the sluices. The usual bowlder crew consists of four men working one shift. Three air drills equipped with ⅞-inch hexagon steel are used for drilling. The depth of the holes is 5 to 30 inches, and 40 to 50 steels are used per shift. About 300 shots are averaged per day. In 1923, 1½ tons of 60 per cent dynamite costing $11 per box, 25,000 detonators, and 72,000 feet of fuse were used. The compressed air for the drills is produced by a 12 by 10 single-stage compressor, belt-driven by a 20-inch Pelton water wheel operating under a 150-foot head.

DISPOSAL OF TAILING

Tailing from hydraulic mines in the higher bench deposits can usually be dumped over the bank into the stream below. With grades generally not less than 12 inches in 12 feet, the tail boxes can be extended from time to time and the tailing spread over worked-out or barren ground. The grade of the surface must be much steeper than that of the sluice to provide ample room for the tailing below the end of the lowest box.

Creek deposits and benches only slightly elevated above the stream bed seldom afford these required conditions, and the tailing must be stacked. This stacking is usually done with a giant or, where water is scarce, by scrapers of the Bagley or slip-tooth type or by cableway excavator, operated by steam. It may be practical to use part of the water that would be required by the giant stacker to provide water power for a scraper. Horse-drawn scrapers were at one time used, but they have been replaced by the cheaper mechanical methods.

In stacking tailing with water under pressure the stacker giant is set beside the end of the sluice and the heavier tailing material is piped into a pile, the lighter tailing being carried down the bedrock sluice to the creek. On very low grades another giant is often set farther downstream to boost along this lighter material and keep the channel open (see fig. 51). Where there is much sand or fine material in the tailing to be stacked, the efficiency is lowered, as the fine material tends to run back into the sump. At some properties the stacking may have to be continuous, and at others an hour or two each shift may suffice; therefore the quantity of water required by a stacker giant varies widely and may range from one-fifth to the total amount required by a field giant. Where there is much heavy material or tailing room is limited, the stacker giant may require even more water than a field giant.

On Dan Creek tailing that holds many bowlders, some 15 inches in size, has been stacked to a height of 52 feet by a giant with 4-inch nozzle under 310-foot head.

At one mine on Mastodon Creek in the Circle district (fig. 1, *37*) tailing was stacked to a height of 35 feet without difficulty by a 3-inch nozzle under 100-foot head, the biggest stones being about 12

inches in largest dimension. The tailing was at one time piped up an inclined chute 4 feet wide and 3 feet deep, the bottom of which was fitted with beveled steel-shod riffles set at an angle to keep the sand and fine material from running back into the sump. In general, the tailing can be stacked to a height of one-third the head on the giant in feet and at a distance from the giant of one-half the head. The height and length of the tailing pile are, however, also governed by the character of the material; so for efficient giant stacking under average conditions the face of the pile should be kept as long as practical and at an angle of slope not exceeding 25°.

Former practice in tailing disposal at Crow Creek was to extend the sluices as the tailing accumulated. This required the addition

FIGURE 51.—Stacking tailing with the giant

of one or two boxes a day, so that the sluice eventually contained 60 to 90 boxes. As enough water under pressure is available, 8 to 10 boxes set on 6-inch grade are now used and the tailing is stacked with a giant. This method has been found to be more practicable and cheaper than the old method.

Although there are no débris laws in Alaska, tailing should not be dumped indiscriminately into the stream beds, but preventive measures should be taken to impound it, so it will not be eventually deposited over workable ground, the property of another, or pollute his water supply. Fortunately there are now few instances where this involves a serious problem or expense. Proper stacking partly overcomes this, although in narrow valleys subject to high floods exceptionally strong dams may be required.

to four men are engaged in the elevator pit per shift. Usually enough water is available for mining about 50 days of each working season. From 20,000 to 40,000 cubic yards of gravel and bedrock are elevated during a season, and from 75,000 to 100,000 cubic yards of muck are stripped.

DREDGING

HISTORY OF DREDGING IN ALASKA

The first gold dredge in the Yukon was started on the Lewes River in 1899. During that same year a dredge was started on Snake River at Nome, although active dredging really began in 1903 with two small dredges on the Seward Peninsula. Gold dredging started in the Fortymile district (fig. 1, *41*) in 1907 and in the Iditarod, Circle, and Fairbanks districts (fig. 1, *21*, *37*, and *33*) in 1912. The number of dredges increased rapidly, and in 1914, 42 were at work, producing 22 per cent of the Alaska placer-gold output for that year. In 1916 only 34 were active. Although the number of dredges oper- ated since 1914 has decreased, the percentage of the gold output won by dredges has increased. In 1923, 25 dredges produced 51 per cent of the annual placer-gold output. In 1924, 28 dredges operated; 18 of these were on the Seward Peninsula and 10 in the interior dis- tricts, although four of the Seward Peninsula dredges ran for only about one month. Annual statistics on the number of gold dredges operated, the production, and the average quantity of gold recovered are given under " Production."

FUTURE OF DREDGING

Although many dredges have been operated in Alaska and much gold has been won, most of the dredging has been conducted on a com- paratively small scale, due mainly to operating conditions and the character and extent of the deposits. The more favorably situated, richer, shallower deposits were dredged first, and permanently frozen areas avoided as much as possible. Recent advances in cold-water thawing have been of the greatest importance to Alaska gold dredg- ing by making possible the working of large areas of so-called low- grade ground formerly regarded as too lean or too deep to be suc- cessfully thawed. The development of the Diesel engine and other means of reducing power costs and improved transportation facil- ities to the interior districts served by the Alaska Railroad have also favored dredge operation and development. Conditions have be- come more satisfactory for acquiring the different small holdings necessary to make a dredging area. Two fields in Alaska have been made available for large-scale operations. The year 1923 witnessed the beginning of such operations at Nome, and all indications point to an extensive dredging program in the Fairbanks district.

Alaska gold dredging is entering a new era, with prospects for success, particularly in the Nome, Fairbanks, and Kuskokwim districts. Much encouraging prospecting has been done during the past few years, and the results indicate that six or eight new dredges will be started within the next two or three years. Some small dredges that have been idle will resume operations in the near future, although five or six of the present active dredges soon will have exhausted their ground.

FACTORS DETERMINING DREDGING

Dredging possibilities in Alaska lie mainly in deposits formerly mined by other methods, including creek placers, low benches, elevated beach lines, and gravel plains. In these known fields low-grade gravels and wet areas that could not be mined successfully have been left. In former mining gold was lost in the tailings, and much gold may have been left where creviced, slabby bedrock was encountered. In fact, it has become almost axiomatic among dredge operators on the Seward Peninsula that any ground can be dredged profitably which has been worked profitably by hand methods, even when it has been worked over several times. Although the fact that such ground has produced gold is indicative, it is risky to install a dredge without thorough prospecting. Numerous failures have resulted from such procedure; prospecting is especially necessary in ground that has been cut up by former mining. Known placers that have not been mined to some extent, except possibly thawed, water-soaked deposits or properties acquired by dredging interests soon after discovery, seldom contain enough gold for profitable dredging.

Experience and sound judgment are essential in determining the dredging possibilities of a deposit. All the physical and economic features affecting dredging must be determined before a dredge best suited to a particular deposit can be selected. A volume of gravel must be assured which will repay all invested capital and leave a net profit commensurate with the undertaking. The surface conditions, the depth and character of the overburden, the value, character, and distribution of the gold or other valuable content, the depth, character, and extent of the deposit, the presence and extent of frost, the character and contour of bedrock, and the underground water level should all be determined by prospecting. Accessibility, transportation facilities, climate, length of the operating season, water supply, cost of labor, supplies, fuel, or power, and the cost of the property or royalties, taxes, and titles must be investigated, as all of these features affect mining costs. Adverse factors that reduce the digging capacity of a dredge and may prevent profitable dredging include frozen ground and the presence of stiff or sticky clays, bowlders, slabby or hard bedrock, and high bedrock gradients.

DATA ON DREDGES

The following tables on Alaska gold dredges have been compiled from field data and from operators. Each season shows changes in the number of dredges operated, location, management, and mechanical detail. Eight or ten dredges that have been idle for a number of years and show no indication of future activity have been omitted. The tables are as complete as it is practical to make them. The daily yardage dug by the dredges fluctuates, but many of the figures given are averages derived from operating data. The amount of water used for sluicing can be stated only approximately. The table giving the physical condition of the placers dredged by the different dredges explains in a general way the application of the different sizes and types of dredges, daily yardage handled, and some of the difficulties that may be encountered.

TYPES OF DREDGES

The bucket dredge of the single-lift type is now the only kind in use. During the early days of dredging around Nome many so-called land dredges, often of freakish construction, were operated for short periods. Dipper and suction dredges were also tried, but none of these was a success. Moreover, many of the earlier bucket dredges failed.

Selection of the wrong type or size of dredge has often led to failure. Many dredges are too large for shallow deposits, necessitating the digging of much additional bedrock or the construction of dams to float them. In general, large dredges are unsuitable for Alaska, except in the more accessible districts (such as Nome and Fairbanks) where a large volume of gravel 20 or more feet deep is assured. The size is also governed by other operating conditions and the capital available. The most practical sizes for average Alaska conditions are the 2½ to 5 cubic foot bucket dredges.

As a dredge is usually far removed from the source of replacements, it should be strongly constructed to lessen possibility of a serious breakdown. The dredge is put in repair before starting and is expected to operate throughout the season. One serious breakdown may cause the loss of much time and money. A large stock of additional parts should be kept on hand, and in isolated districts a machine shop must be maintained. An oxyacetylene welding outfit is indispensable for repairing broken parts, building up tumbler plates, mending buckets, etc.

Alaska gold dredges in 1924 and physical condition of p…

Dredge No.	Operator	Location	Type	Size of bucket	Type of bucket line	Horsepower	Make of engines	Kind of fuel or power	Fuel con… per operat… ing day…
	Seward Peninsula			Cubic feet					
1	Alaska Dredging Association [b]	Candle Creek	Flume	1¾	Open	1-50	Western	Distillate	90 gal…
2	Alaska Investment & Development Co. [c]	Osborne Creek	Stacker	2¾	do	1-50; 1-30	Standard	do	140 gal…
3	Alaska Kougarok Co. [c]	Taylor Creek	do	2½	do	1-50; 1-20	do	do	120 gal…
4	Alaska Mines Corporation [c]	Snake River	do	3½	Close	1-100; 1-24	Metz & Weiss	Diesel oil	
5	Bangor Dredging Co. [c]	Anvil Creek	do	3½	do	1-80; 1-60	Bolinder semi-Diesel	do	165 gal…
6	Bering Dredging Corporation [c]	Kougarok River	(e)	2½	do	2-50	Western	Distillate	200 gal…
7	Candle Creek Dredging Co. [b]	Candle Creek	Flume	3½	do	2-50	do	do	
8	Casadepaga Mining Syndicate [c]	Canyon Creek	do	2½	Open	1-60	do	do	100 gal…
9	Crooked Creek Dredge [c]	Crooked Creek	do	2½	do	1-40; 1-25	do	do	110 gal…
10	Dexter Creek Dredging Co. [c]	Dexter Creek	Stacker	2¾	do	1-50; 1-35	do	Gasoline	130 gal…
11	Dime Creek Dredging Co. [c]	Dime Creek	Flume	1½	do	1-25	do [f]	Distillate	50 gal…
12	Eskimo Gold Mining Co. [c]	Solomon River	Stacker [g]	5	Close	1-200	Dow Willans Diesel	Diesel electric	230 gal…
13	Hammon Consolidated Goldfields Co. No. 1 [c]	Little Creek	do	9	do	592	Electric [h]	do	
14	Hammon Consolidated Goldfields Co. No. 2 [c]	do	do	9	do	592	do [h]	do	
15	Hammon Consolidated Goldfields Co. No. 3 [c]	do	do	9	do	592	do [h]	do	
16	Iverson & Johnson [c]	Big Hurrah Creek	Flume	1¼	Open	1-35	Western	Distillate	70 gal…
17	Luther Gold Dredging Co. [c]	Budd Creek	Stacker	2¾	do	1-50; 1-40	Standard	do	
18	Northern Light Mining Co. [c]	Ophir Creek	Flume	2½	do	2-35	Western	do	130 gal…
19	Shovel Creek Dredging Co. [c]	Shovel Creek	do	2½	Close	2-35	Scandia semi-Diesel	Diesel oil	110 gal…
20	Swanson Creek Mining Co. [b]	Swanson Creek	do	2	Open			Distillate	
21	Wild Goose Mining & Trading Co. No. 1 [c]	Ophir Creek	Stacker	3½	Close	140	Electric [i]	Hydroelectric	
22	Wild Goose Mining & Trading Co. No. 2 [b]	do	do [f]	3	do	2-50	Atlas semi-Diesel	Diesel oil	180 gal…
	Yentna district								
23	Cache Creek Dredging Co. [c]	Cache Creek	(f)	6½	do	310	Electric	Hydroelectric	
	Circle district								
24	Berry Dredging Co. [c]	Mammoth Creek	(e)	3½	do	2-75	Wolf locomobile	Wood	4 cords…
	Fairbanks district								
25	Fairbanks Gold Dredging Co. No. 1 [c]	Fairbanks Creek	Stacker	4	do	2-110	Scandia semi-Diesel	Diesel oil	250 gal…
26	Fairbanks Gold Dredging Co. No. 2 [c]	do	do	3½	Open	2-75	Werkspoor Diesel	do	150 gal…
27	Chatham Gold Dredging Co. [c]	Cleary Creek	Flume	1½	Close	2-32	Doman tractor	Gasoline	110 gal…
	Iditarod district								
28	Riley Investment Co. [c]	Otter Creek	(e)	3½	do	1-120	Atlas Diesel	Diesel oil	do…
29	Northern Alaska Dredging Co. [c]	do	(e)	3	do	1-110	do	do	do…
	Innoko district								
30	Flume Dredge Co. [c]	Yankee Creek	Flume	2½	Open	1-60	Western [i]	Gasoline [i]	100 gal…
31	do [b]	Little Creek	do	2½	do	1-60	do [i]	(i)	
32	Innoko Dredging Co. [b]	Ganes Creek	(e)	3½	Close	2-75	Morris Condensing	Wood	8 cords…
33	Guinan & Ames Dredging Corporation [c]	do	(e)	2	Open	1-60	Scandia semi-Diesel	Diesel oil	100 gal…
	Mount McKinley district								
34	Kuskokwim Dredging Co. [c]	Candle Creek	Stacker	3½	Close	1-60; 1-80	Bolinder semi-Diesel	do	150 gal…

