	0	1-1/4	13
Guerin..........	9	28	0	1	9	1/2 by 1/2	-	0	1-1/4	-
Wallace.........	16-1/2	60	12-1/2	9/2	4	1 and 3/8	-	0	flat	-
La Grange.......	23	54	3	3	5	3/8, 1/2 and 5/8	-	5	1-1/2	-
Rhyolite........	14	48	7	1	6	3/8	3/8	1	-	-

1/ Two screen sections, one outside the main trommel; the inside screen is 8-1/2 by 4 feet and is perforated with 1-inch diameter holes; the outside section is 6 by 6 feet and contains 4 feet with 1- by 1/8-inch slots and 2 feet with 1- by 1/4-inch slots. 2/ Two screen sections, one outside the main trommel; the inside screen is 8 by 4 feet and is perforated with 5/8-inch diameter holes; the outside section is 6 by 8 feet and contains 4 feet with 1/4-inch diameter holes and 4 feet with 1/4- by 5/8-inch slots. 3/ Also an outer shell with 2-inch-diameter holes. 4/ Four feet with 1/4-inch-diameter holes, 9 feet with 1/4- by 1/2-inch slots, and 12 feet with 5/8- by 1-inch slots. 5/ Also an outer shell with 3-inch-diameter holes. 6/ Four feet with 1/4-inch-diameter holes, 8-1/2 feet with 3/8- by 1-inch slots, and 1-1/2 feet with 5/8- by 1/2-inch slots. 7/ Three concentric screens; inside screen 30 inches in diameter with 2-inch round holes, middle screen 41 inches in diameter with 3/4-inch round holes, and outside 52 inches in diameter with 1/4-inch by 1-inch slots. 8/ The inside screen is 4 feet by 52 inches with 1/2-inch-diameter holes, and the outside screen is 4 feet by 70 inches, comprised of 2 feet with 1/4-inch and 2 feet with 3/8-inch-diameter perforations. 9/ The two screen sections are constructed one within the other; the inside screen has 1-inch-diameter holes and the outside 3/8-inch-diameter holes.

TABLE 6. - Excavating and transportation equipment at placer operations using movable and stationary land plants.

	Excavator				
	Type	Capacity of bucket, cubic yards	Length of boom, feet	Horse-power of engine	Kind of power or fuel
Movable land plants:					
Skeels	Shovel	1-1/4	-	-	Gasoline
Pantle	Dragline	1	50	85	Diesel
Pan-Due	Shovel	1-1/4	22	100	Gasoline
Peerless	do.	1-1/4	30	90	do.
Fairplay	Dragline	1-1/4	50	-	Diesel
Blackhawk	Shovel	1-1/4	23	150	Gasoline
Humphreys, Clear Creek	Dragline	2-1/2	50	150	do.
	do.	2-1/2	50	150	do.
	Shovel	1-1/4	22	130	Diesel
Dixie	Dragline	3/4	45	-	Gasoline
Humphreys, Virginia City	Dragline	2-1/2	50	100	Electric
	do.	2-1/2	50	100	do.
	Shovel	1-3/4	-	75	do.
Eldorado	Dragline	1-1/8	-	60	-
Pikes Peak	do.	1-1/4	50	-	Gasoline
Hallett	do.	1/ 1-1/4, 1	-	-	Fuel oil
Jett-Ross	do.	1-1/4	50	125	Burning oil
Fisher	do.	1-1/4	60	-	Fuel oil
Stationary plants:					
Ash Canyon	Shovel	1/2	-	65	Gasoline
Chittendon	do.	1/2	35	-	do.
Von der Hellen	do.	1-1/4	21	-	do.
Guerin	do.	3/8	-	-	do.
Wallace	do.	1-1/4	30	92	do.
La Grange	do.	3/4	-	-	do.
Rhyolite	do.	5/8	-	-	do.

1/ The 1-1/4-cubic-yard dragline is used for stripping and moving reject from washer.

TABLE 7. - Movable and stationary treatment plants; general data and gold washing and gold saving equipment - Continued.

	Trommel									
				Screen						
	Length, feet	Diameter, inches	Scrubber length, feet	Number of sections	Length of section, feet	Size of holes, inches	Bridge, inches	Discharge length, feet	Slope, inches per ft.	r.p.m.
Movable land plants:										
Skeels	16	48	4	[1] 2	8-1/2, 6	(1)	-	3-1/2	-	-
Pantle	14	48	3	[2] 2	8	(2)	-	3	-	-
Pan-Due	24	60	4	3	5-2/3	3/8	-	3	7/8	9
Peerless	12	50	4	1	8	1/4 by 1/8	-	0	-	15
Fairplay	16	42	4	3	4, 4, 3	1/4,5/8 5/8	-	1	1	12 to 20
Blackhawk	12	62	6	3	-	5/8,5/8 and 7/8	-	0	2	14
Humphreys, Clear Creek	18	72	-	-	-	1-1/8	-	-	2	11
Dixie	19	48	5	3	4	1/4,3/8 and 3/8	-	2	1-1/4	20
Humphreys, Virginia City	24	84	4	1	18	1-1/8	-	2	-	18
Eldorado	32	48	6	[3] 3	4, 9, 12	[4]	-	1	1	-
Pikes Peak	23	48	6	[5] 3	4, 8-1/2, 1-1/2	[6]	-	4	1	14
Hallett	12	[7]	0	3	[7]	[7]	-	-	3/4	-
Jett-Ross	0	0	0	0	0	0	0	0	0	0
Fisher	22	54	5	3	4	1/4,1/2 and 3/4 by 1-1/2	-	5	-	14

(See footnotes on page 32.)

TABLE 7. - Movable and stationary treatment plants; general data and gold washing and gold saving equipment - Continued.

	Type of plant	Type of construction and mountings	Feeder unit
Stationary plants:			
Ash Canyon........	Trommel and 1 centrifugal bowl.	Wooden frame.	Grizzly and hopper.
Chittendon........	Trommel and sluices.	do.	4-cubic-yard hopper; 75-foot belt conveyor.
Von der Hellen....	do.	do.	6-cubic-yard hopper.
Guerin............	do.	do.	5- by 5-foot hopper.
Wallace...........	do.	-	8-inch grizzly, hopper.
La Grange.........	do.	Steel frame.	8-inch grizzly 20-cubic-yard bin electric plate feeder.
Rhyolite..........	do.	Wooden frame.	-

TABLE 7. - Movable and stationary treatment plants; general data and gold-washing and gold-saving equipment - Continued.

	Stacker		Fresh-water pumps				
	Length, feet	Width of belt, inches	Size of discharge, inches	Horsepower	Horsepower of plant	Kind of power or fuel	Recovery, 10/ percent
Movable land plants:							
Skeels	40	24	4	25	44	Diesel.	94
Pantle	48	18	4	11/ 10	38	Electric.	-
Pan-Due	80	24	-	15	80	Gasoline.	-
Peerless	25	24	-	-	30	do.	-
Fairplay	13/ 0	0	0	0	14/	do.	90 to 95
Blackhawk	16/ 70	-	6 and 5	30, 25	-	Electric.	-
Humphreys, Clear Creek	100	36	8 and 4	115, 50	18/ 480	Gasoline.	90
Dixie	36	24	-	10	19/ 34	do.	-
Humphreys, Virginia City	120	48	20/	30	21/ 710	Electric.	90
Eldorado	40	24	-	-	24-1/2	Gasoline.	97
Pikes Peak	40	24	6	25	22	do.	-
Hallett	-	-	-	-	65	do.	50 to 75
Jett-Ross	22/ 0	0	10	165	0	do.	97
Fisher	40	26	-	75	30	do.	100
Stationary plants:							
Ash Canyon	0	0	-	20	14/	do.	-
Chittendon	13/ 0	0	6	14/	14/	do.	75
Von der Hellen	13/ 0	0	23/	40	24/	do.	100
Guerin	0	0	4	14/	14/	do.	-
Wallace	-	-	-	-	30	Electric.	-
La Grange	65	24	10	50	25/ 60	do.	100
Rhyolite	80	16	-	-	-	Gasoline.	-

10/ Based on method of testing gravel deposit. 11/ Also a 40-horsepower motor for pumping water from the pit. 12/ The screens are 1-1/2- by 1-inch mesh, using No. 00 gage wire, and 1-1/2- by 1-inch mesh, using No. 1 gage wire. 13/ The oversize is dumped back in the pit by a truck. 14/ Four-cylinder automobile engine. 15/ Also a Wilfley table. 16/ Being increased to 85 feet. 17/ Includes 336 square feet of iron riffles with corduroy under the last few feet, 112 square feet of 1/16- by 1/2-inch mesh screen, and 213 square feet of corduroy cloth tables. 18/ Includes 150 horsepower for moving the screening and washing plant, 40 horsepower for stacker and feeder, 50 horsepower for the trommel, and 150 horsepower for a sand pump to pump the undersize to the gold-saving plant; the gold-saving plant uses 90 horsepower for moving; a 40-horsepower sand pump is used occasionally; all are gasoline engines. 19/ Gasoline horsepower comprises washing plant 18, stacker 6, and pump 10. 20/ 1,200 g.p.m. 21/ Includes 365-horsepower for pumping; 205 horsepower for feeder, trommel, stacker and boom, and sluice hoists; and 140 horsepower for moving the plant. 22/ Rock chute for discharging oversize. 23/ 2,500 g.p.m. 24/ Trommel is run by a 4-cylinder automobile engine; a 25-horsepower Hercules engine operates a 1,000-g.p.m. pump to remove 700 g.p.m. from the pit. 25/ Connected electric horsepower comprises trommel 50, feeder 5, and stacker 5.

TABLE 7. - Movable and stationary treatment plants; general data and gold-washing and gold-saving equipment - Continued.

	Sluices		Gold-saving devices		
	Square feet	Grade, inches per foot	Type	Size, inches	Spacing, inches
Movable land plants:					
Skeels	0	0	Four centrifugal bowls.	36	0
Pantle	0	0	do.	36	0
Pan-Due	0	0	do.	36	0
Peerless	C	0	do.	36	0
Fairplay	77	2 and 1	Wire screen over burlap.	12/	12/
Blackhawk	15/447	-	Riffles, screen, matting, burlap.	-	-
Humphreys, Clear Creek	17/661	1-1/4	Riffles, screen, and corduroy.	3/16 by 1-1/4	1-3/8
Dixie	100	-	Riffles and screen on burlap.	1 by 1	1
Humphreys, Virginia City	935	1-1/4 to 1-1/2	Angle-iron riffles.	1-1/4 by 1-1/4	1-1/4
Eldorado	54	1-1/2	"T"-iron riffles.	1	1
Pikes Peak	72	1-1/2	Iron-clad wooden riffles.	1-1/2 by 1	1
Hallett	0	0	Four centrifugal bowls.	36	0
Jett-Ross	190	1-1/2 to 2	Steel and pole riffles.	2	7/8 to 1-1/2
Fisher	372	-	Iron-clad wooden riffles.	1-7/8 by 1-3/8	1-1/4
Stationary plants:					
Ash Canyon	0	0	One centrifugal bowl.	36	0
Chittendon	328	1-1/2	Iron-clad wooden riffles and screen over burlap.	1-1/4 by 1	-
Von der Hellen	262	1-1/4	Angle iron.	1-1/4 by 1-1/4	1-1/4
Guerin	70	1-1/4	Double-layer 1/2-inch screen on Brussels carpet.	-	-
Wallace	400	-	-	-	-
La Grange	500	1	Angle iron on matting.	1-1/4 by 1-1/4	1-1/4
Rhyolite	-	-	Pan-American jig, angle-iron riffles.	-	-

(See footnotes on following page.)

TABLE 8. - Operating data at placer mines using movable or stationary treatment plants - Continued.

	Labor										
	Washing and gold saving						Miscellaneous				
	Operators		Helpers		Pumpmen		Foremen		Extras		
	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour	Number	Rate per hour	Total number of employees
Movable land plants:											
Skeels	2	$0.50	0	-	2	$0.50	1	$1.00	0	-	7
Pantle	2	.50	0	-	2	.50	1	1.00	0	-	7
Pan-Duo	4	.50	0	-	2	.50	1	-	0	-	9
Peerless	2	.50	0	-	0	-	0	-	0	-	3
Fairplay	4	.40	0	-	0	-	0	-	2/3	-	9
Blackhawk	6	-	2	-	0	-	1	-	8/5	-	16
Humphreys, Clear Creek	2 2	.70 .60	6	$0.50	4	.60	1	-	3/3	-	4/26
Dixie	1	-	0	-	0	-	1	-	2	-	7
Humphreys, Virginia City	3	1.00	3	.625	0	-	3	-	5/5	-	32
Eldorado	5	.50	0	-	0	-	1	-	1	-	9
Pikes Peak	5	.50	0	-	0	-	0	-	0	-	9
Hallett	1	.75	2	.40	1	.40	1	1.04	1	$0.60	10
Jott-Ross	4	.50	0	-	3	.4375	1	-	0	-	14
Fisher	8	.50	0	-	0	-	3	-	0	-	17
Stationary plants:											
Ash Canyon	1	-	0	-	1	-	1	-	0	-	4
Chittendon	9/1	-	1	.5625	0	-	0	-	10/2	.5625	5
Von der Hellen	6	-	10/10	-	2	-	0	-	11/6	-	28
Guorin	9/1	-	0	-	0	-	0	-	0	-	2
Wallace	-	-	-	-	-	-	-	-	-	-	-
La Grange	1	.625	0	-	0	-	1	-	10/2	.625	5
Rhyolite	2	13/	1	.50	0	-	0	-	0	-	5

1/ Includes stripping. 2/ Includes owner, a trucker, and occasionally a mechanic. 3/ Includes superintendent, assistant superintendent, and time keeper. 4/ Does not include eight men sampling ground. 5/ Includes superintendent, bookkeeper, metallurgist, assistant metallurgist, and mechanic. 6/ Also a 10-hour shift for stripping. 7/ Lost time 60 percent due to changing and remodeling plant during first few months. 8/ One amalgamator, 1 carpenter, 2 extras, and owner. 9/ Co-owner. 10/ Truck-drivers. 11/ Superintendent, mechanic, welder, carpenter, clerk, and cook. 12/ Truck drivers operate shovel. 13/ Lessees.

TABLE 8. - Operating data at placer mines using movable or stationary treatment plants

	Shift				Labor			
					Excavation			
					Operator		Oilers	
	Number per 24 hours	Hours per shift	Operating time, hours per day	Gravel washed per hour operating time, cu. yds.	Number	Rate per hour	Number	Rate per hour
Movable land plants:								
Skeols	2	8	12.8	40	2	$1.00	0	-
Pantle	2	9	16	1/100	2	1.00	0	-
Pan Due	2	8	14	50	2	1.00	0	-
Peerless	1	10	8.5	-	1	1.10	0	-
Fairplay	2	10	-	20	2	.60	0	-
Blackhawk	2	10	1/8	70	2	1.25	0	-
Humphreys, Clear Creek	2	10	15	180	6	1.00	1	$ 0.60
							1	.50
Dixie	6/ 1	10	10	-	2	-	1	-
Humphreys, Virginia City	3	8	20	240	9	1.25	2	.75
							2	.625
							5	.50
Eldorado	1	8	-	-	2	1.50	0	-
Pikes Peak	6/ 1	10	7.5	25	2	1.50	2	.50
Hallett	1	8	-	37	3	.75	1	.40
Jott-Ross	3	8	20	75	1	1.25	3	.50
					2	1.125		
Fisher	3	8	-	73	3	1.25	3	.50
Stationary plants:								
Ash Canyon	1	8	7	4-1/2	1	-	0	-
Chittendon	1	10	9	40	9/ 1	-	0	-
Von der Hellen	2	9	16	75	2	1.28	2	-
Guerin	1	9	7	7	9/ 1	-	0	-
Wallace	3	8	-	100	-	-	-	-
La Grange	1	8	8	62	1	1.00	0	-
Rhyolite	1	12	12	10	12/	13/	0	-

(See footnotes on following page.)

The gravel is charged to a hopper in most of the movable land plants visited. In several of the washers an even distribution of the feed is obtained by some mechanical type of feeder. The others attempt to obtain a uniform flow into the washer by washing the gravel down with sprays or by hand feeding.

A wide variation exists in the design and mounting of the trommels. The trommel lengths range from 12 to 32 feet and the diameters from 48 to 84 inches. Two operators use a trommel with two screen sections, one being about a foot outside the other. Two other operators have placed a screen lining inside of old trommel shells. Perforations in the outer shells are 2 and 3 inches in diameter, respectively.

The Jett-Ross plant, which does not use a screen, depends upon sprays to disintegrate the gravel and wash it through a grizzly directly to sluices.

The slope of the trommels where data were available ranged from 7/8 to 2 inches per foot, with 1 inch per foot being favored. Less standardization exists in the speed of rotation for trommels on movable land plants than on floating plants. The range is from 9 to 20 r.p.m.

Table 7 shows the wide variation in size, shape, and arrangement of perforations. Increasing the size of the holes from section to section along the screen is a common method used to obtain an even distribution of the feed and a more even flow. Slotted perforations, particularly in the last few feet of the screen, are used by a few operators to assure catching elongated and flat nuggets of gold. At nine of the operations listed gold is saved in sluices, and at five, in Ainlay bowls.

Sluices generally are mounted beneath or at the side of the trommels; the boxes range from a single sluice, through which all the undersize passes, to banks of several sluices. Each size of gravel from the trommel is passed through a separate box. The size of sluices and types of riffles are shown in table 7. The bowls, where used (except the Pan-Due), are mounted beneath the trommel and are fed from a distributor box through launders. All bowls are 36 inches in diameter and turn at 100 r.p.m.

Descriptions of one typical plant of its class (Pantle) and five unusual plants follow. One Alaska operation is described, chiefly because of its unusual excavation problem.

Pantle

The Pantle Bros., operating in the Lincoln district, California, have a movable land plant consisting essentially of a hopper, trommel, centrifugal bowls, and stacker. It is typical of this type of plant using Ainlay bowls.

TABLE 8. - Operating data at placer mines using movable or stationary treatment plants - Continued.

	Fuel consumed					Wash water		
	Excavating		Washing and gold saving					
	Per hour, gallons	Per cubic yard, gallons	Per hour, gallons	Per cubic yard, gallons	Cost per gallon	g.p.m.	Gallons per cubic yard	Water reclaimed
Movable land plants:								
Skeels	-	-	-	-	-	450	670	None.
Pantle	-	-	0	0	-	-	-	do.
Fan-Due	4.4	0.091	-	-	-	400	480	do.
Peerless	5.2	-	3.5	-	$0.17	-	-	do.
Fairplay	14/2	14/.1	15/2.5	15/.13	14/.13 15/.17	-	-	do.
Blackhawk	5.0	.07	0	0	-	16/1,300	1,110	Recirculated.
Humphreys, Clear Creek	17/30 19/2.5	17/.167 19/.014	- -	- -	17/.105 19/.105	18/2,300 -	580 -	None.
Dixie	-	-	-	-	-	600	-	
Humphreys, Virginia City	0	0	0	0	0	4,200	1,400	20/ Some.
Eldorado	17/8.75	-	-	-	.175	420	-	-
Hallett	-	-	-	-	-	-	-	Recirculated.
Jett-Ross	3.1	.05	0	0	.115	21/4,000	3,200	None.
Fisher	1.04	.014	1.25	.017	.205	560	450	do.
Stationary plants:								
Ash Canyon	17/3	.67	-	-	.145	50	670	do.
Chittendon	3.2	.08	5.0	.125	.15	800	1,200	do.
Von der Hellen	22/21.1	23/.29	6.7	.09	.14	2,500	2,000	do.
Guerin	24/3.9	24/.56	-	-	.14	-	-	do.
Wallace	-	-	-	-	-	3,000	1,800	-
La Grange	17/6.25	.10	-	-	.155	800	770	None.
Rhyolite	3	25/.12	7	26/.7	27/.135	275	28/1,650	Recirculated.

14/ Diesel oil. 15/ Gasoline. 16/ Includes 300 g.p.m. added to sluices. 17/ Gasoline for entire plant. 18/ Includes 1,500 g.p.m. for washing and 800 g.p.m. additional for the gold-saving plant. 19/ Diesel oil for entire plant. 20/ In midsummer only 300 g.p.m. fresh water is available; 300 g.p.m. more is obtained by recirculation. 21/ No screening done. 22/ Includes 11.7 gallons per hour for trucking. 23/ Includes 0.16 gallons per cubic yard for trucking. 24/ Includes hoisting and washing. 25/ Includes stripping. 26/ Includes 20 gallons per 12 hours for trucks and 25 gallons per day for bulldozer. 27/ Twenty gallons per day at 17-1/2 cents. 28/ Twenty-five g.p.m. new water; water consumption 150 gallons per cubic yard.

The undersize from the trommel is pumped by an 8-inch manganese-steel sand pump through an 8-inch line to the gold-saving plant. The pump is driven by a 150-horsepower gasoline engine. The maximum length of the pipe line is 600 feet. ***. The sand pump breaks up any balls of clay that get through the screen and thus contributes to the washing of the undersize. ***. The gold-saving plant is mounted on the chassis of a crawler crane and is propelled by a 90-horsepower gasoline engine. The caterpillar treads are 12 feet long, 15 inches wide, and have a 10-foot gage.

The ground is leveled off before the plant is set on a new site. The machine is equipped with hydraulic jacks for leveling it across the line of sluices should it be found necessary. ***.

The undersize from the screening plant is discharged into a distributing box at the top of the gold-saving plant, from which it flows through pipes to sluice boxes. Clear water from the pit is pumped into the distributing box through a 6-inch pipe. The gold-saving equipment consists principally of 8 main sluices set in two banks of 4 sluices each, one bank on each side of the plant. The sluices are each 14 inches wide and 48 feet long. The first 36 feet contains riffles and the bottom of the last 12 feet is a screen with 1/16- by 1/2-inch holes. The speed of the top of the water through the main sluices is a little less than 10 feet per second. The grade of all of the sluice boxes is 1-1/4 inches to the foot. The undersize from the screens in the main sluices drops to the head of eight 20-inch sluices, four on each side of the plant. They are 16 feet long and are lined with corduroy cloth. The cloth plant was put in to recover extremely fine gold that is carried over the riffles in the main sluices. It is thought that this gold comes mainly from mill tailings. The lower ends of the corduroy boxes are suspended from a rope block, which permits easy control of the grade.

The riffles in the main sluices are strips of 3/16-inch iron; they are 1-1/4 inches high and are set 1-3/8 inches apart with the tops sloping down current. They are welded to end pieces in sections 3 feet long.

A 1-cubic-yard dragline is used to strip about 10 to 12 feet of overburden from the deposit. The overburden is overcast into the pit already worked. The remaining 6 feet of gravel and 2 feet of decomposed granite bedrock is fed to the plant. The shovel works on two 9-hour shifts and alternates between stripping and digging gravel, spending about half of the time on each operation.