[a] Relative conditions, regardless of any frost difficulties: A, average; B, many bowlders; F, favorable; D, difficult; S, seasonal frost only; PF, wholly permanently frozen; PPF, partly permanently frozen.
[b] Idle during 1924.
[c] Operated during 1924.
[d] Depth of gravel after stripping of overb…
[e] Combination revolving screen, one flum…
[f] Shore Diesel electric plant.
[g] Shaking screens.
[h] Power from 6-525 horsepower Werkspoo…

Alaska gold dredges in 1924 and physical condition of placers dredged

Dredge No.	Operator	Location	Type	Size of bucket	Type of bucket line	Horsepower	Make of engines	Kind of fuel or power	Fuel consumption per operating day	Digging depth below water	Average dug per day	Manager or superintendent	Physical conditions of placer [a]: Depth of deposit dredged	Physical conditions of placer [a]: Character of gravel	Physical conditions of placer [a]: Frost conditions	General relative conditions: Digging	General relative conditions: Sluicing
	Seward Peninsula			*Cubic feet*						*Feet*	*Cubic yards*		*Feet*				
1	Alaska Dredging Association [b]	Candle Creek	Flume	1⅜	Open	1- 50	Western	Distillate	90 gallons	12	600	E. E. Pierce	5-10	A, light	PPF	A	F
2	Alaska Investment & Development Co. [c]	Osborne Creek	Stacker	2⅝	do	1- 50, 1- 30	Standard	do	140 gallons	15	1,000	D. S. Webb	6-12	A, B	S	A	A
3	Alaska Kougarok Co. [c]	Taylor Creek	do	2½	do	1- 50, 1- 20	do	do	120 gallons	12	500	J. Kelliher	[d] 6- 8	A	PF	F	F
4	Alaska Mines Corporation [c]	Snake River	do	3½	Close	1-100, 1- 24	Metz & Weiss	Diesel oil		30		J. J. Keenan	20-35	A	PF	A	A
5	Bangor Dredging Co. [c]	Anvil Creek	do	3½	do	1- 80, 1- 60	Bolinder semi-Diesel	do	165 gallons	25	2,000	O. Olson	9-15	A	S	A	A
6	Bering Dredging Corporation [c]	Kougarok River	([e])	2½	do	2- 50	Western	Distillate	200 gallons	15	1,500	J. Matthews	3- 8	A	S	A	A
7	Candle Creek Dredging Co. [b]	Candle Creek	Flume	3½	do	2- 50	do	do		15		E. E. Pierce	[d] 8-12	A, light	PF	A	F
8	Casadepaga Mining Syndicate [c]	Canyon Creek	do	2½	Open	1- 60	do	do	100 gallons	12	900	C. L. Peck	4-12	Light	S	A	F
9	Crooked Creek Dredge [c]	Crooked Creek	do	2½	do	1- 40, 1- 25	do	do	110 gallons	12	900	F. Mebes	4-14	A	S	D	A
10	Dexter Creek Dredging Co. [c]	Dexter Creek	Stacker	2⅝	do	1- 50, 1- 35	do	Gasoline	130 gallons	16	900	A. N. Kittleson	9-14	A	S	A	A
11	Dime Creek Dredging Co. [c]	Dime Creek	Flume	1½	do	1- 25	do [f]	Distillate	50 gallons	15	500	A. Garrod	[d] 10-15	Light	PPF	A	A
12	Eskimo Gold Mining Co. [c]	Solomon River	Stacker [g]	5	Close	1-200	Dow Willans Diesel	Diesel electric	220 gallons	20	3,000	R. S. Oglesby	8-14	A	PPF	F	F
13	Hammon Consolidated Goldfields Co. No. 1 [c]	Little Creek	do	9	do	592	Electric [h]	do		60	6,000	H. R. Edwards	55-68	A	PF	A	A
14	Hammon Consolidated Goldfields Co. No. 2 [c]	do	do	9	do	592	do [h]	do		40	6,000	do	33-65	A	PF	A	A
15	Hammon Consolidated Goldfields Co. No. 3 [c]	do	do	9	do	592	do [h]	do		60	6,000	do	53-85	A	PF	A	A
16	Iverson & Johnson [c]	Big Hurrah Creek	Flume	1¼	Open	1- 35	Western	Distillate	70 gallons	10	500	P. Iverson	5-10	Light	S	F	F
17	Luther Gold Dredging Co. [c]	Budd Creek	Stacker	2⅝	do	1- 50, 1- 40	Standard	do		15	1,000	M. Luther	16	Light	S	F	F
18	Northern Light Mining Co. [c]	Ophir Creek	Flume	2½	do	2- 35	Western	do	130 gallons	15	1,000	G. Russell	5-15	A	PPF	A	A
19	Shovel Creek Dredging Co. [c]	Shovel Creek	do	2½	Close	2- 35	Scandia semi-Diesel	Diesel oil	110 gallons	15	1,500	A. Nylan	6-10	Light	S	F	F
20	Swanson Creek Mining Co. [b]	Swanson Creek	do	3	Open			Distillate		12		C. Rice					
21	Wild Goose Mining & Trading Co. No. 1 [c]	Ophir Creek	Stacker	3½	Close	140	Electric [l]	Hydroelectric		21	2,200	F. Ayer	7-24	A	PPF	D	A
22	Wild Goose Mining & Trading Co. No. 2 [b]	do	do [f]	3	do	2- 50	Atlas semi-Diesel	Diesel oil	180 gallons	20	1,800	do	11-20	A	S	A	A
	Yentna district																
23	Cache Creek Dredging Co. [c]	Cache Creek	([j])	6½	do	310	Electric	Hydroelectric		20	3,000	R. Humphries	3-10	A+B	None	A	A
	Circle district																
24	Berry Dredging Co. [c]	Mammoth Creek	([k])	3½	do	2- 75	Wolf locomobile	Wood	4 cords	18	2,200	Wm. Heitman	[d] 5-18	A, B	S	D	F
	Fairbanks district																
25	Fairbanks Gold Dredging Co. No. 1 [c]	Fairbanks Creek	Stacker	4	do	2-110	Scandia semi-Diesel	Diesel oil	250 gallons	25	2,200	G. Aarons	18-22	A	PPF	A	A
26	Fairbanks Gold Dredging Co. No. 2 [c]	do	do	3½	Open	2- 75	Werkspoor Diesel	do	150 gallons	28	600	do	12-20	A	PPF	A	A
27	Chatham Gold Dredging Co. [c]	Cleary Creek	Flume	1½	Close	2- 32	Doman tractor	Gasoline	110 gallons	14	1,000	F. H. Holbrook	12-23	A	S	F	A
	Iditarod district																
28	Riley Investment Co. [c]	Otter Creek	([e])	3½	do	1-120	Atlas Diesel	Diesel oil	do	15	1,800	H. Donnelly	12-15	A	PPF	A	A
29	Northern Alaska Dredging Co. [c]	do	([e])	3	do	1-110	do	do	do	15	1,500	A. Matheson	12-15	A	PPF+S	A	A
	Innoko district																
30	Flume Dredge Co. [c]	Yankee Creek	Flume	2½	Open	1- 60	Western [i]	Gasoline [i]	100 gallons	12	900	J. Saupe	8-10	A	S	F	D
31	do [b]	Little Creek	do	2½	do	1- 60	do [i]	([i])		12		do					
32	Innoko Dredging Co. [b]	Ganes Creek	([k])	3½	Close	2- 75	Morris Condensing	Wood	8 cords	15	1,500		8-15	A, light	S	F	A
33	Guinan & Ames Dredging Corporation [c]	do	([e])	3	Open	1- 60	Scandia semi-Diesel	Diesel oil	100 gallons	18	900	J. Guinan		A	S	A	A
	Mount McKinley district																
34	Kuskokwim Dredging Co. [c]	Candle Creek	Stacker	3½	Close	1- 60, 1- 80	Bolinder semi-Diesel	do	150 gallons	35	1,200	T. Aitken	[d] 15-20	A	PPF	D	D

[a] Relative conditions, regardless of any frost difficulties: A, average; B, many bowlders; F, favorable; D, difficult; S, seasonal frost only; PF, wholly permanently frozen; PPF, partly permanently frozen.
[b] Idle during 1924.
[d] Depth of gravel after stripping of overburden.
[e] Combination revolving screen, one flume, and conveyer.
[f] Shore Diesel electric plant.
[g] Shaking screen.
[h] Power from 6-525 horsepower Werkspoor Diesel unit plant.
[i] Auxiliary 160-horsepower Washburn distillate engine.
[j] Revolving screen, one flume.
[k] Revolving screen, two flumes, and conveyer.
[l] Installing hydroelectric plant.

FLUME OR SINGLE-SLUICE DREDGE

The flume or single-sluice type of dredge has been developed for dredging relatively narrow, shallow, rich creek placers with coarse gold in easily washed material. Flume dredges are of light draft

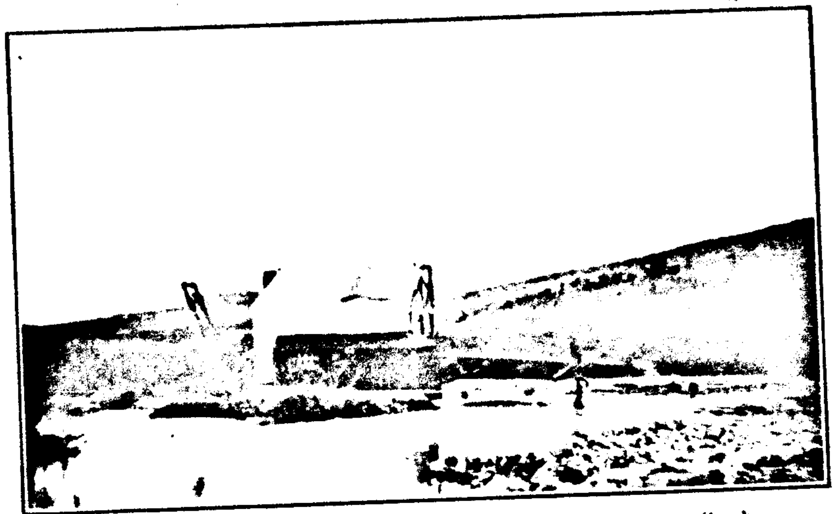


FIGURE 56.—A 1¼-cubic foot flume dredge, formerly on Warm Creek

and construction and are usually operated by distillate engines. The buckets discharge directly into the head of the flume, and the tailing is dumped astern. The depth of ground that can be dredged ranges

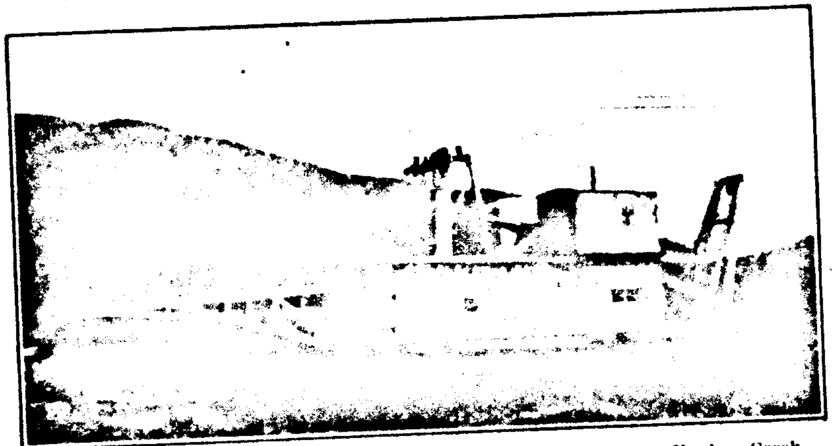


FIGURE 57.—The 2½ cubic foot distillate-driven flume dredge on Yankee Creek

up to 12 and 15 feet and is limited by the disposal of tailing. For satisfactory operation the gravel and bedrock must permit easy digging and free sluicing (see figs. 56, 57, and 58).

Operator	Number	[Pump]ing per minute	Anchorage	Dimensions, feet	inches	charge, inches	water per minute	
ssociation	31	18	Lines	None		10	3,000	No
& Development Co	32	14	Spuds	4 by 21	⅜, ½, ⅝	6	1,750	
'o.	31	15	Lines	4 by 24	⅝, 1	10	3,000	
oration	74	27	Spuds	6 by 20	¼, ⅝	12	4,500	
'o.	86	22	do	5 by 23	⅜, ⅝, 1¼	10	3,000	
orporation	54	24	Lines	4 by 21	2½	7 and 10	3,600	
lging Co	52	27	Spuds	None		14	4,000	No
g Syndicate	30		do	None		12	4,500	No
edge	29	16	Spud	None		10	3,000	No
lging Co	34	12	Spuds	4 by 24	⅜, 1	10	3,000	
ging Co	29	19	do	None; shaking		6	900	No
ing Co	64	21	do	1, 7 by 12; 1, 7½ by 12.	⅜, 1½	5 and 10		
lated Goldfields Co. No. 1	108	22	do	7 by 40	⅜, ½, 1¼	2, 12; 2, 6; 1, 4	12,000	
lated Goldfields Co. No. 2	82	22	do	7 by 40	⅜, ½, 1½	2, 12; 2, 6; 1, 4	12,000	
lated Goldfields Co. No. 3	103		do	7 by 40	⅜, ½, 1½	2, 12; 2, 6; 1, 4	12,000	
n	27	18	Lines	None		8	1,600	No
ging Co.		16	Spuds	4 by 21		12	3,600	
lining Co	30	16	do	None		5 and 10	3,600	No
lging Co	52	21	do	None		8		No
lining Co				None				
ng Trading Co. No. 1	63	22	Spuds	4½ by 22	¼, ⅜ to 1¼	10	3,000	
ng Trading Co. No. 2	55	21	Spud	Shaking	⅜, ½	• 5 and 10	3,600	
lging Co	66	18	do	6 by 12	8	5 and 15	6,000	No
'o	57	25	Spuds	4 by 15	2	8 and 12	4,200	
Dredging Co. No. 1	79	24	do	5 by 24	½, ¾, 1	6 and 10	4,000	
Dredging Co. No. 2 b	38	13	Lines	3 by 22	½, ⅜, 1	12	3,600	
redging Co	60	33	do	None		8	1,500	No
Co.	54	22	Spuds	4 by 14	2½	8 and 12	4,500	
Dredging Co.	54	24	Spud-lines	4 by 14	2½	8 and 10		
o.	29	12	Spuds	None		12	4,000	No
			do	None		12	4,000	No
Co.	59	28	do	4½ by 19	1, 2½	8 and 12	5,000	
Dredging Corporation	31	15	Spud	4 by 16	1, ¼	8	1,800	
lging Co. b	73	17	do	6 by 20	⅛, ⅜	3 and 10	3,600	

Operator	Table and sluice data: Flume dimensions, feet	Table and sluice data: Gold-saving area, square feet •	Table and sluice data: Grade of flume or main tables	Riffles d	Save-all area, square feet	Approximate total weight of dredge, tons	Size of hull, feet	Orig[in]
g Association	3 by 70	210	10 inches to 12 feet	Rail		68	24 by 44 by 4½	Union (
ent & Development Co.		525	1¼ inches to 1 foot	Rail and SH	17	145	30 by 60 by 5½	Do.
ok Co.							34 by 60 by 5½	Risdon
Corporation		580	1¼ inches to 1 foot	AI	20		38 by 74 by 5½	(•).
ng Co.		500	1½ inches to 1 foot	do	36	325	36 by 92 by 6¼	Union (
g Corporation	3 by 80		¾ inch to 1 foot	Rail		135	30 by 60 by 5½	Do.
Dredging Co.	3½ by 72	248	10 inches to 12 feet	do			30 by 62 by 5	Do.
ning Syndicate	3 by 70	210 UC		do		125	28 by 60 by 5	Kimbal
Dredge	2½ by 60		10 inches to 12 feet	do	20		28 by 50 by 3½	(•).
Dredging Co.		200	1¼ inches to 1 foot	SH	32		30 by 60	Union
redging Co.	1½ by 54	81	9 inches to 12 feet	Rail		55	18 by 37 by 3	(•).
Mining Co.		755	1¾ inches to 1 foot	SH	40		44½ by 86 by 7	Wester
olidated Goldfields Co. No. 1		4,000	1¼ inches to 1 foot	do		1,750	56 by 140 by 11½	Yuba
olidated Goldfields Co. No. 2		4,000	1¼ inches to 1 foot	do		1,500	56 by 115 by 11½	Do
olidated Goldfields Co. No. 3		4,000	1¼ inches to 1 foot	do		1,750		Do
son	2 by 60	UC	12 inches to 12 feet	Rail		55	25 by 50 by 3	(•).
redging Co.		UC					30 by 60 by 5½	Union
Mining Co.	3 by 80	240	12 inches to 12 feet	Rail		160	28 by 60 by 5½	Union
Dredging Co.	2⅔ by 78	208	12 inches to 12 feet	do			30 by 60 by 5	Yuba Co.•
Mining Co.							30 by 60	B. Ber
ining & Trading Co. No. 1		612	1 inch to 1 foot	SH	36	360	36 by 75 by 6½	Yuba
ining & Trading Co. No. 2	4 by 20	492	1 inch to 1 foot	SH and AI			32 by 96	I. B. I
Dredging Co.	4 by 108	432	10 inches to [illegible] feet	Rail and MnL	90		55 by 87 by 7⅔	Bucyru
g Co.	2, 2½ by 66	340	10 inches to 12 feet	AI and MnG	28	250	40 by 66 by 5½	Union
l Dredging Co. No. 1		730	1¼ inches to 1 foot	AI	21	350	40 by 90 by 6	Do
l Dredging Co. No. 2 b		298	1½ inches to 1 foot	AI and SH	26		38 by 90 by 5	Risdon
Dredging Co.	2½ by 60	150 UC	1 inch to 1 foot	Rail		75	22½ by 46 by 4	Holbro
ent Co.	3½ by 75	264	1 inch to 1 foot	MnG, rail, AI	26	140	30 by 62½ by 5½	Union
ka Dredging Co.	3 by 75	225	1 inch to 1 foot	Rail and AI	26		30 by 60 by 5½	Do
Co.	2½ by 74	185 UC	10 inches to 12 feet	Rail		125	28 by 60 by 4	Kimba
	2½ by 74	185 UC	10 inches to 12 feet	do		125	28 by 60 by 4	Do
ing Co.	2, 2½ by 75	465	18 inches to 12 feet	AI and CI	45	260	38 by 73½ by 5	Union
es Dredging Corporation	2½ by 75	187	10 inches to 12 feet	CI	30	115	26 by 50 by 4½	Do
Dredging Co. b	None	560	1 and 1¼ inches to 1 foot.	AI	30	350	36 by 90 by 6½	Do

ump.

clusive of save-all or undercurrent; UC, undercurrent.

on shod Hungarian riffles; AI, angle-iron Hungarian riffles; MnL, manganese-plate shod longitudinal riffles; MnG, manganese grate riffles; C

tructed

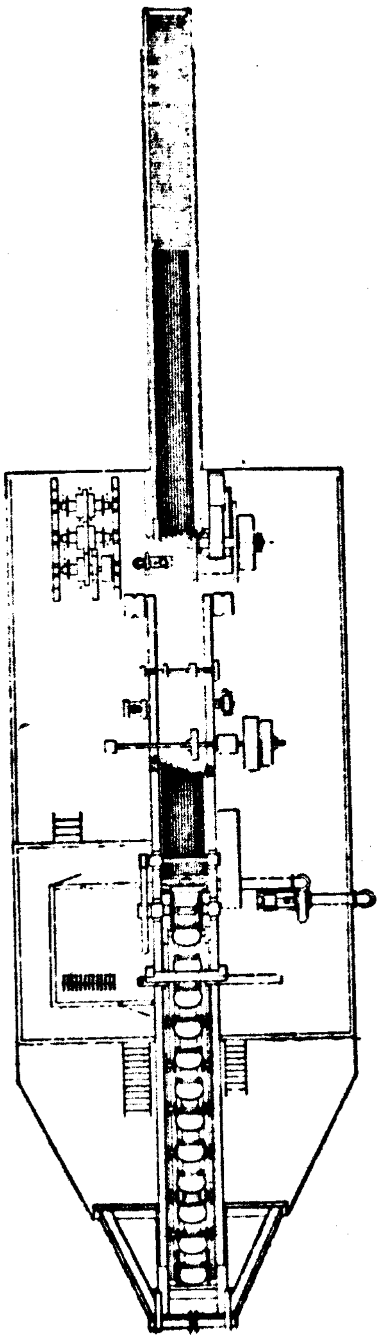


Figure 58.—Plan of 2½-cubic foot distillate-driven flume dredge with undercurrent

FLUME-TYPE DREDGE WITH REVOLVING SCREEN

The flume-type dredge with revolving screen is an improvement over the single-sluice dredge. The dredge at Cache Creek (see No. 23, in table, and fig. 59) is working shallow gravels with many

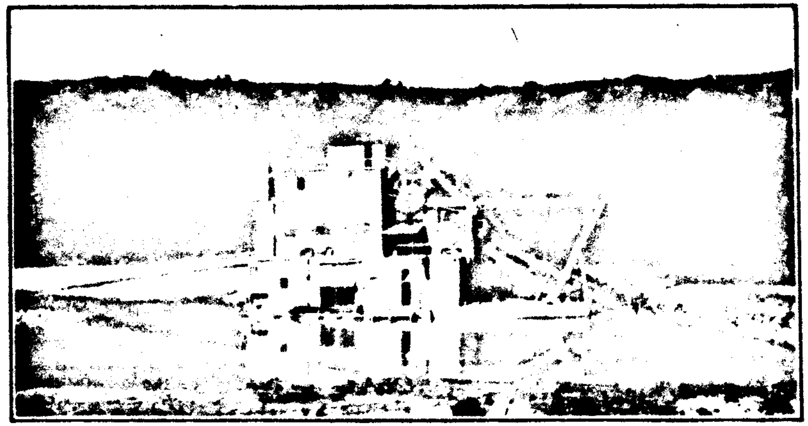


Figure 59.—Electrically driven 6½-cubic foot screen-flume dredge on Cache Creek

large bowlders and some clay. The buckets deliver to the revolving screen. At the lower end of the screen are three high-pressure 1¾-inch nozzles for disintegrating the material. The oversize (over 8

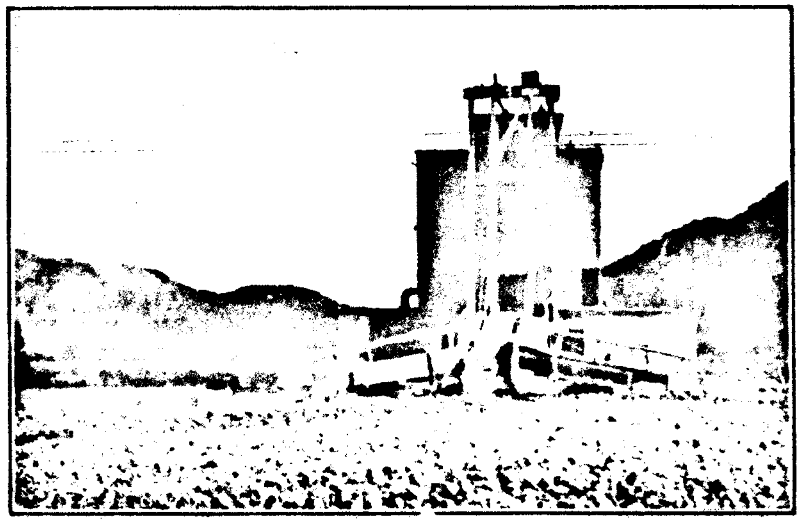


Figure 60.—Flume of the Cache Creek dredge

inches) passes through a chute which has two outlets and is dumped 10 feet astern. The undersize goes to the head of the riffled flume. The lowest 20 feet of this flume is divided into three branches, and by shifting the flow from one to the other the tailing is dumped level across the series of cuts. With these arrangements the gold saving is greatly improved, the sands are prevented from running back under the dredge, and the water level in the pond can be better maintained (fig. 60).

COMBINATION-TYPE DREDGE

For average Alaska dredging conditions, where the gravels are not more than about 20 feet deep or not too shallow for proper flotation, the combination type of dredge with revolving screen, flume, and conveyer is, in general, better adapted than other types. The material is disintegrated on the coarse-mesh screen with water under pressure, the oversize going to a belt conveyer and the undersize to the flume. The conveyer is really a fixed stacker (figs. 61

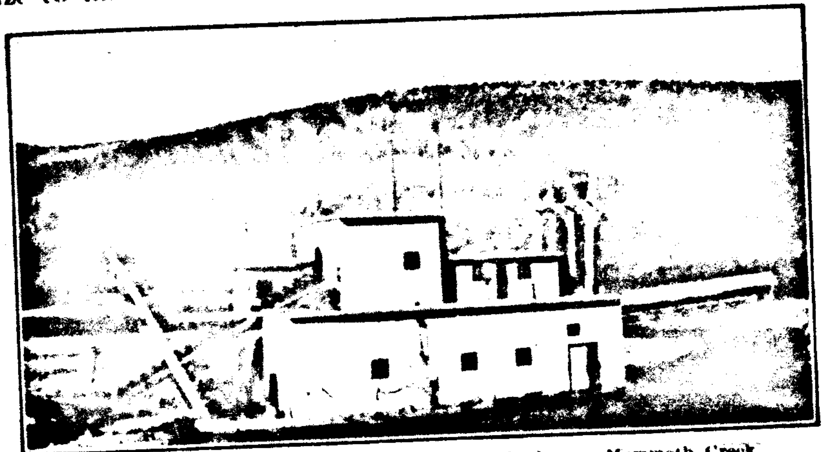


FIGURE 61. Steam-driven combination-type dredge on Mammoth Creek

and 62). Such dredges are lighter and less expensive than table-stacker dredges of similar capacity.