The plant weighs about 15 to 16 tons; it is 9 feet wide and 30 feet long (fig. 6b). It is mounted at the rear on caterpillar treads 5 feet long, and on 8-inch steel wheels in front. The gage is 12 feet and the distance from front to rear axle is 14 feet. The plant is powered with a 35-horsepower electric motor, using about 19 horsepower, and a 2-horsepower motor for the stacker.

The gravel is charged to a 3-cubic-yard hopper and is hand-fed to a 4- by 10-foot trommel. The trommel consists of a 3-foot blank section equipped with 3-inch lifters, 8 feet of screen perforated with 5/8-inch holes, and 3 feet of blank screen. A second 8- by 6-foot screen is constructed around the outside of the screen section. This outside screen consists of 4 feet with 1/4-inch round holex and 4 feet with 1/4- by 5/8-inch slots.

The undersize from the trommel, consisting of from 40 to 50 percent of the gravel, is distributed to four 36-inch Ainlay centrifugal gold savers running at 100 r.p.m. The tail from the bowls discharges into a sump and is pumped by a 4-inch sand pump to the pit back of barriers made in overcasting.

A 48-foot stacker with an 18-inch belt discharges the rock to the abandoned pit. The stacker may be swung laterally by hand and raised or lowered with blocks and tackle.

Humphreys, Clear Creek

The mine of the Humphreys Gold Corporation on Clear Creek is about 30 miles from Denver, Colo. Gardner and Guiteras[7] describe the Humphreys Gold Corporation placer operations on Clear Creek, Colo.; the same operations have been described by Schloss.[8]

The gravel is excavated with two 2-1/2-cubic-yard draglines powered with 150 horsepower gasoline engines on the bank and a 1-1/4-cubic-yard Diesel shovel with a 130-horsepower engine in the pit. An essential difference between this and other similar plants is the gold-saving plant that is separate from the washing equipment. Gardner and Guiteras[9] describe the arrangement as follows:

7/ Gardner, E. D., and Guiteras, Jos. R., Placer operations of Humphreys Gold Corporation, Clear Creek, Colo.: Inf. Circ. 6961, Bureau of Mines, 1937. 16 pp.

8/ Schloss, Charles M., Clear Creek Dry-Reclamation Placer Gold Mining: The Mining Congress Journal, Sept. 1935, pp. 58-60.

9/ Work cited, p. 39. (See footnote 7.)

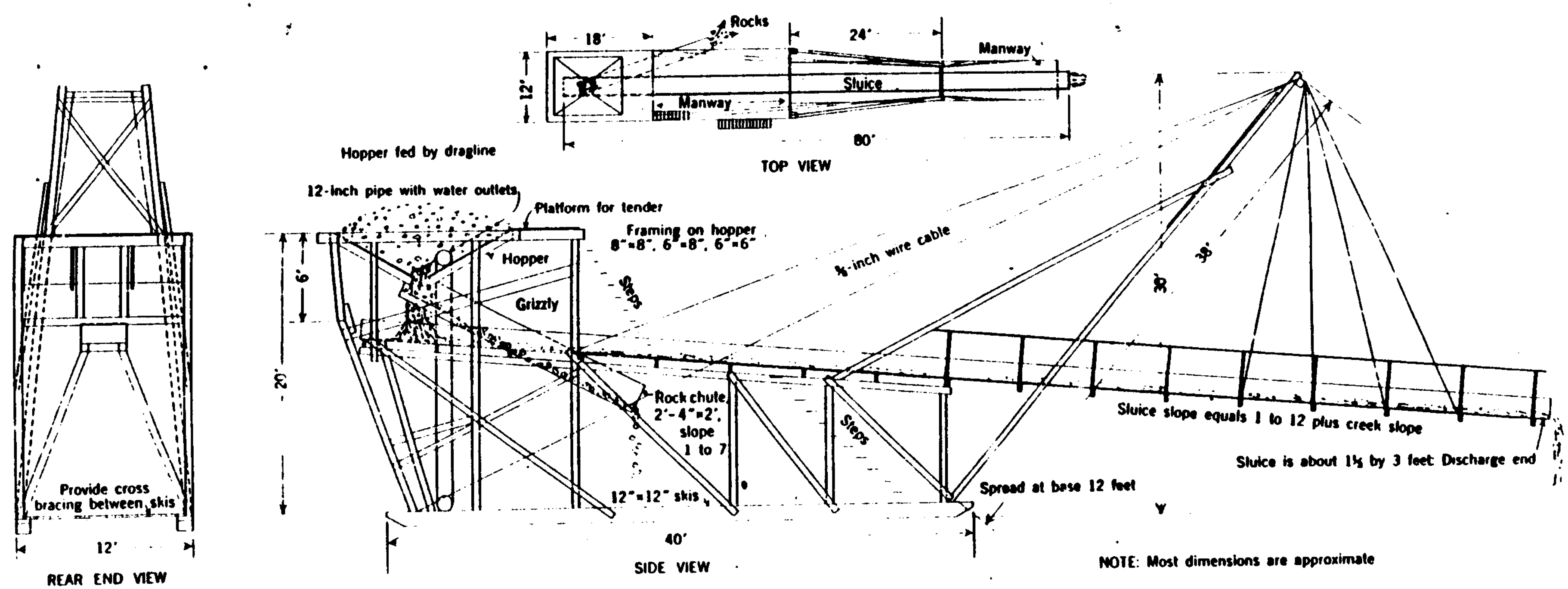


Figure 7.—Jett-Ross gold washer.

Humphreys, Virginia City

The Humphreys Gold Corporation operates a large movable plant on Alder Gulch, Virginia City, Mont. Operations began in July 1935. The operation has been described by Corry.10/

The gravel has been worked before by drift mining. The range in depth is from 3 to 28 feet, the average being about 17 feet. The bedrock of volcanic ash is dug to a minimum of 6 inches, as enrichment occurs to about this depth. Few boulders exist in the gravel.

The gravel is dug with two 2-1/2-cubic-yard, 100-horsepower, electric draglines, and an auxiliary 1-3/4-cubic-yard power shovel is used to clean bottom and reach corners not within reach of the draglines. The shovel dipper has a flat lip to facilitate cleaning bedrock.

The washing plant is a huge machine weighing 500 tons. It is mounted on two tractor chassis and a third set of caterpillar treads. The plant is propelled by individual motors for each tractor chassis. The treads run on mats that are moved up by the draglines. The plant is on the bank; it was designed to be used in this position principally because it was feared it would bog down on the soft wet bedrock.

The gravel is discharged into a 20-cubic-yard hopper and fed to a trommel by a 48-inch plate belt feeder. The trommel is 84 inches in diameter and 24 feet long; it is made up of a 4-foot blank section on the feed end and 18 feet of screen perforated with 1-1/8-inch round holes, and a 2-foot blank section at the lower end. A header spray using 1,500 g.p.m. washes the gravel as it enters the trommel; midway in the screen is another spray using 1,500 g.p.m. of return water from the overflow from the dewatering screws and another using 1,200 g.p.m. of fresh water.

The oversize discharges to a 48-inch belt conveyor 120 feet long and is conveyed to the spoil pile in the pit. The undersize goes to a sump and is elevated by a 12-inch sand pump, having a capacity of 4,200 g.p.m., to a distribution box, from whence it goes to 12 sluices, 14 inches wide and 53 feet long, with adjustable grade control. These discharge into four return sluices each 29 inches wide and 20 feet long. Gravel from the return sluices discharges into twin dewatering screws 24 inches by 19 feet long. Solids are discharged onto the stacker belt and the slime overflows and is pumped to a settling pond in the rear of the plant.

Sluices are equipped with Hungarian riffles consisting of iron bars 14 inches long, 1-1/4 inches high, and spaced 1-1/4 inches apart. They have a downstream batter.

10/ Corry, Arthur V., Dragline Installation for Recovering Gold at Virginia City, Mont.: Mining and Metallurgy, Oct. 1936, pp. 467-470.

Jett-Ross

Jett-Ross Mines, Inc., is placer-mining on Big Atlantic Gulch, Atlantic City, Wyo. The design of the washing plant is unusual. Most of the information on gravel and excavation is shown in tables 5 to 8.

The washing plant (fig. 7) weighs about 30 tons, is made of wood, and is mounted on skids. It is 40 feet long and 12 feet wide. The plant is towed forward by the dragline.

Gravel is dumped into a hopper 20 feet above the ground. The oversize from a grizzly having 6-inch spacing between the bars is discharged back to the pit by a rock chute. The gravel is disintegrated and washed to a sluice by water from a 10-inch centrifugal pump powered by a 165-horsepower, 4-cylinder motor.

The sluice is 88 feet long and 26 inches wide and has a grade of 1-1/2 to 2 inches per foot. It is equipped with alternating sections of steel hungarian and pole riffles. The steel riffles are 2 inches deep and spaced 7/8 to 1-1/2 inches apart; they are made up in 24- by 25-1/2-inch sections. The pole riffles are in sections 48 by 25-1/2 inches.

Dixie

Dixie Placers, L. J. Burrows, manager, is operating a dragline shovel and movable dry land washer on a placer deposit on Crooked Creek near Dixie, Idaho County, Idaho.11/ The operating season opens between April 15 and May 1, and closes between October 1 and October 15 each year. Mining has continued steadily for three seasons. It will be necessary to mine a fourth season to work out the deposit.

The gravel deposit is 3-1/2 miles long, 50 to 150 feet wide (average 120 feet), and about 13 feet deep. Large boulders are numerous, particularly in the narrow portions of the channel; parts of narrow channel are left as the gravel cannot be dug by the equipment at the mine. Bedrock is composed of decomposed granite and schist cut by hard dikes. About 6 to 12 inches of the bedrock is dug and washed.

Excavating is done by means of a Northwest gasoline-powered dragline shovel with a 45-foot boom and a 3/4-cubic-yard bucket. A 60-horsepower gasoline-powered bulldozer is used to clear the ground ahead of the dragline and to do other work. About 10 feet of the surface is stripped by the dragline during a 10-hour night shift.

The movable washing plant is 33 feet long, 10 feet wide, and 16 feet high, and it weighs 25 tons. It is mounted on eight 28- by 12-inch wheels, grooved to fit round timber track.

11/ Information furnished by S. H. Lorain, mining engineer, Bureau of Mines, Moscow, Idaho.