Two dredges of the combination type (Nos. 24 and 32 in table) have two flumes, one at either side of the screen and conveyer (fig. 63). The undersize from the screen drops onto a short, wide, riffled sluice set on a steep angle, then passes onto another sluice set in the reverse direction, and is distributed to the two flumes. These two dredges have more than double the gold-saving area of the dredges with single flumes and in many respects are quite similar to the table-stacker dredge.

The conveyer on the combination dredge stacks the heavy material where it is most needed. Thus, when the deposit contains much fine material, the flume is extended beyond the end of the conveyer. The heavy material from the conveyer then prevents the fine material from the flume from running back under the boat. Should the

dredge have only one flume, the conveyer is installed at one side or over it. To maintain the pond, if the gravel contains little clay or

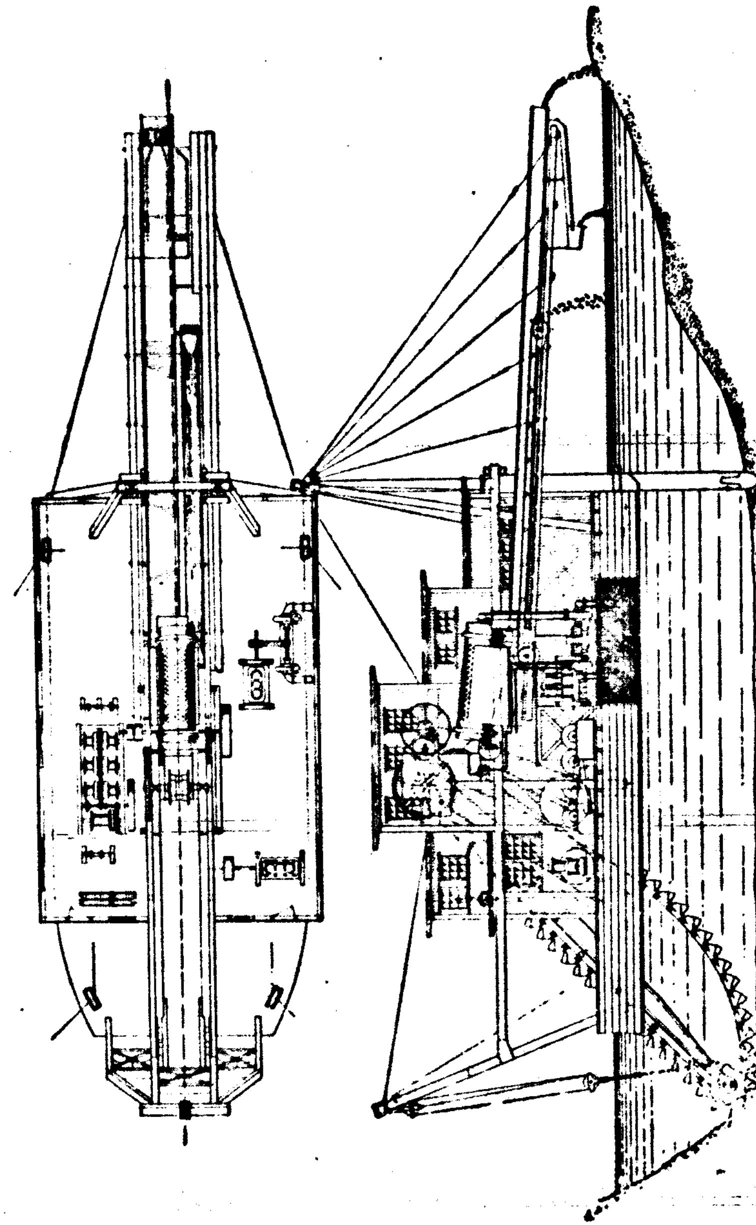


FIGURE 62.—Plan and elevation of 3½-cubic foot combination-type dredge with revolving screen, flume, and conveyer and equipped with undercurrent

fine material, the conveyer is extended beyond the end of the flume, so that the fine material is backed by the coarse gravel.

STACKER-TYPE DREDGE

The stacker or California type dredge has the widest field of usefulness of any of the dredges. It is the best dredge for gold that is

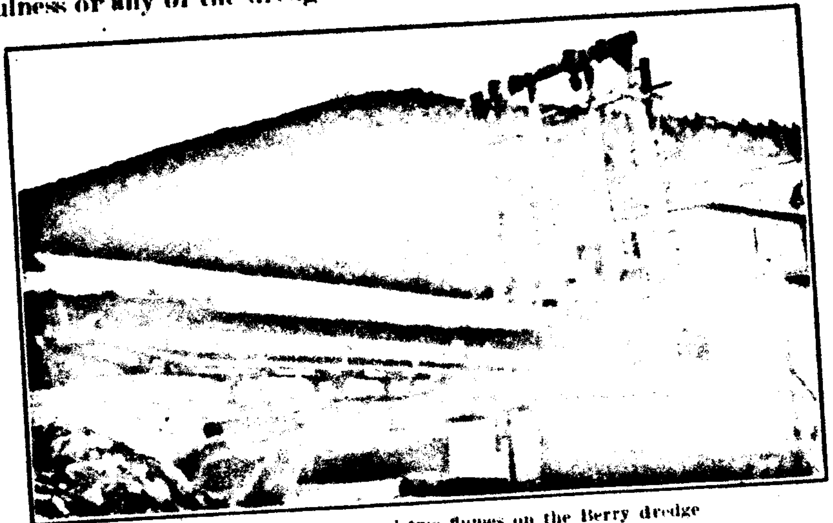


FIGURE 63.—Conveyer and two flumes on the Berry dredge

difficult to save and is the only dredge satisfactory for the more difficult and deep deposits. The buckets deliver to a revolving screen with perforations generally not more than 1 inch in diameter.

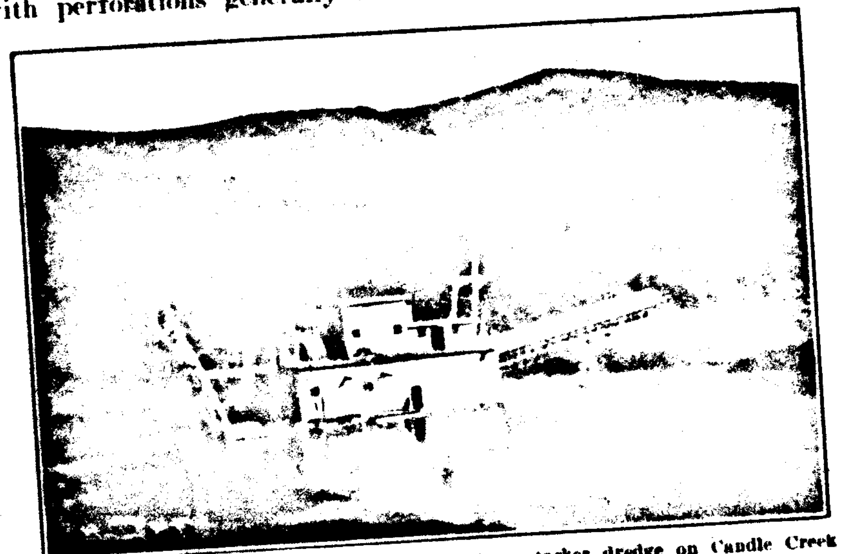


FIGURE 64.—The 8½-cubic foot semi-Diesel-driven stacker dredge on Candle Creek in the Kuskokwim

After disintegration and washing, the oversize is stacked behind the dredge, the undersize is distributed to the gold-saving tables and sluices, and the tailing is discharged astern (figs. 64 and 65).

Two dredges of this type (see Tables 12 and 22) are equipped with shaking screens made in two sections, timed to work in opposite directions. The motion is imparted by eccentrics, and on the No. 12 dredge was 124 three-inch strokes per minute. The screens are equipped with bars, and cast-iron "fingers" suspended over them retard and help disintegrate the material, which is washed by jets of water under high pressure. The oversize, which may still include some unwashed clayey material, goes to the stacker, the undersize falls on riffled chutes and is distributed to the tables, and the tailing is discharged through sluices astern of the dredge. An extra man must be employed as a screen and flume tender.

Dredges 26 and 34 were both digging downstream, and to keep back the sand were equipped with sand elevators. The tailing from the tables is delivered to a sump and thence is elevated by the sand

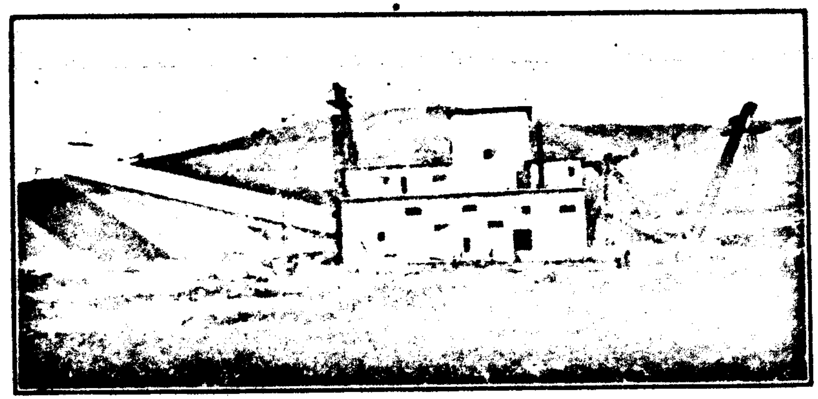


FIGURE 65.—No. 1 dredge of Hammon Consolidated Goldfields Co., at Nome; a 9-cubic foot electrically operated stacker dredge

buckets into a chute, which delivers it to the stacker. No. 26 has one elevator and No. 34 has two, one for each set of tables. Few dredges on the creeks experience difficulty with sand unless they are digging downstream. In fact, several dredges have to deliver tailing to provide anchorage for the spuds.

In addition to the water required for stripping or thawing, plenty must be available for floating and sluicing. For the average Alaska dredge not less than 35 to 50 miner's inches of clear water should flow constantly into the pond, otherwise the pond water will become too thick, causing excessive wear of the pumps and interfering with the gold saving. For some dredges larger quantities may be required. The straight flume type requires more water for sluicing than dredges of similar capacities with screens. Except in dry seasons the local creek supply is generally ample for dredging purposes.

DETAILS OF DREDGE CONSTRUCTION

It is not practicable to discuss the many details of dredge design, construction, and operation; the reader is referred to the various books and articles on this subject. Special reference should be made to "Gold Dredging in the United States," by Charles Janin, published as Bureau of Mines Bulletin 127. Some of the principal features which apply especially to dredging in Alaska are, however, mentioned below.

HULLS

Many of the hulls made for use in Alaska were too small, as shown by the number that have been extended and widened or have pontoons added to increase buoyancy. Smaller dredges have used

FIGURE 66.—A light 2½-cubic foot open-connected bucket line on flume dredge

empty oil drums for this purpose. Wooden hulls are used exclusively; the large dredges recently constructed at Nome have steel frame-work. With reasonable care, a hull should last the life of the property. One hull is still in fair condition after 20 seasons of dredging. Native timber makes very poor hulls.

BUCKET LINES

Most of the smaller dredges have open-connected bucket lines (fig. 66). Their main advantages are lighter weight and lower power requirements, and at one time they were favored for digging difficult bedrock and bowlders. The advantage of the modern close-connected line is so marked that comparison is hardly necessary. The shape and weight of the buckets are determined mainly by the character and depth of the ground and the size of the gravel. For

tight, hard digging ground a smaller, strongly built bucket should be used. Ground with bowlders requires larger buckets (fig. 67). For clayey ground the buckets should be wide, shallow, and free from inside projections so their load can be more easily dumped. With a strong, properly designed manganese-steel bucket line and enough power, practically any unfrozen bedrock in Alaska dredging fields can be satisfactorily dug. Dredge 21 on Ophir Creek has dug 10 feet of slabby limestone bedrock with no great difficulty. Except on some of the smaller flume dredges, most of the ladder trusses are equipped with chutes or pans to catch the spill from the buckets and return it to the digging face. During freezing weather steam or hot water run down this chute helps to keep the material from freezing to the ladder. In discharging into the screen hopper

FIGURE 67.—A 6½-cubic foot close-connected bucket line of special design

or flume the buckets also spill some material, which falls onto a steeply inclined grizzly in the well hole, the undersize going to the save-all sluices.

Upper and lower tumblers of various shapes are used on the older dredges. The newer and the modernized dredges are mostly equipped with a round lower tumbler and a five or six sided upper tumbler. Except on the larger dredges and several other stacker dredges, the main bucket line is driven by a single bull gear. This subjects the shaft to severe strains, and has caused many breaks of the shaft or gear. The double-gear drive equalizes this strain and improves the working of the bucket line.

Lack of enough power for the bucket line is sometimes due to having the engine which drives the bucket line also drive other equipment. One dredge in interior Alaska has recently increased its daily capacity by about 300 cubic yards by changing a pump drive to the other engine. The speed of the bucket line should be readily adjustable to suit different digging conditions. The variable-speed motor on electric dredges answers this requirement most successfully.

The buckets and lips last three to five or more seasons of average digging, for the yardage handled during a season is relatively small. Frozen ground causes the most wear and requires much additional power. At a mine recently worked at Nome all the bucket lips on one of the large dredges had to be replaced after one season's digging in partly thawed ground.

EFFECT OF DIGGING CONDITIONS

High bedrock gradients increase the difficulties of operation and seriously affect the operating cost. Dams must be constructed to raise the level of the water in the pond, and in the shallower ground much additional bedrock must be dug to provide enough draft. A dredge should not dig downstream unless the conditions are not a handicap. It generally means working against the "lay" or gravel flow, especially if the gravel is flat and shingled. Downstream work usually necessitates the building of dams unless the gradient is very low, complicates tailing disposal, and makes digging more difficult.

One dredge in the interior started at the head of the creek, working downstream on a 7½ per cent grade. Digging conditions were generally bad, including numerous bowlders to be disposed of; moreover, dams had to be constructed across the narrow channel about every 40 feet of advance. The cost of the dams alone is stated to have amounted to about 60 cents for every cubic yard of ground dredged. Although the grade has now decreased to about 2 per cent and dams are no longer necessary, digging from that direction is more difficult. The dredge averages only about 60 per cent of the yardage that one of this size will normally handle, partly due to the reasons stated and partly to the fact that much clay is present, which also slows down washing.

LENGTH OF DREDGING SEASON

The dredging season in Alaska normally lasts three to five months. On the Seward Peninsula it averages about 100 days, most of the dredges starting in June and closing in October. A number work 120 to 145 days during a favorable season, others about half this time. One of the large dredges at Nome started July 6, 1923, and operated until December 2, or 149 days; and another started on May 1, 1924, and continued to December 7, or 220 days, which establishes a new record for Alaska. In 1912 and 1915 the Blue Goose, which then had steam power, ran for 162 days on Ophir Creek.

Starting is generally delayed on creeks fed by springs, as the successive overflows build up thick ice known as "glacier" ice, which generally covers the entire valley. In the spring of 1922 the ice on Shovel Creek was over 15 feet thick; it virtually covered the dredge and caused serious damage. On July 13, 5 feet of this ice still remained, and dredging was not possible until August, when further difficulties were encountered because of the seasonal frost. The average season on this creek is about 75 days.

The dredging season in the interior averages 130 to 165 days, from early in May or June to late in October or early in November. The record is 194 days, attained by one of the Otter Creek dredges in 1916. In 1923 the Kuskokwim dredge and the Cache Creek dredge each ran 174 days.

ICE

In the fall the ice as it forms is broken and pushed aside by the dredge, or the cakes are removed. Slush and anchor ice, however, quickly close on the dredge and soon freeze it in tightly. There is no practical way of combating this kind of ice, although heating the hulls or the pond water with steam has been tried. Experienced operators know that when thick ice starts to form the end of the season is at hand, and the dredge should be put into winter quarters. Some dredges continue to dig until frozen in and are left until spring. This practice may leave the dredge unprotected from early spring floods and other dangers. The better procedure is to stop early enough to dig a level bench at some protected place and lower the water, letting the dredge rest on an even bottom. Dredges are only removed from the ponds when repairs of the hull become necessary.

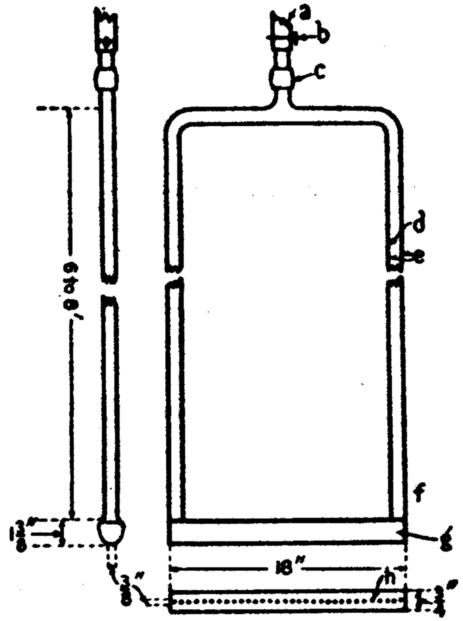


FIGURE 68.—Steam ice cutter, 120 pounds pressure: a, Steam hose; b, hose clamp; c, sleeve; d, ½-inch gas pipe; e, asbestos tape insulation, outer steel casing; f, brazed connection; g, 1-inch outside diameter brass tubing; h, 1/16-inch holes

In the spring the dredge is cut loose from the ice, water run into the pond, and the dredge floated. The ice in the pond is sometimes cut with saws and axes, but more often with steam points or steam ice cutters. Figure 68 shows one of these ice cutters. The pond ice may also be blasted. For an early start the ice cakes are re-moved from the pond, and the ground ahead of the dredge is stripped of snow and ice. Where the seasonal frost is shallow, some good results have been obtained by scattering ashes over the ground. Enough ground is thawed ahead with steam, at some operations with water, to get the dredge under way. Experience has shown that the best practice is to start dredging as early as may be practicable in the spring and stop earlier in the fall rather than fight the freezing weather.

HEAT AND LIGHT

The dredges are heated with steam when necessary, generally with a boiler supplied just for this purpose. During freezing weather the stackers and sometimes the flumes are housed in canvas and steam heated. Hot water or steam is applied to the ladder chute, or the line is relieved of the accumulating frozen material from time to time with a steam jet.

Virtually all dredges are lighted by electricity. Daylight is continuous during several summer months. The lighting generator is generally driven by a small auxiliary internal-combustion engine, except on the electric and the steam driven dredges.

OPERATING DATA

Alaska dredges dig 20 to 60 per cent of their theoretical capacity, this wide range being due mainly to the differing efficiency of the various dredges and conditions of operation. An average derived from the performance of all the dredges would be of no practical value, but most dredges working under average conditions realize 40 to 45 per cent of their theoretical capacity. The short dredging season makes it especially imperative that the greatest possible operating time be realized. Many of the dredges work 22 hours daily, sometimes a little longer, for days at a time. The flume dredges often average a longer operating time than other dredges. Some operators claim an average operating time of 90 per cent, which would be possible only under exceptional conditions, but the running time should average 75 to 85 per cent of the total time available. The principal causes of lost time are engine or power trouble, mechanical accidents, floods, lack of water, frozen ground, stepping ahead or moving in shallow ground, and clean-ups.

The following table shows the causes and the amount of time lost by two dredges operated under widely differing physical conditions; further data are given under "Dredging costs."

Lost time in percentage of total time

Causes of delay	Wild Goose dredge No. 1 [a]		Cache Creek dredge, 1922
	1919	1920 [b]	
	Per cent	*Per cent*	
Step ahead	2.57	2.84	----
Moving to cuts	.91	.96	1.72
Moving lines	1.47	2.12	.56
Rocks	1.52	2.93	.28
Clean-up	.04	.02	1.09
Sluices	.08	.02	.19
Stacker	.52	.21	----
Repairs, machinery	1.47	1.42	----
Engine trouble	.32	.22	----
Bucket line, ladder	2.57	1.53	1.18
Screen	.12	.09	.35
Winches	.25	.23	.26
Pumps	.03	.10	.15
Electric equipment	.35	1.27	.42
Spuds	.06	.11	.05
Frost	----	.48	----
Pond and dam	2.06	1.08	----
Miscellaneous	.65	.36	[c] 18.20
Lower tumbler, oiling	----	----	.07
Upper tumbler, repairs	----	----	.21
Power plant, ditch, etc	----	----	.71
Hopper	----	----	.16
Lost time ... per cent	15.53	15.94	25.60
Do ... hours	335.42	409.25	1,063.08
Running time ... do	1,824.58	2,158.75	3,088.97
Total time ... do	2,160.00	2,568.00	4,152.00

[a] Digging downstream.
[b] Time lost in 1917 was 34.9 per cent.
[c] Time lost on account of floods, pond, and ditch trouble.

Most dredges are operated on 12-hour shifts, the shore men, stripping and thawing crews, and others that may be required working 10 hours. Several companies have adopted the eight-hour shift. On account of the short season and the increased wage, dredge men usually prefer the longer shift. The average shift on the dredges comprises one winch man, one engineer, and an oiler, with one or two shore men or roustabouts on the day shift. Most companies employ a dredge master as superintendent. On distillate-driven flume dredges the engineer spends about half his time with the engines and may also act as oiler and flume tender. In all, five men constitute the entire crew for steady operation on the smallest flume dredges.

WAGES

The wages paid by the dredging companies vary widely, even in the same districts. The following is the average scale; board and lodging is provided in addition. The shore men and other laborers are paid the prevailing wages, as given in the section on "Labor."

Dredge wages

	Winch men	Engineers	Oilers	Dredge master
Seward Peninsula	$7.00-$9.00	$8.00-$9.00	$6.00-$7.50	$10.00-$12.00
Interior:				
Iditarod-Innoko	8.00- 9.00	7.50	7.00- 7.50	12.00- 13.00
Innoko (eight hours)	7.50	7.50	6.50	
Fairbanks	8.00	8.00	7.00	[a] 275.00-300.00
Circle	9.00	9.00	6.50	
Yentna (eight hours)	6.00	[a, b] 225.00	5.00	[a] 225.00

[a] Per month.
[b] Electrician.

Dredge masters, winch men, and engineers living in the United States or elsewhere out of the district are generally given traveling expenses both ways and receive wages only when on the property.

POWER COSTS

The table on Alaska dredges shows the power used and the amount of gasoline, distillate, fuel oil, Diesel oil, or wood fuel consumed by the dredges in an average working-day. The cost of power on distillate-driven dredges and dredges in isolated districts, where cheap fuel or hydroelectric power is not obtainable, is generally the greatest single item of the operating cost. Two companies operate their electric shore plants with Diesel engines; both are located close to tidewater. Two dredges are operated by hydroelectric power, and one of the companies in the Innoko district (fig. 1, *22*) is now installing a hydroelectric plant. In most districts there is little opportunity for developing reliable and economical water power. The Wild Goose Co. had available for power use the ditch and pipe line from former hydraulic operations. This water power is available for about 100 days each season, and an auxiliary distillate engine aboard the dredge is used when the water fails. Although climatic conditions at Cache Creek would permit the use of water for power during the entire season, the head is low, and during an unusually dry season there may be a month or so when lack of water seriously affects the operation of the power plant.

The Diesel engine has greatly reduced power costs and will receive greater attention for dredge power in future.

Steam is the ideal power for the average Alaska dredge but should not be installed unless there is an abundant supply of good wood or coal near by. Early steam dredges had old and inefficient steam equipment, which consumed large amounts of fuel. As the wood supply soon had to be hauled long distances, the power costs became prohibitive, necessitating a change in power generation. Locomobile-type steam equipment is the most practical and economical dredge power in those isolated districts where wood can be obtained at reasonable cost.

The Berry dredge is equipped with two 75-horsepower locomobiles which have given satisfactory service. For power purposes they consumed an average of 4 cords of wood per operating day. An additional half cord of wood is consumed during the spring and fall, when the dredge must be heated. The wood now costs $15 per cord on the dredge. At $60 per day for wood and $23 for the wages and board of two engineers, one on each shift, this daily power cost is $83, or $0.554 per horsepower-day. On a basis of 2,200 cubic yards dredged per day, this amounts to $0.038 per cubic yard.

The following table has been compiled from data on 11 dredges operated on the Seward Peninsula in 1921, and shows that the cost of power is exceptionally high on the distillate and semi-Diesel dredges.

Dredge power cost, Seward Peninsula, 1921

Number of dredges	Kind of power	Cubic yards dredged in season	Total horsepower	Cost of power [a]		
				Per day	Per cubic yard dredged	Percentage of operating cost
5	Distillate	309,700	320	$441.00	$0.142	46.6
4	Semi-Diesel	475,250	342	331.50	.069	33.1
1	Diesel-electric	278,000	200	87.75	.034	20.0
1	Hydroelectric	[b] 2,020	140	50.00	.025	12.9
11			1,002	910.25		
Average		[b] 12,470			.73	33.8

[a] Includes only cost of fuel, lubricating oil, and labor in attendance. At most of the distillate-driven dredges the engineer devotes only part of his time to the engines.
[b] Per day.

The average cost of distillate delivered to the above dredges was 68 cents per gallon. The 24° Diesel oil at the semi-Diesel dredges cost 36 cents per gallon and at the Diesel-electric plant 30 cents. Distillate cost 17 cents and 24° Diesel oil 6⅜ cents per gallon at Seattle. The charge of $50 per day at the hydroelectric plant includes the proportional cost of ditch maintenance and attendance at the plant, the latter being mainly part of the dredge master's wages, all prorated on the basis of 100 days for the season.