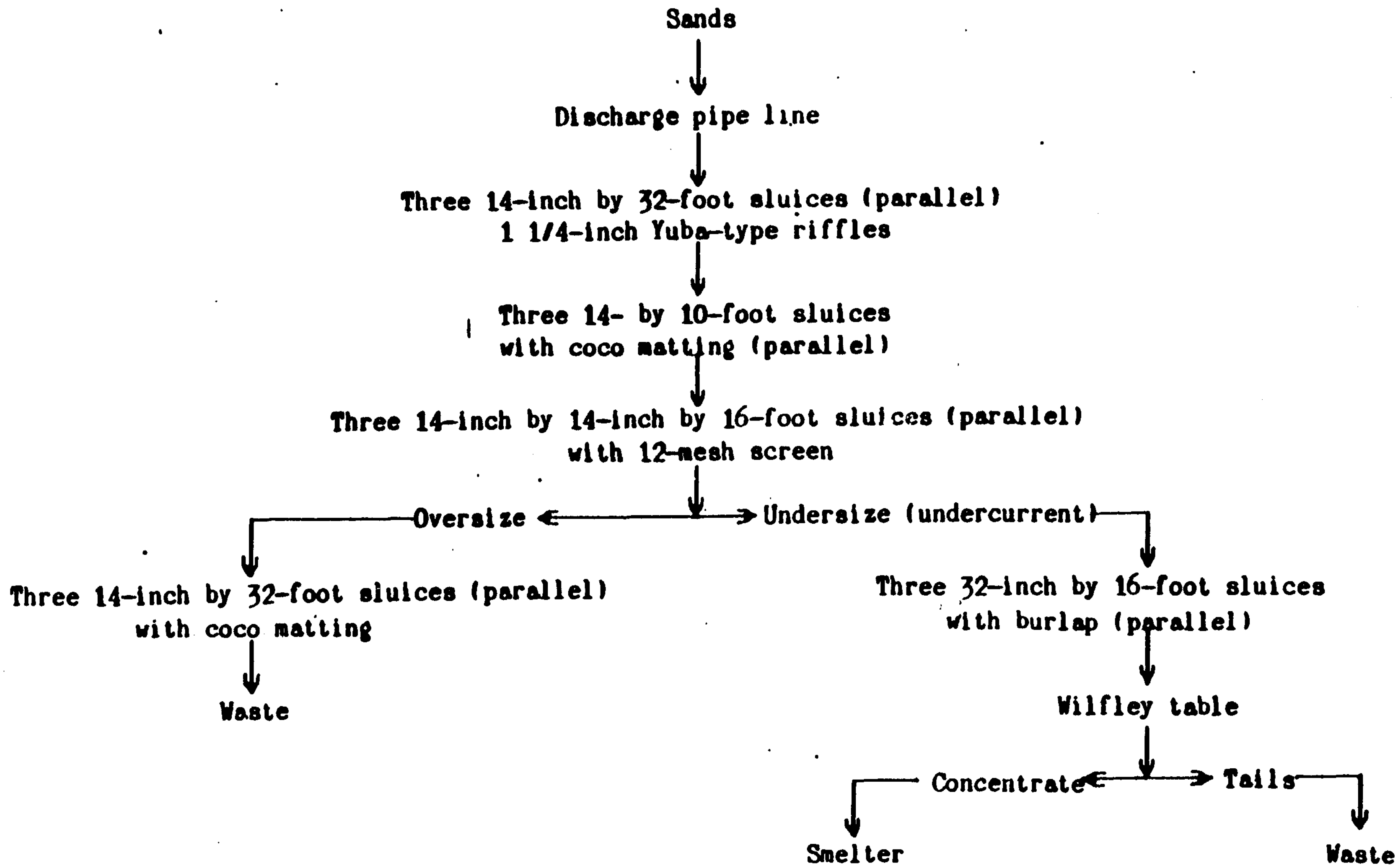


Figure 8.- Flow sheet, Blackhawk placer.

Gravel is discharged into a small steel hopper and washed and screened in a 48-inch by 19-foot trommel screen. The oversize (plus 1/4 inch) is discharged to a 36-foot stacker and discarded. The undersize passes over standard dredge tables suspended in swinging cradles under the trommel. Tables are 18 inches wide and have an area of about 100 square feet. Gold is saved in Yuba-type dredge riffles 1 inch wide and spaced 1 inch apart. In some of the sluices these riffles are followed by 1/2-inch-mesh, no. 9, wire smoke-stack screen laid over burlap. Undersize finally discharges from the last table sections to a drag-type dewaterer, which delivers the de-watered sand to the tailing stacker.

The plant uses about 600 gallons of water per minute. This is provided by the normal flow of Crooked Creek until midsummer, when the supply drops to about 300 g.p.m.; the additional requirements are made up by recirculating half of the water discharged from the plant during this period.

During 1936, a total of 229,000 cubic yards was dug; about a quarter of this was washed. The cost before depreciation, based on yardage dug, was $0.075 a cubic yard.

Blackhawk

Edward Manion is placer mining on a branch of Clear Creek just below Blackhawk, Colo. Gold amalgam and concentrate from old stamp mills constitute part of the value recovered. The lay-out comprises a shovel, a movable washing plant, and a stationary gold-saving unit. Operations began in the middle of April 1937; 50,000 cubic yards had been handled to the middle of September 1937. The capacity is 1,400 cubic yards on two 10-hour shifts. Only about 40 percent of the time has been spent in digging gravel, owing to continual remodeling of the plant.

Gravel is 25 to 27 feet deep and is reported to run a little under $1.00 per cubic yard. The gold is concentrated chiefly on the bedrock, although some is distributed through the entire depth. Bedrock, comprising granite and schist, is mined to a depth of 12 to 15 inches.

The gravel is dug with a 1-1/4-cubic yard shovel powered by a 150-horsepower gasoline engine. Washing and screening is done in a movable plant with a trommel screen back of the shovel. Oversize is stacked in the pit by a 70-foot belt stacker. The stacker is being lengthened to 85 feet in order to gain sufficient height to dispose of the gravel. Undersize is pumped to a gold-saving plant.

The gold-saving plant, comprising sluices and a Wilfley table, is on top of the tailings pile, where it can not be washed away by cloudbursts. Sands are pumped 150 to 600 feet to the plant by a 6-inch pump run by a 50-horsepower motor through a 6-inch pipe line. About two-thirds of the line is welded steel pipe and one-third is rubber hose. The steel pipe lasts from 80 to 90 days, and some of the hose has been in service for 3 years. When visited, the flow sheet of the gold-saving plant was arranged as shown in figure 8.

richer and mined on a fairly large scale. Relatively few deposits rich enough to be worked by this method on a small scale remain. Most of them have been worked previously by hand and other methods.

With the exception of the Ash Canyon, the seven plants listed in this paper were successful. Brief descriptions of the plants follow.

Ash Canyon

The stationary washing plant operated by R. R. Meier in Ash Canyon, Cochise County, Ariz., has some interesting problems. The deposit consists of about 80 percent of barren overburden, which had to be stripped; the narrow canyon, with steep walls, precluded dumping the barren material at the side of the gold-bearing gravel. The power shovel on hand could not dispose of the stripping far enough back of a movable plant used in the pit to leave working room. The washing and screening equipment was then moved to a new plant on a hillside, 1,500 feet by road and about 75 feet vertically above the pit.

The gravel is tight, requiring a power shovel to dig it. About 8 feet are stripped and cast back into the pit; 2 feet of enriched gravel and 2 or 3 inches of a cemented gravel bedrock are dug and transported to the washing plant in a 1-1/2-cubic-yard truck.

The gravel is dumped onto a grizzly with bars spaced 2-1/2 inches apart. The plus 2-1/2-inch material is discharged by a rock chute to the canyon below. The undersize goes to a hopper that discharges to a 3- by 8-foot revolving screen. The screen is made of 1/4-inch steel, with 1/2-inch round punched holes; it revolves at 15 r.p.m. A spray 18 inches in from the feed end washes the gravel. The oversize is discharged to a chute and passes back into the canyon. The undersize goes to a 36-inch Ainlay bowl containing iron riffles. The bowl discharge goes into the gulch. About 50 g.p.m. of water was pumped from a well.

The plant is powered by an old 4-cylinder automobile engine. Difficulties with the old engine materially reduced the operating time per shift. Lost time from all causes reduced the average daily yardage handled to such an extent as to make the operation unprofitable.

Chittendon

In March 1937, Charles N. Chittendon was operating a placer on Old Virginia Ravine, 6 miles from Lincoln, Calif. About 400 cubic yards of gravel, loose measure, are washed daily on one 10-hour shift in a stationary washing plant. About 85,000 cubic yards, loose measure, was washed in 1936.

The gravel is up to 20 feet deep; the average is 15 feet. Although it is tight, no boulders and only a small amount of clay are encountered. It is not stripped. The digging unit is a 1/2-cubic-yard gasoline shovel. A caterpillar tractor with a bulldozer blade is used for cleaning bedrock; it also is employed for building roads and doing other jobs in connection with the operations.

Washing and disintegration are promoted materially by the practice of pumping sands to the sluices.

No quicksilver is added to the sluices; however, 10 to 12 pounds that come from amalgam lost during earlier milling operations are recovered during clean-up.

Water is discharged back on the rock pile and permitted to clarify by percolation through the gravel; it is caught and recirculated.

Alaska

The following description[12] of an Alaskan placer mine is typical of dragline placer operations in the Fairbanks and Circle districts. The working season is from May to October. The gold-bearing gravel is about 5 feet thick and is overlain by 6 to 20 feet of barren silt. The whole deposit is frozen solidly. The surface is protected from summer thawing by a foot of moss. In mining, the moss is first scraped off by a bulldozer. As the silt is thawed by the summer sun, it is scraped off in layers by the bulldozer until the gravel is reached. Some of the gravel is naturally thawed by subsurface waters; the rest is thawed by the sun at a rate of about 6 inches in 24 hours. The frozen gravel is uncovered by the bulldozer each day. The thawed gravel and 1 to 2 feet of bedrock are dug by a gasoline-powered dragline with a 1-1/2-cubic-yard bucket and dumped into the hopper of a washing plant.

The washing plant consists of steel hopper and sluice mounted on steel skids. Gravel is disintegrated and washed to the sluice by a hydraulic giant to which water is supplied by a pump; the water is returned from a pond made by temporary earth dams below the plant.

The plant is operated by five men on each of two shifts. The cost of the installations in the district is stated to be from $50,000 to $80,000.

STATIONARY PLANTS

General and detailed information concerning placer mines with stationary washing plants is given in tables 5 to 8. Generally, operating costs with this type of plant are higher than with movable land plants because of the additional expense for transportation of the excavated gravel to the plant. The stationary plants have an advantage over the movable plants in that they are cheaper to build and can be more substantially constructed on a solid foundation. They can be placed at the most advantageous site for efficient disposal of tailings. Moreover, water from the plant does not get into the pit and cause difficulties, as it sometimes does at mines using movable plants. Some deposits are only amenable to working with a stationary plant. To be mined successfully, however, the gravels usually must be relatively

12/ Information furnished by H. B. Humphrey, Safety and Health Branch, Bureau of Mines.

A 1-1/2-cubic-yard gasoline-powered shovel is the digging unit. The gravel is transported to the washing plant and the oversize hauled away by trucks. An average of 9 truck shifts are worked daily on two 9-hour shifts.

The loaded trucks are backed up a dirt ramp and dumped into a 6-cubic-yard hopper at the top of the washing plant. The plant consists of a trommel and sluice. The gravel is fed to the trommel by means of a 2-inch stream of water under a pressure of about 12 pounds per square inch from a manually operated hose.

The trommel is 5 by 20 feet; lifter bars or retarding rings are not used because of the coarse material handled (up to 2 feet). It is made up of four 5-foot sections all perforated. The first section contains 1-1/2-inch, the next two 3/4-inch, and the last 1/2-inch holes. The usual order of graduated hole size, with the smaller at the top and the larger at the discharge end, is reversed. Since all the undersize drops into a single sluice box running parallel to the trommel, distribution appears to be unimportant; however, surges caused by dumping each load of gravel would be reduced and washing improved by the standard practice.

The trommel has a slope of 1-1/2 inches to the foot and rotates at 14 r.p.m. A 6-inch spray pipe containing 1-inch-diameter spray holes washes the gravel within the trommel; the pressure is about 12 pounds per square inch.

The undersize is caught by a 4- by 16-foot sluice beneath the trommel and is conveyed to a second sluice 34 inches wide and 70 feet long. The slope is 1-1/4 inches to the foot. Standard 1-1/4- by 1-1/4-inch angle-iron riffles spaced 1-1/4 inches apart are used in both sluices. The riffles are made up into sections by welding iron header-straps to each end. Quicksilver is fed at the head of the second sluice to a section of 3/4-inch steel plate perforated with 1-1/4-inch diameter holes; the bridge is 3/4 inch.