CACHE CREEK DREDGE

Until 1921 the Cache Creek dredge was steam operated, and a poor-grade lignite coal mined close by was used for fuel. The coal proved unsatisfactory, the steam power too costly, and with the heavy steam equipment aboard the dredge drew too much water for proper draft. Hydroelectric power was then developed, a 1-mile ditch be... constructed to deliver the water through a double pipe line 1,50... feet long and 34 inches in diameter to a 23-inch double-discharg... turbine water wheel under 85-foot head. The 300 kv. a. belt-driv... generator produces the alternating current, which is trans...tted at 11,000 volts to the transformer near the dredge, where it ... stepped down to 2,300 volts and transformed to 410 volts aboard ... dredge. An average of 3,800 kw. h. is used per operatin... day. In 1922 power, which included ditch and pipe-line mainten... and the cost of labor, supplies, and power-plant repairs, cost $0... per kilowatt-hour, or $0.0283 per cubic yard dredged. The av... cost of this power for three seasons has been $52.43 per day, or $...0258 per cubic yard dredged. The pipe line, turbine, and most of ... electrical equipment was secondhand. The entire power installat... cost $52,634, including $19,473 for the ditch and pipe line and $10,078 for the dredge electrical equipment.

DREDGING AT NOME

The largest power plant for dredge operation in Alaska is at Nome a... has six 525-horsepower Diesel engines. These use 14 to 16° fue... l, delivered to the Nome anchorage in tank steamers. The fuel co...mption under average load is approximately 25 gallons per ho... per engine. The engines are direct connected to 2,300-volt alt...nating-current generators. This current is transformed to 11,000 volts and transmitted 3½ miles to the dredges. Conditions are also ...vorable for developing cheap power from coal or Diesel oil in the Fairbanks district, where the plant can be located close to the Ala... Railroad.

METHODS OF ESTIMATING YARDAGE DREDGED

Metho... of estimating the volume of ground dredged vary. A number ... the smaller operators roughly measure the area dredged at the e... of the season and, knowing the average depth dredged, can app...ximate the yardage. Several operators dredging shallow deposits ... the unit, "square feet of bedrock dredged," but also state the ...verage depth dug during the season. The more systematic operato... make a survey every two weeks, or each month, recording the area ... square feet, the average depth in feet, and the volume in cubic ya... Allowance is made for the slope of the banks and irregula...ties in the slope or depth of the cut, especially in the deeper ground.

A met...od used by a number of the companies is to lay out a base line al... one or both sides of the course to be dredged, setting stakes ... intervals of 100 or more feet. From these points the survey is ma...e, then plotted, and the area obtained with a planimeter, or calculated. From the area and the average depth of ground dug, derived from the daily dredge reports, the yardage is determined. The area ahead of the dredge is often staked out in 100-foot or other size squares. With either method the position and progress of the dredge and the cut measurements can be quickly determined. In ground where the distribution of gold is irregular or prospecting has not been thorough, close drilling may be done ahead of the dredge. The course to be followed by the dredge and the depth of the bedrock to be dug are further ascertained by frequently panning the material dug, and unprofitable areas can thus be avoided.

GOLD CONTENT OF GROUND DREDGED

The average recovery of gold per cubic yard dredged in Alaska each season from 1911 to 1922 was 51 to 77 cents per cubic yard, according to Brooks.[45] In 1923 this average dropped to 40 cents, the lowest in history. Most of the gold gravels now being dredged yield 20 to 50 cents per cubic yard, about one-third averaging around 50 cents. Three dredges report gold recoveries of 60 to 75 cents per cubic yard and one more than $1.25. There appears to be small opportunity of acquiring dredgeable ground which will exceed 40 to 50 cents per cubic yard unless new virgin fields should be discovered.

DREDGE OPERATING COSTS

Alaska dredging costs are usually high and vary widely, as the dredges differ in size and efficiency and work under widely differing conditions. Moreover, the operating cost for the same dredge may vary greatly from season to season. This report gives the operating cost only, and unless otherwise noted does not include depreciation, depletion, royalty, interest, or other charges against capital invested.

The operating cost is 15 to 35 cents per cubic yard. The higher figure has sometimes been exceeded, due to unusually adverse conditions, serious accidents, or inefficient management. Costs of 15 to 18 cents are only realized by a few well-managed properties in the more accessible districts under generally favorable conditions. Some of the low costs claimed are often due to the bookkeeping system employed or to the fact that office expense, management, etc. are not included. From incomplete data supplied by operators of 11 dredges running under widely differing conditions on the Seward Peninsula in 1921, an attempt has been made to estimate the cost of dredging for that year. The data cover operation of

[45] Brooks, A. H., and Capps, S. R., "The Alaskan mining industry in 1922"; Mineral Resources of Alaska, 1922; U. S. Geol. Survey Bull. 755, 1924, p. 15.

four dredges in the Nome districts, three in the Solomon district, and four in the Council district. With the exception of a very small yardage which was artificially thawed at two of the places, the ground dredged was unfrozen, except for some seasonal frost. The 11 dredges dug 1,323,500 cubic yards, but 740,000 cubic yards of this were handled by three dredges.

The operating costs were 15 to 38 cents per cubic yard, the average being 21.6 cents. The total amount of capital invested in dredging equipment was estimated at $590,000. This is low, but a number of these dredges were acquired for nominal sums and could not now be replaced for twice the amount. Although the life of the property usually could not be definitely determined, the depreciation on equipment roughly averaged 4.64 cents and simple interest at 6 per cent averaged 2.67 cents, a total of 7.31 cents per cubic yard; at the various mines it ranged from 2 to 20 cents. In this estimate the cost of land, royalties, etc., are not included. The season of 1921 was longer than the average season and operating conditions were generally more favorable. The number of days worked by the dredges varied from 75 to 129, the average being about 100.

One engineer estimates that the frozen ground on the Nome tundra can be dredged at an operating cost of 9 to 10 cents per cubic yard, exclusive of thawing costs. The total cost, including thawing and all capital charges, is estimated at 23 cents per cubic yard. The estimate is based on the assumption that four dredges are operated for a season of seven months and are capable of digging 800,000 cubic yards per month.

DETAILED DATA FROM INDIVIDUAL OPERATIONS

The following detailed data and costs cover operations conducted by dredges of different sizes and types under differing conditions. Much of the information obtained concerning production and capital charges of mining operations, and in some instances the operating costs, is confidential and must be omitted. It is particularly gratifying to be able to present complete costs for the Wild Goose Mining & Trading Co.'s No. 1 dredge, which were freely given, for these data contain detailed accounts of its very successful operation from 1910, when it started, to the shutdown in 1924. This dredge was formerly driven by distillate engines. In 1915 it was electrically equipped and operated by hydroelectric power, except during the late fall or during short periods of water shortage, when power was supplied by the auxiliary distillate engine.

Operations of Wild Goose dredge No. 1

[Total cubic yards dredged, 1910-1924, inclusive, 3,023,774]

Year	Length of season	Operating time	Dredged— Per season	Dredged— Per day	Average value recovered per cubic yard	Operating cost per cubic yard
	Days	*Per cent*	*Cubic yards*	*Cubic yards*		*Cents*
1910			12,550		$1.7013	ª 53.67
1911	135.6	66.4	223,719	1,640	.8573	ª 28.99
1912	124.5	72.4	224,490	1,917	.2002	ª 21.25
1913	126.5	75.0	197,793	1,563	.6207	ª 31.77
1914	124.5	80.2	272,403	2,189	.7606	ª 15.34
1915	123.2	84.9	265,393	2,154	.7180	ª 15.75
1916			229,876			ª 19.81
1917	143	65.1	215,730	1,589	.5559	24.00
1918			149,508		.7617	ᵇ 29.45
1919	90	84.5	164,224	1,835	.8164	ᵇ 29.91
1920	107	84.1	217,347	2,081	.6038	21.81
1921	129		260,548	2,020	.7146	19.34
1922	111	87.7	229,984	2,072	.9360	17.47
1923	108	84.7	201,455	1,865	.6718	18.48
1924	77	90.1	158,759	2,062	.4701	18.51

ª Exclusive of management, which amounts to from 2.2 to 4 cents per cubic yard.
ᵇ Difficulty with frozen ground conditions. Retarded digging.

NOTE.—Before 1920 some small areas were thawed. Ground usually contained only seasonal frost. Depth dug varied from 7 to 24 feet. Bedrock was schist and thin-bedded limestone. Gravel was medium size with some bowlders. Dredge was digging downstream.

Operating costs of Wild Goose dredge No. 1

	1917	1918	1919	1920
Labor and mess	$13,725.10	$7,660.37	$8,081.50	$10,746.69
Repairs and renewals	12,551.75	14,438.62	11,186.52	9,777.56
Distillate and oil	9,455.47	4,357.32	2,151.20	1,306.96
Supplies	1,925.92	2,349.98	4,009.67	1,645.32
Freight on supplies	1,525.32	1,326.26	1,712.12	1,385.27
General expense	1,914.26	1,802.45	1,915.19	2,104.16
Stable	4,031.92	2,645.53	4,424.82	3,444.91
Ditch	1,402.66	2,087.01	3,052.05	4,288.25
Dams			2,282.30	1,230.80
Camp installation			721.60	1,292.55
Bullion charges	218.68	297.21	346.65	416.28
Insurance		1,750.00	3,361.91	2,466.98
Management, etc	4,654.96	4,900.83	5,037.80	6,196.96
Traveling expense	315.26	408.55	744.40	1,057.01
Total	51,784.28	44,024.14	40,120.82	47,400.46
Per cubic yard	.240	.2045	.2091	.2181

NOTE.—Capital invested in dredge and its equipment, $125,000; in power plant, $15,000. Depreciation and interest, 6 per cent; amounts to $18,576 per season, or $0.07 to $0.126 per cubic yard (estimated).

Operations of Wild Goose dredge No. 2

Year	Length of season, days	Cubic yards dredged— Per season	Cubic yards dredged— Per day	Average value per cubic yard, cents	Operating cost per cubic yard, cents
1921	137	208,267	1,479	26.81	21.06
1922	100	213,797	2,138	24.47	17.79
1923	91	150,368	1,652	53.65	17.74

NOTE.—Cost includes management, etc. Former Blue Goose dredge purchased by Wild Goose Co. for $15,000; operated by them for three years only; shaft broke late in 1923; operation finished; ground condition similar to No. 1 dredge but digging was upstream.

Riley Investment Co., dredging costs and data, Otter Creek

	1921	1923
ts:		
eration, renewals, and repairs	$35,861.79	[a] $40,066.27
hateing, brushing, etc	6,441.40	1,219.90
	768.00	768.00
account, including management	7,827.47	6,636.55
	50,572.10	32,651.98
	110,460.85	----------
rofit from machine shop) [b]	7,542.00	----------
	102,918.85	81,374.04
re foot of bedrock .... cents	33.2	17.4
yard [c] .... do	61.8	22.6
ta		
et of bedrock dug	308,475	465,960
depth dug .... feet	14.5	14.9
rds dug [c]	166,200	241,604
et of bedrock thawed [d]	200,000	265,000
cost -		
square foot .... cents	23.0	12.5
cubic yard .... do	42.6	23.7
square foot dredged .... do	19.2	7.0
cubic yard dredged [c] .... do	35.8	13.5
value of gold recovered per cubic yard [c] .... do	61.4	34.2
of operating days [e]	[f] 161	[g] 162

aising sunken dredge, $7,475, not included. Includes $6,372.84 for new buckets, lips, etc.
ge made against dredge and thawing; credited later
rd value, cost, and other data calculated from square foot data.
d thawed, approximately half was thawed with steam and half with water.
about 20 days lost due to labor strike.
o Oct. 28.
o Nov. 4.

redge was constructed in 1914. In 1923 this dredge operated a season of 162 days, digging 488,675 r 271,486 cubic yards. The average depth dug was 15 feet. About two-thirds of the ground frozen and was thawed with water at natural temperature. The operating cost was 25.1 bic yard.

Beaton & Donnelly dredge data, Otter Creek [a]

	1920	1921	1922
ost:			
preliminary	$6,328.53	$9,645.85	$4,442.71
operation	29,441.44	32,768.74	31,858.96
e account	2,183.55	2,566.29	2,188.41
nary stripping	4,595.60	1,947.15	7,417.60
ccount loss	----------	----------	2,301.93
epair	1,822.20	----------	----------
repairs	----------	----------	1,168.85
nary thawing	644.31	698.40	----------
g operations	32,371.79	6,419.06	390.90
l [b]	76,466.82	54,045.45	49,648.76
er square foot of bedrock .... cents	14.5	11.8	11.3
er cubic yard .... do	29.9	23.7	21.8
data:			
k dug .... square feet	525,000	456,300	439,200
e depth dug .... feet	13.5	13.5	14.0
yards dug	262,500	228,150	227,733
k thawed .... square feet	[c] 235,000	Small area.	Very little.
er of operating days	[d] 187	[e] 112	[f] 161

constructed in 1916. Since 1923 operated by Northern Alaska Dredging Co.
agement charged. Would add 1.5 to 2 cents per cubic yard.

Cache Creek dredge data

	1921	1922	1923	1924
Operating cost:				
Labor, salaries, management, etc	$15,653.08	$49,656.07	$37,530.78	$40,794.37
Dredge and power supplies	7,167.34	12,543.20	8,038.31	23,118.39
Miscellaneous [a]	3,991.34	8,830.19	12,632.13	9,100.62
San Francisco office, etc	908.06	645.00	875.62	([b])
Total	27,722.82	71,674.46	59,085.94	73,013.38
Per cubic yard .... cents	0.1456	0.1709	0.1921	0.3246
Operating data:				
Working days	[c] 94	[d] 173	[e] 174	[f] 181
Digging time .... per cent	73.0	74.4	76.0	83.0
Lost time .... do	27.0	[g] 25.6	[h] 24.0	[i] 17.0
Cubic yards dug	190,155	398,323	307,044	224,897
Average depth dug .... feet	9.0	8.6	9.4	8.7

[a] Includes bullion charges, insurance, traveling expense, sundries, etc.
[b] Office expense, etc., included above.
[c] July 24 to Oct. 25.
[d] May 17 to Nov. 5.
[e] May 13 to Nov. 3.
[f] May 13 to Oct. 11.
[g] Floods caused four shutdowns, with loss of 31½ days.
[h] During August operated only half of time due to water shortage for hydroelectric power; nine days lost through floods.
[i] Broken spud caused loss of 12 days.

NOTE.—Unfrozen shallow creek deposit, gravels medium size with numerous bowlders in certain areas; must dig up to about 6 feet of easy-digging coal formation bedrock to provide dredge flotation; digging upstream over average grade of about 2.5 per cent.

Berry dredge data

	1922	1923	1924
Operating cost:			
Labor and superintendence	[a] $20,903.08	[b] $25,733.42	[c] $25,444.08
Supplies, etc	[a] 15,062.66	[b] 13,709.57	14,632.34
Office expense	562.61	474.44	469.32
General expense	2,138.99	773.94	2,075.78
Traveling expenses	1,324.97	1,153.83	1,581.14
Insurance and taxes	2,652.05	2,541.68	2,956.04
Total	42,644.36	44,386.88	47,158.68
Per cubic yard .... cents	0.2279	0.1764	0.3302
Operating data:			
Days operated	[d] 92	[e] 125	[f] 99
Operating time .... per cent	94.4	80.2	----------
Cubic yards dug	187,132	251,692	142,841

[a] Includes stripping and thawing labor, $3,991.15; supplies, cost not segregated; steam thawed, 40,000 cubic yards.
[b] Includes stripping and thawing labor, $6,750.74; supplies, $571.05; stripped 76,000 cubic yards of overburden for natural thawing.
[c] Includes stripping and thawing labor, $8,716.44; stripped 86,000 cubic yards of overburden.
[d] July 2 to 18, July 30 to Oct. 12. Shut down July 19 to 29 to thaw ahead of dredge.
[e] June 20 to Oct. 23.
[f] July 1 to Oct. 7. Includes about 20 days—July 12 to Aug. 1—when dredge was shut down, lacking water for floating.

NOTE.—Cost of prospecting labor and supplies in 1923, $1,904.76, not included in above cost. Moving and reconstruction of dredge completed June, 1922 (cost $13,267.42) and charged to capital account. Steam-operated dredge; ground partly frozen, mostly seasonal frost; from 5 to 18 feet deep after stripping off 4 feet of overburden; average depth, 10 feet; bedrock, schist, and granite; some high, hard reefs; large granite bowlders now.

Alaska Mines Co., Nome, dredging costs, 1920

	Operating cost	Cost per cubic yard dredged	Per cent of operating cost
		Cents	
Labor, dredge only	$9,525.89		
Material, dredge	383.89		
Repairs, labor and material	1,914.51		
Miscellaneous	1,362.65		
Total	13,186.94	6.73	24.4
Thawing	10,195.00	5.20	19.0
Power	30,598.00	15.61	56.6
Total operating	53,979.94	27.54	100.0
Overhead	11,423.00	5.83	
Total	65,402.94	33.37	

This 8-cubic foot electric-driven dredge was formerly operated at Nome. It dug 196,000 cubic yards in 1920, of which 25,290 cubic yards were old tailing. During the 100 days the dredge operated the actual running time was 79 per cent, the greatest loss of time being due to lack of oil for power. Power was produced by a 650-kilowatt shore plant at a cost of 6.5 cents per kilowatt hour, which was excessive. Of the ground dredged, 88,807 cubic yards were thawed with water at natural temperature at a cost of 11.49 cents per cubic yard.

TYPICAL PLACER IN INTERIOR DISTRICT

The following will illustrate the operation of a 2½-cubic foot, distillate-engine driven, flume dredge in an isolated interior district. In 1922, the second season of its operation, this dredge dug 136,000 cubic yards from June 3 to October 22, or 142 days, averaging about 20 hours of digging time each day. The average depth dug was 11 feet. The ground was unfrozen, but for some seasonal frost, and afforded favorable digging conditions. The operating costs for 1922 were:

Operating costs for distillate-driven flume dredge

	Total	Per cubic yard
Labor	$14,973.54	
Mess	3,807.41	
Mining material	540.40	
Distillate and oil	10,769.65	
Express and postage	800.50	
Traveling expenses and miscellaneous	866.50	
	31,757.91	$0.2335
Management, San Francisco office expense, etc.	6,081.16	.0447
	37,839.07	.2782

The capital invested in the dredge is $42,706; depreciation in eight years plus 6 per cent simple interest amounts to 5.8 cents per cubic yard dredged in 1922. Dredges of this type and size were formerly operated on the Seward Peninsula at an operating cost of about 15 cents per cubic yard.

COST OF GOLD DREDGES

The cost of the gold dredges has increased 50 to 70 per cent since 8 or 10 years ago. As formerly mentioned, some of the earlier Alaska dredges could not be duplicated and placed in operation now for twice the original cost. Although it is difficult to estimate the cost and capacity of a dredge unless all conditions are known, the following table, compiled from data obtained from several dredge builders, gives the weight, approximate average monthly capacity, and other details for dredges of different sizes and types and their approximate cost f. o. b. Pacific coast.

Approximate cost and weight of gold dredges

Type of dredge	Size of bucket	Type of bucket	Average monthly capacity	Kind of power	Approximate horsepower	Digging depth	Lumber in hull	Total weight of dredge	Approximate cost f. o. b. San Francisco
	Cubic feet		*Cubic yards*			*Ft.*	*Board feet*	*Tons*	
Flume	1¼	Open	17,500	Distillate	30	12	17,000	52	[a]$15,000
Combination flume screen and conveyer	2	Close connected.	36,000	Steam locomobile	80	30	75,000	210	48,000
Do	2	Close	36,000	do	75	20			45,000
Flume	2½	Open	30,000	Distillate	60	18	60,000	125	24,500
Screen and stacker	3	Close	45,000	Diesel engine	100	20	80,000		62,000
Do	3½	do	52,000	do	150	35	105,000	325	86,000
Do	3½	do	52,000	do	150	20			75,000
Combination flume screen and conveyer	4	do	60,000	Steam locomobile	150	35	105,000	345	82,000
Screen and stacker	4	do	60,000	Diesel engine	220	35			100,000
Do	5	do	85,000	Steam electric	250	40	200,000	670	200,000
Do	6	do	100,000	do	300	40	220,000	[b]875	215,000
Do	7½	do	120,000	do	400	40	250,000	825	285,000

[a] Cost of machinery only.
[b] Includes steam shore plant.

NOTE.—Full Diesel engine power costs $1,000 to $1,500 more than steam-locomobile power on 3 to 3½ cubic foot dredges.

From a study of the preceding table and the tables on ocean and inland freighting costs an approximate estimate can be made of the cost of a dredge landed at the property. To this must be added the cost of erection. Under average conditions, 2½-cubic foot flume dredges have been erected for $7,000 to $9,000, the combination 3½-cubic foot dredges for $12,000 to $18,000, and the 3½ to 4 cubic foot stacker dredges from $18,000 to $25,000. Dredge 32 (see table on Alaska dredges, p. 178) was recently erected in 43 days at a cost of $15,000.

SPECIMEN COSTS

Dredge 2[45] ready to operate cost $50,000 in 1911. Dredge 5, as originally erected on Bangor Creek in 1914, cost $127,000. It cost $90,000 in Oakland. Dredge 6 cost $85,000 erected in 1915. About 10 years ago a 2½-cubic foot flume dredge similar to dredge 8, cost about $27,500, erected in the Council and Solomon districts. These dredges, erected in districts of average accessibility, would now cost $45,000 to $50,000. Although the cost of the large dredges is not definitely known, dredge 13 cost about $500,000 erected and dredge 14 about $600,000. Their erection was completed during the winter when extremely cold weather added greatly to the cost. Dredge 21, as now constructed, cost about $125,000. Dredge 24 cost $86,000 erected in 1915. Dredge 25 cost $135,000 at Oakland in 1917 and erected at the property $180,000. Dredge 28 cost $80,000 erected. Dredge 30 cost $50,000 in 1921. Dredge 33, as originally erected on Glacier Creek, cost $28,000 in 1915. Dredge 34 cost $112,-000 erected in 1918, but an additional sum has been spent in changes made later. Many dredges on Seward Peninsula have changed ownership at least once or twice and have often been acquired for very nominal costs through direct sale or bankruptcy proceedings. Others have been constructed with parts from older dredges.

MOVEMENT OF DREDGES

Some dredges which have proved unprofitable or which have completed the dredging of their original ground have been moved to new locations. These used dredges have at times been acquired for a small part of their original cost or have been amortized during their earlier period of operation, and thus made it possible afterward to dredge lower-grade gravels or smaller areas which could not otherwise be worked at a profit. This is typical of a number of the dredging operations, particularly on the Seward Peninsula.

Dredges have been moved to new localities on the same creek, to distant creeks, and often to new districts. Some small dredges on Seward Peninsula weighing from 125 to 200 tons have been moved over the snow without dismantling; dredges weighing 250 to 400 tons must be dismantled, and the hull is cut in half, lengthwise. During the winter of 1921 dredge 5 was moved from Bangor Creek to Anvil Creek, a distance of 14 miles. The dredge was dismantled and the hull cut in two lengthwise. The dismantling cost $4,500, the hauling $11,000. The entire job, including the re-erection of the dredge, was contracted for at $28,000. In 1916 dredge 18 was moved from Mystery Creek to Ophir Creek, a distance of 12 miles. The dredge was dismantled and the hull cut in half. The contract cost of dismantling and rebuilding the dredge was

45 Dredge numbers refer to first column of table facing p. 178.

$3,000, and the cost of moving was $3,000. The dredge ready to operate on Ophir Creek cost the company $28,500. Dredge 24 was dismantled and hauled 2½ miles down the creek for $3,500 and reconstructed. This entire cost was about $15,000, which included additional material. Several dredges have dug their way for several miles downstream through old tailing to a new area, the gold recovery by the dredge paying a part of the moving cost.

GOLD SAVING

The high cost of placer mining in Alaska and the lower average gold content of the gravels now being mined necessitate efficient gold-saving equipment. At most mines the gold is chiefly coarse or heavy, and although some fine gold is generally present, practically all can usually be saved with very few refinements in gold-saving practice if the gold-bearing material is thoroughly washed and disintegrated. Quite often the gold is coated with a film of iron oxide or with some compound of sulphur, arsenic, or other impurity. It is difficult to save coated fine gold in the sluices. Light flaky or flour gold is rarely present in appreciable quantity, and only a very small proportion can be saved by usual methods.

The loss of gold in the tailing can not be accurately determined, as there is no practical way of accurately sampling the gold-bearing material or the tailing. The average placer miner does not like to admit that gold is being lost. However, many dumps contain chunks of unwashed material which carry gold and sometimes amalgam. Gold loss in tailing is further evidenced in the number of "snipers" working over old dumps and in the results of drilling or subsequent mining.

Gold losses in the earlier days were probably larger than at present, for the deposits contained a higher gold content, and a loss was not considered so serious. The sluices were often poorly adapted for the work or were overloaded. Purington[46] estimated that in the interior districts where two or five boxes with no drop-offs were used in saving the gold, 10 to 20 per cent of the gold lifted into the boxes was lost. Losses of 50 per cent were not uncommon in those days, and there still are a few mines where only 70 per cent of the gold put into the sluices is recovered.

With free-washing gravel—that is, gravel free of difficult clay—a high percentage of the gold can usually be saved by the customary methods. Most gold losses are accounted for by the presence of stiff sticky clay, which is difficult to disintegrate and tends to rob the riffles of gold or amalgam, and by the lack of suitable sluice

46 Purington, C. W., Methods and Costs of Gravel and Placer Mining in Alaska: U. S. Geol. Survey Bull. 263, 1905, p. 191.

gradients. Some loss may also result from shortage of water for sluicing; or the intermittent use of water in "splashes," which agitate the riffles, carries gold through the boxes. Lack of grade may prevent employment of added refinements in gold saving at most hydraulic and some open-cut mines; however, refinements in gold saving should be practiced at the drift mines where only the richer part of the deposit is mined and at mechanical or other operations where large amounts of barren or low-grade material are first removed at considerable cost to get to the "pay." Conditions are generally favorable for this at such mines, as the gold-bearing material is elevated and grade thus provided.

Although it is unnecessary here to discuss the refinements of gold saving, certain Alaska methods will be briefly mentioned.

GOLD SAVING IN MINING METHODS OTHER THAN DREDGING

SLUICES

Long sluices are seldom used in Alaska on account of lack of grade. Except where special hydraulic mining methods are employed, sluices more than 200 feet long are used only to aid in disposal of tailing. The longer the sluice the more thoroughly can the material be disintegrated. Narrow sluices and a deep flow of the material through them generally cause gold losses, especially if the gold is fine. The flow through the sluices should be deep enough to cover the largest bowlders but under average conditions should not be over 6 or 8 inches. The tendency for the riffles to pack increases with the depth of the flow.