Guerin

Omer and Steve Guerin own and operate a small but successful placer (fig. 3b) on McConnel bar near the Von der Hellen operation. The placer pit and plant are on a part of the bar forming an island in the Klamath River.

The plant was built in April 1936. It is operated on one 9-hour shift by the two brothers; 2 hours are required to pump out the pit and get started and 7 hours are used for digging and washing. The plant has a capacity of 100 cubic yards a day; an average of 50 cubic yards is washed daily.

When visited, the bottom of the pit was in a good pay streak about 27 feet from the surface; the real bedrock had not been reached. The gravel is free of clay and similar to that at the Von der Hellen pit; about 10 percent consists of boulders over 12 inches in diameter.

The gravel is transported about 400 feet by two trucks to the washing plant, which is outside the pit limits, and is dumped into a hopper and hand-fed to a 75-foot conveyor belt, which discharges into a trommel.

The trommel is 52 inches by 12 feet long, with an outer screen. The scrubber section is 8 feet long; it contains two 4-inch retarding rings that reach half way around the periphery and an 8-inch ring at the lower end of the section. The inside screen section is 4 feet long and has 1/2-inch round perforations. The bridging is 2 inches. The outer screen is 72 inches by 4 feet; the first 2 feet has 1/4-inch perforations and the last 2 feet has 3/8-inch perforations. Disintegration in the inside screen is assisted by two retarding rings, lifter bars made from 2-inch angle iron, and the steel member of the trommel frame. The trommel slopes 1 inch to the foot and revolvex at the rate of 14 r.p.m.

Wash water is pumped at the rate of 600 to 800 g.p.m. under a pressure of 20 pounds per square inch into 4-inch slotted pipe that extends the entire length of the trommel. The oversize from the screen goes to a hopper, from which it is hauled by trucks.

The sluices, consisting of three 14-inch, one 16-inch, and one 24-inch box, run at right angles to the trommel on one side. They are 48 feet long and slope 1-1/2 inches to the foot. The first 15 feet of the boxes contain 1-1/4- by 1-inch wooden riffles, and the remaining 33 feet are equipped with iron screen over burlap.

The tailing is pumped a distance of about 100 feet through a 5-inch pipe by a 4-inch sand pump to a settling pond.

The plant and pumps are run by gasoline engines.

Von der Hellen

Wm. Von der Hellen, grading contractor, operates a stationary washing plant on McConnel Bar about 17 miles northwest of Yreka, Calif., or 6 miles from the junction of U. S. 99 on the Klamath River. The operation started on Feb. 5, 1937; an average of about 1,200 cubic yards is handled per day on two 9-hour shifts.

Gravel dug from a pit on the bar is about 40 feet deep, from which up to 12 feet are stripped as barren overburden. The bottom of the pit is about 55 feet vertically below the washing-plant hopper and 25 feet below the normal water level of the river.

The gravel is tight, difficult to dig even with a power shovel, and contains about 5 percent of boulders over 12 inches in diameter. Boulders over 2 feet are sorted out by the shovel. The bedrock is serpentine, of which from 1-1/2 to 2 feet is dug with the gravel.

Item	Cost per cubic yard
Excavation	$0.025
Transportation	.02
Washing	.025
Tailings disposal	.02
General	.01
Total direct	.10
Indirect	.03
Total1/	.13

1/ Excludes royalties of 10 percent and losses encountered not connected with the operation discussed.

Rhyolite

The Rhyolite placer is in Limerick Canyon, 13 miles from Oreana, Nev. In May 1937, it was being operated under lease by C. E. Swartz and three partners. The gravel is dug with a 5/8-cubic-yard shovel and hauled 1 mile in two 2-1/2-cubic-yard trucks. Fifty loads are hauled daily. About 10 feet of the deposit was first stripped and overcast back into the finished pit; the 4 feet above a false bedrock comprises the pay streak.

The gravel is dumped from the trucks into a 3-yard hopper and fed automatically into a 48-inch by 14-foot trommel. The first 7 feet and last 1 foot of the trommel are blank. The gravel is retarded in the trommel by a screw that makes six turns. The screen section has 3/8-inch round perforations; the bridging is 3/8 inch. Four nozzles, consisting of 2-inch flattened pipes, are used in the hopper and two in the screen section for washing the gravel. The oversize from the screen is discharged by a 16-inch by 80-foot belt elevator. It is then stacked by a bulldozer. The gravel contains some clay; all of it is not emulsified and some passes up the stacker as clay balls. The undersize from the screen first goes to a small Pan-American pulsating jig, which saves 90 percent of the recovered gold. The pulp then passes through a 24-inch by 24-foot sluice with angle iron and steel rail riffles into a drag classifier, 2 feet wide by 3 feet deep and 4 feet long. The sands are discharged onto the stacker belt and the overflow goes to a 20,000-gallon thickening tank and thence to an 8,000-gallon settling tank. Valves at the bottom of the thickener are opened for 2 to 3 minutes to discharge the mud; this contains about 50 percent moisture. The settling tank is cleaned out by hand about once a week.

The plant handles 125 cubic yards in a 12-hour shift. Two of the partners run the truck and two work in the plant. A fifth man is employed to run the bulldozer and do odd jobs. The truck drivers load their own trucks with the shovel. Stripping is done on overtime and concurrently with mining the pay streak.

Water is obtained from a spring and conveyed through a pipe to a tank at the plant; 18,000 gallons of fresh water is used daily.

The digging unit is a 3/8-cubic-yard, 3/4-revolving gasoline shovel. The shovel loads a 3/4-cubic-yard skip that is hoisted and swung to the hopper of the washing plant by a stiff-leg derrick. The derrick and washing plant were constructed of local timber.

The gravel is dumped into a 5- by 5-foot hopper, from which it is washed into a 28-inch by 9-foot revolving screen having a slope of 1-1/4 inches to a foot. The trommel consists of a frame of angle iron with 1/2-inch square-mesh screen welded around the circumference.

The oversize is discharged by a rock chute to the river. The undersize is washed successively in 3 boxes, one below the other. The first box is 28 inches by 6 feet and the second and third are 28 inches by 12 feet. They are equipped with a double layer of 1/2-inch, square-mesh, woven screen laid on brussels carpet. The slope of the boxes is 1-1/4 inches to a foot; they discharge the tailings into the river.

All the equipment is powered with second-hand automobile engines.

<u>Wallace</u>

The Wallace, Calif., plant of the Gold Gravel Product Co. began operations in September 1932. After three false starts it operated continuously from the spring of 1933 to May 1936 when the deposit was exhausted and the plant dismantled. The plant capacity was 100 cubic yards per hour; 1,066,000 cubic yards were handled during the life of the mine.

Gravel was excavated by a 1-1/4-cubic-yard, full-revolving, caterpillar-tread, gasoline-driven shovel with a 30-foot boom and a 92-horsepower engine. Haulage equipment comprised two 8-ton and one 5-ton Plymouth gasoline locomotives, two 17-ton steam locomotives, and four 4-cubic-yard and four 6-cubic-yard cars. Gravel was hauled 1/2 mile to the washing plant; rock reject at the plant was hauled to a nearby waste dump.

An 8-inch grizzly rejected the oversize. Washing was done in a 5-foot diameter by 16-1/2-foot trommel screen provided with lifter bars and a spiral vane 12 inches high and making 15 turns through the length of the screen. The first part of the trommel was a scrubber and the last 4 feet was screen perforated with 1-inch round holes. An outer screen with 3/8-inch holes circled the 4-foot section. The plus 3/8-inch minus 1-inch material was run through a 16-inch sluice, and the minus 3/8-inch sands went through a 32-inch sluice; each was 100 feet long.

About 3,000 gallons of water per minute was pumped for washing, or 1,[illegible]0 gallons per cubic yard of gravel.

The following table gives the estimated cost per cubic yard for the total 1,066,000 cubic yards of gravel excavated and washed:

EXCAVATING EQUIPMENT

Draglines and power shovels

Diesel-engine power units are used on 18 of the 24 draglines listed that serve floating washers; four are powered with electric motors and two with gasoline engines. One operator uses a gasoline engine-powered shovel. Two Diesel-powered draglines, one Diesel-powered shovel, and three draglines using gasoline are employed on operations where data were available for the movable land plants and stationary plants. Fifteen excavators used gasoline engines, 11 of which were on shovels and 4 on draglines. Two electric draglines and one electric shovel were being used at one large movable plant operation in Montana (see tables 2 and 6).

Dragline excavators serving floating plants range in size from 1-1/4- to 3-cubic-yards bucket capacity; the 1-1/4- and 1-1/2-cubic-yard sizes are more common. Those serving movable land plants range from 1 to 2-1/2 cubic yards bucket capacity; the 1-1/4-cubic-yard size is more common. At two large operations, two 2-1/2-cubic-yard draglines, with a small auxiliary shovel, are digging simultaneously. A common practice is to buy a dragline equipped with a bucket 1/4 cubic yard smaller than the rated capacity of the machine to provide reserve power for contingencies, prolong the life of the unit, and reduce repairs.

The capacity of the shovels used at stationary plants ranges from 3/8 to 1-1/4 cubic yards; most of them are old gasoline-powered shovels, but they give fairly good service.

Cables

Shovels are equipped with a hoist and a boom support cable; occasionally some of the smaller shovels are equipped with a cable-type crowd. The dragline, in addition to the hoist and boom cables, requires a drag cable. Usually, cables recommended by the excavator dealer are used; they are constructed to withstand extreme wear and sudden strains and must have maximum flexibility. The boom support cables are subject to little wear and last indefinitely.

Ordinarily, hoist and drag cables are run to failure. The drag cable on a dragline generally is an eighth of an inch larger in diameter than the hoist, owing to the harder service in digging over hoisting. Occasionally, both cables are of the same diameter; the hoist, being twice the length of the drag, may be cut to make two drag cables, thereby increasing the ultimate life and usefulness of the cable.

According to available data, the average length of service for hoist cables on draglines was from 150 to 900 hours, the average being about 500 hours for all operations listed. The life of drag cables ranged from 150 to 400 hours, with an average for all of about 200 hours. Hoist cables

The plant is run by a 35-horsepower commercial gasoline engine and the water-recirculating pump by an old automobile engine. A total of 125 gallons of gasoline is used daily by the plant, bulldozer, trucks, and shovel. The rental of the plant is $1,000 per month. Supplies other than gasoline average about $300 per month. Counting the partners' time at $6 per day, the indicated cost of handling the gravel through the washer is $0.76 per cubic yard.

La Grange

La Grange Placer Mines, P. C. Alexander, superintendent, operate a placer mine on the south bank of Tuolumne River about 3/4 mile west of La Grange, Calif. The plant comprises an open pit, stationary washer, and gold-saving unit. The plant began operating July 4, 1937, and had operated 75 days when visited. Operations were on one 8-hour shift per day. A total of approximately 28,000 cubic yards had been dug and washed; the plant capacity is 500 cubic yards a shift.

About 4,000,000 cubic yards are said to have been proved by test pits spaced 50 feet apart.

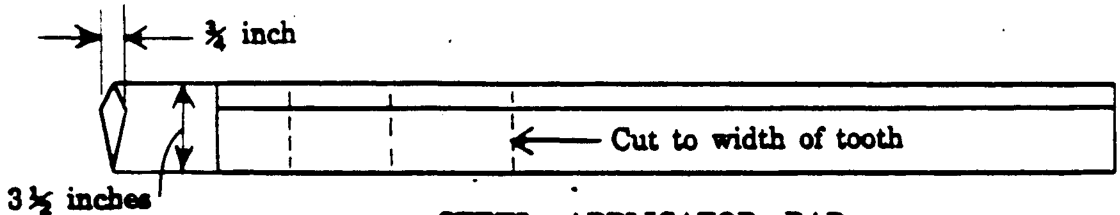
The gravel is tight, contains few boulders over 12 inches in diameter, and no troublesome clay. The pit is 20 to 30 feet deep, the average being 25 feet. Bedrock is volcanic tuff and is drained by a ditch to the adjoining river bed.

A revolving shovel powered by a 6-cylinder gasoline engine and equipped with a 3/4-cubic-yard dipper excavates the gravel. Two 3-cubic-yard trucks haul the gravel 600 feet to the grizzly over a bin at the washing plant at an elevation of about 80 feet above the pit.

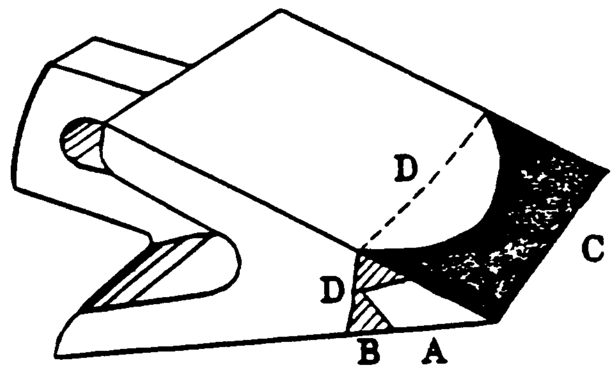
Gravel is fed evenly from the 20-cubic-yard bin to a trommel of the washing plant by an electrically operated, plate-type, arc-gate feeder. The oversize from the trommel is discharged to the river bed by a 65-foot stacker; the undersize passes over side tables at right angles to the trommel, is then collected in a single longitudinal sluice, and finally discharged to the river bed.

Water is pumped from the Tuolumne River, 1,300 feet against a head of 156 feet to the plant through a 10-inch pipe. A turbine pump run by a 50-horsepower motor delivers the water at the rate of 800 g.p.m. and a pressure of 40 pounds per square inch.

The entire equipment, comprising shovel, trucks, washing and gold-saving equipment, and pump, is new. The plant is laid out on a hillside for efficient operation. Trommel, sluices, and riffles are patterned after those used on the more successful floating boats.

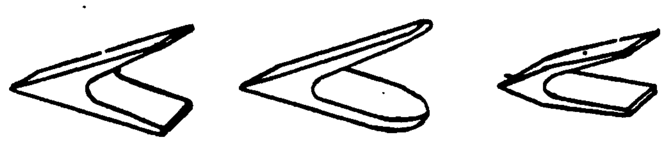


STEEL APPLICATOR BAR



REBUILT TOOTH

A. Steel applicator bar
B. Welding-rod filling
C. Hard face
D. Point before rebuilding



TYPICAL REPOINTS FOR TEETH

Figure 9.—Methods of rebuilding dipper and bucket teeth.

on shovels lasted from 300 to 600 hours, but few data are available. A comparison between hoist or drag cables on draglines and hoist cables on shovels is impracticable, since larger cables are used on shovels of similar capacity.

Teeth

A considerable saving in cost of supplies is claimed by most of the placer operators who utilize some method of building up worn bucket and dipper teeth. Three general types of teeth are used; one type consists of two parts, the base (often called an adapter) and the point; a second type incorporates the base as an integral part of the bucket, and only the point may be removed; the third type is made up of the base and point in one single detachable unit. The cost of teeth varies greatly, depending mainly upon the type, size, and material from which they are made; the range is from about $2.75 to $8.50 per tooth.

Table 9 contains data on rebuilding teeth at a few typical placer operations. The life of teeth varies because of the wide range in hardness and abrasize qualities of the gravel at different mines.

Several methods of rebuilding and prolonging the life of teeth are in use. Some operators reconstruct the entire point from welding rod. Another method is to weld on repointers; when these are used, care is taken not to wear into the stock of the tooth or it will have to be rebuilt before the repointer is applied. The use of applicator bars has found favor with many operators; these may be bought from several manufacturers of steel products and are highly recommended by them. The bars are of manganese steel or some other suitable steel, and come in lengths of several feet; they may be cut into sizes the width of a tooth. These are welded on and filled out to size with welding rod. A surface of hard facing applied to the point is proving to be economical in prolonging the life of teeth at some places. Figure 9 shows a typical applicator bar and its application to a tooth with hard facing added. Typical repointers are also shown.

An arc-welding machine is considered by many small-scale mechanical placer operators to be essential equipment for a complete plant.

One manufacturer in Pennsylvania quotes $1,095 for a 1-arc, 200-ampere, variable-voltage, engine-driven, arc welder mounted on skids, and $2,835 for one with a 600-ampere rating. Machines with 200-, 300- and 400-ampere ratings also may be purchased at prices between these limits. The same machines mounted on plain wheels cost $1,155 and $2,935, respectively. The prices are f.o.b. factory and the weights for the wheel-mounted machines are 2,200 and 5,650 pounds, respectively.

Model number	Number cylinders	Approximate draw-bar horsepower	Gage model, inches	Fuel	Approximate weight, pounds	Price
RD 8	6	95	78	Diesel	32,600	$7,325.00
RD 7	4	60	74	do.	20,980	5,300.00
	4	60	60	do.	20,320	5,050.00
RD 6	3	45	74	do.	15,520	3,925.00
	3	45	56	do.	14,860	3,725.00
50	4	50	74	Gasoline	18,890	3,980.00
	4	50	60	do.	18,080	3,730.00
R 5	4	55	74	do.	14,130	3,210.00
	4	55	56	do.	13,320	3,010.00

The same manufacturer furnished the following prices, submitted to them on bulldozers suitable for use on their tractors:

TABLE 9. - Data on rebuilding teeth at typical placer operations.

	Change period, hours	Times rebuilt	Cost per new tooth	Remarks
Fay	32	-	1/$2.85	Hard faced.
Jasper-Stacey	8 to 24	-	-	Rebuilt.
Clark	8	100	-	-
Consuelo	24	-	2.75	-
Cinco Mineras	8 to 12	6 to 10	8.50	Applicator bars used.
Penn	8	30	7.00	Repoints cost $1.85.
Midland	36	-	-	Applicator bars used.
Pioneer	24	-	-	Rebuilt at central shop.
Sandberg-Carlson	20	3	2.75 7.00	$7 teeth rebuilt more times.
Olson	40 to 50	6	2.75	Adapters cost $8.
Collins	10	Over 15	2/	Rebuilt in town.
Folsom	64	-	-	Repoint every 64 hours, build up and repoint 450 hours.
Prickly Pear	24	2 or 3	-	-
Pantle	100	5 to 7	7.00	-
Von der Hellen	300	0	-	Not rebuilt.
Cooley	48	-	-	Rebuilt.

1/ Cost rebuilding tooth $0.69.
2/ Cost rebuilding tooth $0.45.

Bulldozers

A bulldozer comprising a tractor with caterpillar treads and road blade mounted in front is considered as an indispensable part of the mechanical placer operation. Its chief use is for clearing away trees and brush and leveling ahead of the dragline or shovel. It is used, also, to build roads and dams and occasionally to strip a few feet of barren clay or soil overburden.

The Caterpillar Tractor Co., Peoria, Ill., furnished the following data on various sizes of their tractors suitable for bulldozing; prices (July 1937) are f.o.b. their factory:

POWER

Five principal types of power motors and combinations thereof are common at plants of the small-scale mechanical type - (1) electric power for excavator and washing plant, (2) Diesel engines for both, (3) Diesel shovel and Diesel electric plant, (4) gasoline-powered shovel and plant, and (5) Diesel shovel and electrically powered treatment plant.

The choice of the most economical power plant depends on a number of variables, and each particular case must be decided on its merits. The Bodinson Manufacturing Co., Inc., of San Francisco, Calif., submits the following table showing first costs for various power plants for a mine with a dragline and floating treatment plant and costs after two years of operation.

Comparative cost of power plants,
125-horsepower dragline and 85-horsepower on boat

	Cost of power plant	Operating cost, 2 years	Salvage value at end of 2 years	Net cost at end of 2 years' operation
Direct electric power..	$4,214	$14,790	$1,685	$17,318
Diesel engines, both shovel and boat......	9,100	7,644	3,480	13,264
Diesel shovel, Diesel electric on boat.....	12,192	6,475	4,800	13,867
Gasoline engines, both shovel and boat......	2,900	23,275	1,000	25,175
Diesel shovel, electric power purchased for boat................	7,912	12,950	2,240	18,622

This table indicates that Diesel power is most economical, although it shows little advantage in economy over the Diesel shovel and Diesel electric plant. The latter has advantages owing to the convenience of electrical drives and elimination of transmission machinery. Most recently purchased excavators and boats are Diesel-powered. Gasoline seldom is used except on the older excavators. Generally, Diesel power has an advantage over electricity, due to the isolation and wide extent of placer deposits. The initial cost of constructing power lines and installing transformers to serve equipment that is used on deposits having a life of sometimes a year or less is prohibitive. Part of the line and transformers must be moved continually to keep up with advancing operations; long trailer cables that are maintained from transformer to equipment demand attention. Electrically-powered and controlled excavators ordinarily give smoother operation and more positive control than Diesel power; however, the modern Diesel engine is being improved rapidly. Considering all factors, Diesel power is more economical than electricity or gasoline for the average placer mine of the type considered in this circular.

Caterpillar tractor number	La Plante-Choate,1/ Cedar Rapids, Iowa, effective July 20, 1936		Kay-Brunner Steel Products, Inc.,2/ Los Angeles, Calif., effective May 12, 1936		R. G. LeTourneau, Inc.,3/ Peoria, Ill., and Stockton, Calif., effective Jan. 15, 1937	
	Approximate weight, pounds	List price, f.o.b. factory	Approximate weight, pounds	List price, f.o.b. factory	Approximate weight, pounds	List price, f.o.b. factory
RD8	8,520	$1,700	6,750	$1,525	4,634	$1,230
RD7-74	5,545	1,375	5,100	1,360	4,532	1,040
60	5,030	1,260	4,750	1,290	3,557	945
RD6-74	4,920	1,230	3,750	1,150	3,196	945
56	4,550	1,140	3,380	1,100	2,987	850
50-74	5,545	1,375	5,100	1,360	-	-
60	5,030	1,260	4,750	1,290	-	-
R5-74	4,920	1,230	3,750	1,150	-	-
56	4,550	1,140	3,380	1,100	3,987	850

1/ Hydraulic two-way pressure control.
2/ Hydraulic control.
3/ Mechanical control.

Caterpillar Diesel electric generator set price list

Alternating current

Volts	D 13,000 - 60 kw.				D 8,800 - 40 kw.				D 6,100 - 25 kw.			
	Diesel side	Electrical side	Total List price	Total Approx. weight	Diesel side	Electrical side	Total List price	Total Approx. weight	Diesel side	Electrical side	Total List price	Total Approx. weight
3-phase, 60-cycle, 900 r.p.m:												
120	$4,142	$1,425	$5,567	11,884	$2,968	$1,269	$4,237	9,788	$2,210	$1,022	$3,232	7,930
240	4,142	1,374	5,516	11,884	2,968	1,224	4,192	9,788	2,210	988	3,198	7,930
480	4,142	1,374	5,516	11,884	2,968	1,224	4,192	9,788	2,210	1,007	3,217	8,430
3-phase, 60-cycle, 750 r.p.m:												
120	4,142	1,755	5,897	12,721	2,968	1,489	4,457	10,238	2,202	1,181	3,383	8,470
240	4,142	1,696	5,838	12,721	2,968	1,438	4,406	10,238	2,202	1,143	3,345	8,470
480	4,142	1,696	5,838	12,721	2,968	1,438	4,406	10,238	2,202	1,166	3,368	8,470
Direct current												
2-wire, 900 r.p.m.												
125	4,169	1,658	5,827	12,242	2,966	1,216	4,182	9,381	2,210	881	3,091	7,660
250	4,169	1,505	5,674	12,242	2,966	1,157	4,123	9,381	2,210	881	3,091	7,660
600	4,169	1,581	5,750	12,242	2,966	1,217	4,183	9,381	2,210	926	3,136	7,660
3-wire, 900 r.p.m:												
125 or 250	4,169	1,716	5,885	12,242	2,966	1,326	4,292	9,381	2,210	1,037	3,247	7,860

Fuel and power consumption per cubic yard for shovels and draglines has a wide range. Variations on excavators of the same size and type are due mostly to physical conditions in the gravel and to the relative experience of operators rather than to the efficiency of power units of the same degree of repair.

The following quotations, effective April 1, 1935, for Diesel and gasoline-power units suitable for use on washing plants were submitted by Caterpillar Tractor Co., Peoria, Ill.

Diesel and gasoline caterpillar power units

Model	Number cylinders	Fuel	Brake horsepower		Approximate shipping weight, pounds 1/	Price, f.o.b. factory 1/
			Maximum	Continuous sustained load		
D 13,000	6	Diesel.	125	95	8,430	$3,950
D 11,000	6	do.	102	76	8,519	3,600
D 8,800	4	do.	77	59	6,310	2,737
D 7,700	4	do.	63	48	6,220	2,487
D 6,100	3	do.	47	36	5,632	2,023
9,500 G	4	Gasoline.	96	81	6,960	1,608
6,500 G	4	do.	51	43	3,660	1,020

1/ Includes engine complete, plus base, pillow blocks, clutch, controls, crank, hood, radiator, and fuel tank.

The following table contains an incomplete list of Diesel electric generator sets submitted by Caterpillar Tractor Co., Peoria, Ill. The price was in effect April 1, 1935, and probably is a little higher now (1937), since metal and machinery prices have gone up since that time. Prices are f.o.b. factory.

Clean water pumps are not recommended, as the recirculated water contains some sand that cuts down their efficiency.

LABOR

The crew for operation of an excavator and floating plant on a 3-shift basis usually comprises 3 excavator operators, 3 oilers, 3 winchmen who operate the washing plant, a boat master to supervise the work, a welder, and a utility man to run the bulldozer, do trucking, and other miscellaneous work. The sluices are cleaned up by the crew on shift during the time the plant is shut down for this purpose.

Actual labor requirement for movable land plants is a little higher than for floating plants, probably partly due to lack of standardization of operations.

Stationary washing-plant operations require additional labor for driving trucks. The unit performance, in terms of labor and yardage, is lower than for either the floating or movable land plants and is reflected in higher unit labor costs.

Additional labor is required in all types of dredging for ground testing. The amount is governed by the method and thoroughness of sampling.

Tables 4 and 8 show the labor employed at individual plants.

SAMPLING AND RECOVERY

The percentage of gold recovered in placer mining is seldom definitely known. Recovery percentages are likely to be misleading unless the relation between the method of sampling and the major method of saving the gold is considered. Most of the placer operations visited reported their recovery to be nearly 100 percent or higher. In each case the figure is based on the estimated amount of gold present in the deposit, as indicated by sampling. When the method used to recover the gold from the samples from pits or shafts closely simulates the procedure used in the operating plant, the indicated recovery usually is nearly 100 percent.

Variations will be caused by the thoroughness of sampling the ground. Moreover, refined methods of washing the samples may be the cause of low indicated recovery at the plants, or careless handling of the samples may indicate a higher recovery than expected.

In drilling gravel deposits a factor generally is used in calculating the gold content of the samples to allow for losses in treating the ground.

The entire amount of gold contained in any placer deposit rarely is recoverable by standard washing plants either on dredges or on the types described in this paper. This is due mainly to the physical condition of the gold and its relation to gangue minerals in the deposit. Often fine and

WATER

Water is used primarily for disintegrating and washing the gravel and flushing it through the sluices. In addition, a relatively large amount is used to maintain a pond for the floating plants. Small additional amounts are used during a clean-up.

Disintegration and washing usually start by spraying water onto the gravel in the hopper. Further washing is done with a spray pipe with holes drilled inside and running the entire length of the trommel, or by sprays that shoot into the lower end of the screen. Occasionally, a small amount of water is added in the sluices to prevent choking. From 700 to 1,800 gallons of water per cubic yard was used on the floating plants for washing the gravel and running it through the sluices; a boat with jigs in addition to sluices used 2,500 gallons per cubic yard. The range on movable and stationary land plants was 450 to 2,000 gallons per cubic yard where trommels were used for washing. At one plant (Rhyolite), where the tailings were thickened, 150 gallons of new water was used per cubic yard. At the Jett-Ross mine, where the gravel was not screened, 3,200 gallons per cubic yard was used.

The amount of water required to wash a cubic yard of gravel is governed mainly by the amount of clay and relative coarseness of the gravel. Gravel containing little or no clay and a large amount of oversize can be washed with a minimum of water (the oversize is handled mechanically); a large amount of clay in fine sandy gravels will require up to three times the amount. Usually, about 700 or 800 gallons per cubic yard and not over 1,000 gallons per cubic yard is sufficient for washing in average gravel. Some of the plants discussed were not using enough water, often from necessity, and others undoubtedly were using too much. An insufficient supply with a muddy return causes the density of the pulp to be too high, which prevents some fine gold from settling down into the riffles. Too great a supply of water causes the riffles to run naked at times, thereby causing some of the settled gold to be boiled out the riffles and carried away with the tailing. At the best managed plants the water supply to the sluices is cut off immediately whenever the feed of gravel is interrupted.

The amount of water required to maintain a pond sufficient for a floating washer depends upon the relative porosity of the gravel and bedrock. The minimum requirements appear to be about 35 to 50 miners' inches, although 20 miners' inches were used at one small plant working in tight gravel and with a limited water supply; 100 to 150 miners' inches was found to be used at a few operations, owing mostly to the abundance of water.

The best practice for floating plants of about 100 cubic yards per hour capacity appears to be to use an 8-inch centrifugal pump to circulate the wash water and a 3- or 4-inch auxiliary pump for cleaning up. Water usually is supplied by the 8-inch pump working against about a 40-foot pressure head and consuming 25 to 30 horsepower. A 3- or 4-inch pump will require about 5 to 10 horsepower.

The value of samples ranged from 4 to 90 cents per cubic yard in gold. Erratically high sample results were discarded or checked. The average grade obtained for the whole tract was 18-1/2 cents per cubic yard in gold. Actual recovery based on this estimate was finally more than 100 percent.

For some subsequent sampling, a Denver mechanical gold pan was used to work down the samples. The results were said to be misleading, as the two crepe-rubber mats and the amalgamating pan recovered more fine and coated gold than it was possible to catch in the riffles during the major operations. The operators concluded that a rocker or sluice box furnished them the best comparison for actual recovery.

Sampling, as practiced by E. T. Fisher Co., Atlantic City, Wyo., has been described by Ross and Gardner15/ as follows:

> The deposit was sampled by driving pipes through the gravel. A single row of holes 150 to 300 feet apart was put down first along the center line of the channel. Rows of holes 1/2 mile apart were then drilled across the deposit; holes in the rows were 20 to 60 feet apart. The spacing depended upon surface indications. The holes extended through the decomposed bedrock to solid rock and averaged 14 feet in depth.
>
> The sampling device was a 4-inch casing with a Keystone cutting shoe. The diameter of the shoe was slightly less than that of the pipe; the samples were retained in the pipe when it was withdrawn. The casings were driven down to refusal with a locally made pile driver. This consisted of a 275-pound hammer, a 20-foot, 4-legged, pole derrick, and a Chevrolet automobile engine and transmission shaft. The cable for raising the hammer ran through a sheave at the top of the derrick to a drum on the transmission shaft. The whole assembly was on a pair of skids and was moved forward by its own power; the end of the cable was attached to a deadman. The sampling outfit cost $300 to build.
>
> The casings were pulled by means of a set of wire blocks having 4 and 5 sheaves. The cable from the blocks was wound on the drum by the engine. About half the time it was necessary to start the casing with jacks set against a clamp put around the top of the pipe. Three sets of casings were used. A pulled casing was laid on saw horses and the gravel removed in 6-inch sections by means of a special spoon; each section of gravel was panned.

15/ Ross, Charles L., and Gardner, E. D., Placer Mining Methods of E. T. Fisher Co., Atlantic City, Wyo: Information Circular 6846, Bureau of Mines, June 1935, pp. 2-3.

rusty gold and that embedded in gangue material is not caught in riffles or quicksilver and is lost. Therefore, the method of estimating the amount of recoverable gold in a bed of gravel that most nearly approaches the method used to work the deposit is considered the safest method of estimation.

Gardner and Johnson[13] have discussed sampling and estimation of gold placers. The most common methods of obtaining samples at the placers discussed here are from pits or shafts. These are dug by hand or with a dragline shovel.

Gold usually is distributed more uniformly along the channel than across it. Usually pits are spaced along the channel or across it to compensate for the variation in the two directions. The distance between the rows across the channel was found to vary from 100 to 1,200 feet, and the distance between individual pits in each row was from 30 to 200 feet. The spacing in each direction should depend upon the uniformity of the gold content of the gravel.

A measured volume of gravel is taken for a sample by making a uniform cut from the top to the bottom of the pit, including in it a proportionate amount of bedrock. Usually, this sample is washed in a rocker or long tom; the clean-up is amalgamated and the gold is recovered and weighed.

The percentage of recovery obtained after working the gravel is calculated from this estimate. An estimate based on the practice of crushing, pulverizing, and recovering the gold by fire assaying is not practicable; while it may be more accurate as a measure of the total amount of gold actually in the sample, it is misleading, since it does not give an accurate estimate of the gold it is possible to recover by placer mining methods.

Prospecting of a gravel bed by the Wyandotte Gold Dredging Co. has been described by Magee.[14] Shafts 3 by 6 feet in cross section were sunk by hand to the false bedrock. A windlass was used in the deeper pits and water was pumped out by a gasoline engine-powered pump when necessary. The distance between rows across the channel was 500 feet and between shafts in the rows about 200 feet; 30 pits were sunk on 75 acres.

A sample was taken by making a cut 1 foot wide by 6 inches deep from the top to the bottom at one end of the shaft. Check samples were taken from the opposite end when necessary. The volume and weight of each sample were determined.

The sample was puddled in a tub of water to completely disintegrate it and it was then washed in a rocker. The washed material was run through the rocker a second time and discarded. The clean-up was panned down and amalgamated with quicksilver; the gold was extracted and weighed.

13/ Work cited, Part 1, pp. 26-46. (See footnote 5.)

14/ Magee, James F., A Successful Dragline Dredge: Tech. Pub. No. 757, The Amer. Inst. of Min. and Met. Eng., 1936. p. 9.

TABLE 10. - Cost of plants and operating costs at placer mines using floating treatment plants

	Cost of plant				Operating cost per cubic yard				
	Excavator	Boat	Miscellaneous	Total	Excavation	Washing	General	Miscellaneous	Total
Lynx Creek.....	-	-	-	-	-	-	-	-	1/0.10
Fay............	$18,500	$10,000	$9,000	$37,500	-	-	-	-	2/.11
Consuelo........	28,500	10,100	8,400	47,000	-	-	-	-	3/.12
Richter.........	8,000	15,000	4,000	4/27,000	-	-	-	-	5/.12
Cinco Mineros...	22,500	12,000	-	34,500	$ 0.04	$0.056	$0.015	-	6/.111
Penn............	39,600	16,000	7/44,400	100,000	.0332	.0374	.0032	$0.0179	.115
England.........	18,000	12,000	10,000	40,000	.0332	.0374	.0198	.0183	8/.1087
Midland.........	-	15,000	-	40,000	-	-	-	-	.15
Gold Acres......	-	-	-	-	-	-	-	-	9/.10
Pioneer 1.......	22,000	-	-	-	-	-	-	-	10/.09
Pioneer 2.......	22,000	-	-	-	-	-	-	-	10/.09
Pioneer 3.......	30,000	21,000	9,000	60,000	-	-	-	-	11/.09
Carlson-Sandburg	-	-	-	-	.03	.03	.03	-	10/.09
Olson...........	21,000	14,000	8,600	43,600	-	-	-	-	10/.09
Collins.........	20,270	22,800	10,600	52,800	-	-	-	-	10/.11
Folsom..........	-	10,000	-	-	.0275	.0275	-	-	12/.055
Lilly...........	-	-	-	50,000	.04	.05	.01	-	12/.10
Schwegler.......	18,500	16,400	3,600	38,500	-	-	-	-	.125
Cooley..........	-	-	-	-	-	-	-	-	13/.18
Fairplay........	-	-	-	-	-	-	-	-	.25
Prickly Pear....	-	-	-	-	.15	.15	-	-	14/.30

1/ Includes direct, general, and depreciation; labor $0.05, power $0.02, other costs, $0.03; excludes royalties.
2/ Cost for 1936 includes depreciation but does not include owner's time as superintendent or royalties.
3/ Includes depreciation over a 4-year period but not owner's wages as superintendent or interest on the investment.
4/ Excludes wages of owner and two sons who constructed the plant.
5/ Excludes wages of owner and two sons.
6/ Does not include depreciation of equipment.
7/ Includes $5,500 for a bulldozer and two light dragline shovels that would not dig the gravel.
8/ Does not include depreciation; costs cover a period from April 5, 1935, to Jan. 1, 1936.
9/ Excludes royalty and depreciation; includes clearing.
10/ Includes depreciation but not royalties.
11/ Based on handling 4,000 cubic yards per day and including depreciation.
12/ Owner's wages not included.
13/ Estimate for first 6 weeks' operation and includes preliminary non-recurring expenses.
14/ Includes 5 to 7 cents depreciation.

The crew consisted of three men. The man in charge panned while the machine was being moved up and the next pipe driven. All three men pulled the casings. A total of 140 holes was put down in 2-1/2 months' time at a cost of $2,200, excluding traveling expenses. The cost per foot was $1.12. From 4 to 7 holes were driven daily when full time was spent in sampling. Four holes were lost because the pipe hit boulders. In these cases new holes were driven alongside.

After the sampling was completed, the area was plotted and the grade and amount of gravel were calculated. This was followed by sinking 46 shafts at average drill-holes throughout the tract. These shafts were 4 by 6 feet and were sunk without timbering. The gravel from the shafts was washed in sluice boxes. Where the shafts were wet, the water pumped from them while sinking was used in washing. Otherwise, sluicing was delayed until the shaft filled with water. A Larson, 2-inch, high-speed, centrifugal pump powered by a 1-1/2-horsepower gasoline engine was used to handle the water.

Two men sank a shaft each day, while the third washed the gravel. The cost of sinking the shafts and washing the gravel was $1.50 to $4.00 per cubic yard of gravel.

The value of the gravel in the area tested, as calculated from the drill holes, averaged 19 cents per cubic yard (gold at $20.67 per ounce). The results of sluicing the gravel from the shafts indicated a value 15 percent higher (21.8 cents per yard). Actual recovery in washing has been very nearly 25 cents per cubic yard (42 cents at $35 per ounce). The discrepancy may be explained by the fact that in sampling all colors having a value of 1 cent or more were discarded.

The percentage of recovery of gold as reported by the operators at the individual plants discussed in the present circular is shown in tables 4 and 7. Many of these figures, however, are based on insufficient data to be accurate.

COSTS

Cost of Plants

The cost of plants, where data were available, is given in tables 10 and 11. Principal factors governing variations in cost of floating plants have been whether equipment is new or second hand and the daily capacity. The cost of washing plants varies less with increases in capacity than does the cost of excavators.

Bodinson Manufacturing Co., Inc., submits a price of $14,000 at the factory to cover the equipment for a floating boat plant having a capacity of 120 to 125 cubic yards per hour for use with a 1- to 1-1/4-cubic-yard dragline. The washing plant comprises a 10- by 10-foot hopper, 54-inch by 26-foot trommel screen, 700 square feet of riffle table, an 8-inch centrifugal pump, and a 30-inch by 50-foot stacker conveyor. Power is furnished by a 65-horsepower Diesel engine not included in estimate. The equipment is on a sectionalized steel frame mounted on a hull. To the factory price must be added the cost of transportation to the site, engine, hull and housing, and erection; a recent plant of this type was erected in Nevada in 1937, ready to run, at a cost of $20,000.

The following major items are typical of costs for a plant of this kind.

Hopper	$750
Trommel with running gear	2,400
Pump	750
Piping	600
Riffle tables and stream-downs	800
Riffles	750
Stacker	1,800
Transmission (engine to trommel, stacker, and pump)	1,300
Splash housing, Saveall chutes, etc.	425
Winches, rigging, and cable	500
Steel frame	2,500
Miscellaneous items	1,425
Total	14,000

In addition to the above items, an engine, lighting plant, hull, and engine housing will be required.

The cost of power plants is given in the section on Power.

The following table gives sizes and costs for washing plants of larger sizes:

Cost of floating washing plants

Size of dragline bucket, cubic yards	Size of hull, feet	Size of trommel, feet	Rated capacity per day, cubic yards	Approximate cost of washing plant	Cost of hull	
					Wood	Steel
1-1/2 to 1-3/4	34 by 40	4-1/2 by 28	3,000	$15,500	$1,600	$3,200
1-3/4 to 2	36 by 42	4-1/2 or 5 by 31	4,000	19,000	1,800	4,000
2 to 3	36 by 42	5 by 31	5,000	22,500	1,850	4,100

TABLE 11. - Costs of plants and operating costs at placer mines using movable or stationary treatment plants

	Cost of plants				Cost of operation					
	Excavators	Washing and gold saving plant	Miscellaneous	Total	Labor	Supervision	Power	Supplies	General	Total
Movable land plants:										
Skeels	-	-	-	-	$0.047	$0.016	-	-	-	1/$0.16
Pantle	-	$12,000	-	-	-	-	-	-	-	1,2/.08
Pan-Due	-	-	-	-	-	-	-	-	-	1/ .20
Fairplay	-	-	-	-	.20	-	-	$0.16	3/$0.10	.46
Blackhawk	-	-	-	-	-	-	-	-	-	4/ .25
Humphreys, Clear Creek	$66,200	70,000	$11,000	$147,200	-	-	-	-	-	5/ .25
Dixie	-	-	-	-	.028	.0041	.014	.018	.011	6/ .075
Humphreys, Virginia City	67,890	170,000	26,905	264,795	.0442	.0114	$0.0194	.0374	.0059	1/ .1183
Eldorado	-	-	-	-	-	-	-	-	-	.11
Hallett	-	7/15,180	7/9,300	-	-	-	-	-	-	1/ .25
Jett-Ross	14,450	4,500	8,050	27,000	-	-	-	-	-	1/ .085
Fisher	14,000	10,150	3,050	27,200	.036	.009	.018	.027	.029	8/ .119
Stationary plants:										
Ash Canyon	-	-	-	-	-	-	-	-	-	2/.13,9/.70
Chittendon	-	-	-	-	-	-	-	-	-	10/.15
Von der Hellen	-	-	-	-	.13	.02	.07	.11	.02	1,11/.35
Guerin	-	-	-	12/2,500	-	-	-	-	-	1,12/.25
Wallace	-	-	-	-	-	-	-	-	-	13/ .13
La Grange	-	-	-	30,000	.046	.020	.024	.020	.052	8/ .16
Rhyolite	-	-	-	-	.25	-	14/.15	.08	15/.28	16/.76

1/ Exclusive of depreciation and royalties. 2/ Based on total yardage dug. 3/ Repairs. 4/ When running at 40 percent of time. 5/ Before depletion. 6/ Excludes income tax, depreciation, and royalties; based on total yardage dug. 7/ 1932. 8/ After depreciation. 9/ Based on yardage washed. 10/ Exclusive of the two owners' time, major repairs, tire wear, and depreciation. 11/ Estimated. 12/ Exclusive of wages of the two owners. 13/ Includes excavation $0.025, transportation $0.02, washing $0.025, tailing disposal $0.02, general $0.01, and indirect $0.03; exclusive of royalties. 14/ Gasoline. 15/ Rental of plant including royalties $1,000 month. 16/ Includes stripping.

The unit cost of mining, where movable land plants are used, ranges between wide limits. Those at the larger operations compare favorably with costs where floating washers are used. Costs at others are from two to four times greater. High cost at some of the placer mines probably can be attributed to inefficient equipment, which makes it difficult to handle the rated amount of gravel.

The cost of mining and washing gravel in stationary plants cannot be predetermined from present experience with any degree of accuracy.

SUMMARY

Dragline and power-shovel placer mining is becoming increasingly important; a substantial part of the placer gold produced is now being obtained by this type of mining. The technique of mining and the mechanical efficiency of washing plants are being improved steadily. The floating washing plant has reached a state of development where reasonably sustained operation can be expected. Although much remains to be done in the standardization of movable land and stationary plants, marked progress has been made within the past 2 or 3 years.

Experienced operators with the right equipment have successfully worked deposits at which other companies previously failed. The type of washing plant, in particular, must be selected to fit conditions on the ground in order to operate successfully.

Present mining costs at some of the dragline placer mines would not have been thought possible a few years ago.

Costs of stationary and small movable plants are largely lacking. Several of the larger movable plants have been rebuilt several times; new plants of the same design could be built at less cost. The use of salvaged material and equipment moved from other operations and lack of standardization in the present plants do not permit a useful general discussion of the costs of movable and stationary plants.

Gardner and Johnson[16] give costs of shovels and draglines suitable for placer mining.

The following tabulation is a summary of prices furnished by the Bucyrus-Erie Co. in 1932:

Bucket, size cubic yards	Boom, length feet	Possible capacity 8-hour shift, cubic yards	Cost, including bucket, f.o.b. factory
1/2	35	344	$6,200
3/4	35	464	9,300
1	45	556	11,000
1-1/2	30	864	13,700
2	45	1,152	17,250
2-1/2	50	1,280	29,300
3	85	1,440	48,400

The Marion Company quoted the following prices:

Size of dipper, cubic yards	Hourly capacity, cubic yards	Cost, f.o.b. factory
3/4	40 - 120	$10,250
1	45 - 140	12,000
1-1/4	50 - 160	13,500
1-1/2	60 - 175	16,000

Cost of mining

Table 10 gives costs of mining per cubic yard at placer mines where floating washers are used, and table 11 gives those for portable land and stationary plants. The costs are based upon estimated yardages, since actual measurements rarely are made.

The unit cost at placers using floating washers, excluding the Prickly Pear, Fairplay, and Folsom, range from 9 to 15 cents per cubic yard. When all costs except royalties are included, 12 cents probably would be about average. Royalties usually are 10 or 15 percent of the recovered gold.

16/ Work cited, Part 3, pp. 27-28. (See footnote 5.)

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