In hydraulic mining, where the material is quite thoroughly disintegrated before it reaches the sluices, short lengths of sluices may prove satisfactory, although if conditions permitted longer sluices and undercurrents would be better practice. In hydraulic mining of creek placers grades of 4 to 6 inches to the 12-foot box are the rule, although higher grades are often created by using special methods of setting the sluice boxes. A grade of 6 inches in 12 feet is generally considered the practicable minimum under average water supply, and higher grades are preferred when available. The sluices should have enough grade to prevent blocking without excessive use of water. At a number of the hydraulic mines a large quantity of ground-sluice water is used because of the low grade available, so the sluices run almost full; yet the gold loss is very slight, for the gold is coarse and heavy, the material is well washed, and the sluices are long.

Fine gold, whether bright or coated, requires special attention. The sluices should be wide, so that the flow may be shallow, and set on steeper grades to keep riffles from packing. The saving of fine

gold is best accomplished by separating the heavier material and passing the undersize over gold tables or undercurrents. When the gold is bright, the use of quicksilver is advisable.

In general, 80 to 90 per cent of the average gold recovered is retained either in the dump box, if one is used, or in the first three or four sluice boxes. The lower end of the sluice usually contains only a very small percentage of the total gold recovered.

SLUICE DROPS

Where practicable, vertical drops in the sluice help in disintegrating the material. Although a fall of a few inches will help, the most efficient drop is 1 to 5 or more feet high and is placed where

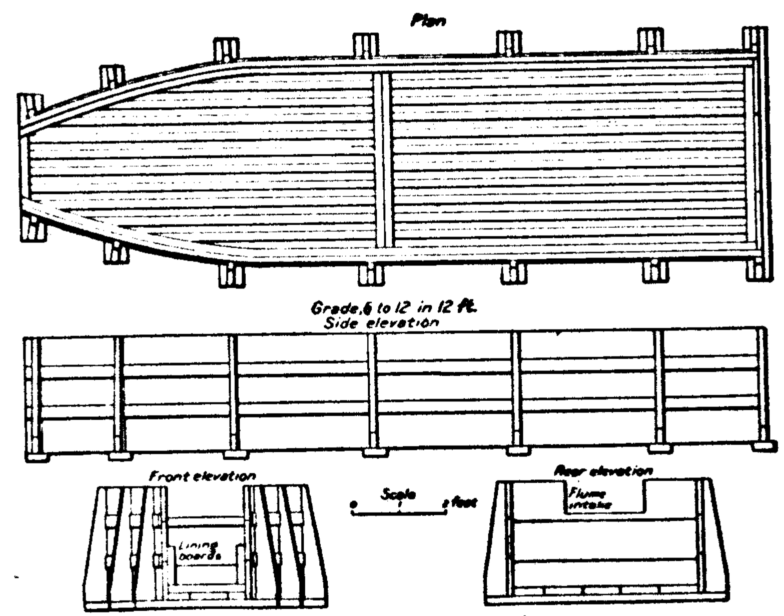


FIGURE 69.—Dump or mud box

the material is first passed over a grizzly or inclined grating. The fine material and water fall into the sluice below, and the washed oversize is dumped outside of the sluice.

MUD OR DUMP BOXES

The use of mud or dump boxes in sluicing is characteristic of drift mining and mechanical mining in Alaska when the material contains clay or mud and is difficult to wash or is delivered intermittently in relatively large loads. Small mud boxes are also used at some placers mined by "shoveling in."

Figure 69 is a sketch of a dump box. The latter is merely a wide sluice box, tapering at the lower end to the width of the regular sluice box and set on a grade of 7 to 14 inches on 12 feet. The box may be paved with pole riffles (usually set lengthwise), with block riffles, or sometimes with steel rails. Where a dump box is used, an extra helper or two may be required to puddle the clayey material, fork out the large rocks, and see that the sluices do not clog. The dump boxes at some mines worked by mechanical methods are 100 feet or more long. Unless the box is of ample size to hold the load properly, it may become clogged and the material on being released booms through the box and sluices, carrying unwashed material to the dump.

RIFFLES

The principal requirements of riffles for Alaska practice are that they be efficient gold savers, cheap but durable, and not too heavy and bulky. However, riffles which are efficient under one set of conditions may not prove suitable under others. The Hungarian or transverse riffle is commonly considered the best, although it retards the flow more than the longitudinal. It is generally good practice to use both, placing the transverse riffles in the upper boxes with the longitudinal below, or alternating with short sets of the transverse. The rolling action of transverse riffles tends to disintegrate the material more readily than the sliding action characteristic of longitudinal ones. The spacing between riffles is regulated by conditions and by the results obtained. At Alaska placers it generally ranges from 1½ to 3 inches; the longitudinal riffles are sometimes given wider spacing.

POLE AND WOODEN-BLOCK RIFFLES

Spruce poles are more generally used in Alaska for making riffles than any other material, especially for the smaller sluices. Pole riffles are cheap and easy to handle but should only be used where the gold is coarse. They are placed longitudinally in the sluices in sets of three to five small green spruce poles 3 to 8 feet long, peeled and held together by nailing them to crosspieces at each end; they are often shod with strips of iron or steel.

Wooden-block riffles are used more at the hydraulic and mechanical operations and are generally made in sets. A number of blocks are set on end with spaces between them and held so by a strip of wood nailed on one or opposite sides. The sets are placed crosswise in the sluice, so that the longitudinal spaces between the blocks are offset or staggered (see fig. 24). The strips should extend beyond the end blocks to allow the liners on the sides of the box to fit over them and hold the riffles in place. Some operators merely "toenail" the blocks to the boxes, but sets properly made are more easily handled and held in place. Spruce and cottonwood blocks are used, but cottonwood makes a poor block.

At one mine the three upper boxes were paved with wooden blocks, with longitudinal rail riffles below. On cleaning up, very little gold was found in the upper boxes, but most of it was found in the rail riffles. The block riffles had been closely spaced and had "broomed" over.

STEEL-RAIL, ANGLE-IRON, AND CAST-IRON RIFFLES

Steel-rail riffles are rapidly replacing wooden blocks, especially where oil rails are obtainable from railroads and other sources at comparatively low cost, but the expense of haulage prevents their use in the more remote localities. Rail riffles answer all requirements for efficient gold savers. The steel rails used weigh 12 to 40 pounds per yard and are placed transversely or longitudinally, usually with the ball side up. When used with the bottom side up, the rails are commonly spaced 1 to 2 inches between edges. It is said that riffles placed bottom side up do not pack, as they cause the proper "boil," and that the gold readily lodges beneath and is protected by the broad flanges. The wide surface of steel exposed when placed longitudinally with the bottom side up lessens the frictional resistance to the flow, which is of advantage where the grade is low. There are numerous kinds of spacers, flanges, and methods of fastening the rails together in sets and for holding them in place in the sluices. Bouery[47] made an extensive study of riffles at the La Grange hydraulic mine in California.

Angle-iron riffles are used mainly on dredges, in some hydraulic elevator sluices, and at a few small open-cut mines. Under favorable conditions they are good savers of fine gold. They should not be used where coarse material is sluiced. The angle irons are set transversely, with the point of the angle usually facing the flow. At several properties in the interior the use of angle irons set at a small inclination improved the "boil" and proved successful. At other mines where angle irons were tried they packed hard and failed, possibly because they were spaced too closely or not set on proper grade.

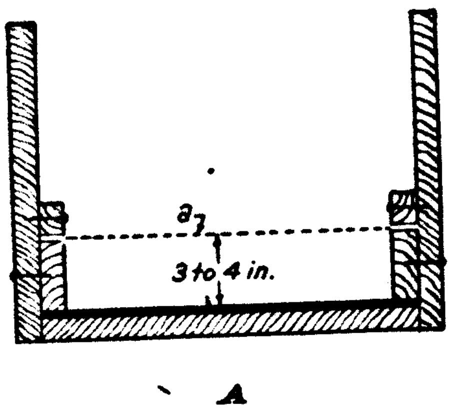
Cast-iron or manganese grate riffles, some of which are patented, are generally constructed so they can be set either transversely or longitudinally. They are easily handled, are excellent gold savers, and are long-lived, but are too expensive for the average operation. Boiler tubes and old plates from dredge screens are used for riffles at several mines.

---

[47] Bouery, P., "A study of riffles for hydraulicking": Eng. and Min. Jour., vol. 95, May 24, 1913, pp. 1055-1060.

STEEL PLATES

Plates of high-carbon steel are sometimes employed. They are elevated above the bottom of the sluice and a transverse space is left between plates, forming a pocket where gold is recovered. This type of riffle is used mainly to save grade and is generally followed by other kinds set at higher grades. The bottoms of the smaller sluices are often lined with boards, so that a space is left between the ends and the sides of the boards where gold can lodge. These are known as "false bottoms," and as they reduce frictional resistance can be set on lower grades, in the same manner as sheet iron or steel is used to line the bottom of unriffled sluices or tail sluices.



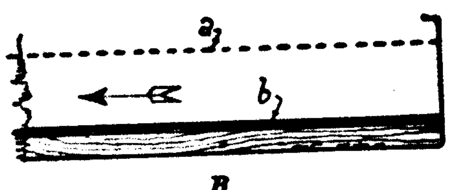


FIGURE 70.—Sluice-box undercurrent. A, Cross section: a, ¼-inch steel plate, ⅝-inch holes. B, Longitudinal section showing riffle and plate: a, Perforated plate; b, expanded metal screen or wooden cleats over matting, burlap, etc.

ROCK OR COBBLE RIFFLES

Rock or cobble riffles are rarely used. They require steeper grades and, being difficult to lay and take up, are more adapted for tail sluices or others which are cleaned up only after long periods of use.

UNDERCURRENTS AND GOLD TABLES

Undercurrents and gold tables are used for saving fine or coated gold. At many mines their use has been discounted, often for the reason that the small amount of gold recovered by them did not justify the additional attention.

The material should be disintegrated as thoroughly as practicable before it reaches the grizzly or screen. Undercurrents are therefore placed near or at the end of the sluice, and all of the water and undersize should pass through the grizzly to the undercurrent, only the clean oversize being retained and dumped to waste.

A sluice-box undercurrent (fig. 70) is used to good advantage at many smaller operations in interior Alaska. An ordinary sluice box is used, but the last box or two is equipped as shown and usually set at a slightly higher grade than the others. The oversize from the grizzly or plate goes to the dump and the undersize passes over gold-saving blankets of burlap, matting, or other material. The material and arrangement of the blankets depend on the character of the fine gold to be saved. Such undercurrents require cleaning every day or two, as the blankets become slimy with mud. They are removed, washed in a tub, and returned. These undercurrents have been credited with 5 to 20 per cent of the total gold recovered; they save much fine rusty gold. Even better results should be obtainable if conditions would permit these undercurrents to be made wider than the regular sluice and placed on higher grades.

On the Upgrade Association property in the Iditarod district the gold is both coarse and fine, sharp and bright, and some of it is attached to quartz. Plenty of grade is available, as the mines are on the side of a mountain. There are no difficulties with clay. The deposit is hydraulicked, usually with a small intermittent water supply. From 8 to 12 boxes 24 inches wide are set on a 17-inch grade and paved with longitudinal riffles made of 2 by 6 inch timbers shod with pieces of manganese steel ⅝ inch thick and 1½ inches wide. These riffles are spaced 1½ inches apart and held together by a crosspiece similarly shod in sets 6 feet long. One or two boxes may be paved with manganese-steel grids set transversely.

At the end of these boxes is a grizzly of manganese-steel bars set transversely with ⅜-inch spacing, the undersize going through a chute to an undercurrent 4 feet wide and 12 feet long, set on a 34-inch grade. The surface of this undercurrent is covered with cocoa matting, in turn covered with wire screen of ¼-inch mesh. Strips of wood 1 inch thick and 1½ inches wide are fastened transversely to this at 30-inch centers. No mercury is used. The material which continues over the grizzly goes to one box equipped with a sluice-box undercurrent similar to the kind described. The undercurrents at this property have recovered from 5 to 20 per cent of the total clean-up.

GOLD SAVING IN DREDGING

The loss of gold in dredge tailing is usually small if the material is thoroughly washed and disintegrated before it flows over the tables or sluices. The same principles for gold saving hold on dredges as for other methods of placer mining but can, in general, be better applied on a dredge. Although numerous factors enter into the saving of gold, much also depends upon the winch man. Bedrock may not be dug clean or the sluices may be overloaded. Unless the gold is coarse or heavy and the gravel is free of sticky clay there may be a large loss of gold on flume dredges. According to the operator, one flume dredge working a deposit containing much sticky clay was losing about 40 per cent of the gold. Another

...to efficient gold saving on flume dr...
...amount of water generally required to car...
through the flume. The resulting high velocity or...
rial does not permit the lighter gold to sink and...
riffles.

RIFFLES

The flumes of these dredges are paved with rail...
lengthwise. It would be better practice if some of...
set transversely, particularly in the upper part o...
cially if clay is present or the gravel is flat. Mat...
transverse riffles and be better disintegrated tha...
over longitudinal riffles, where it tends to slide m...
screen flume dredges this practice is generally fo...
ganese or cast-iron grate riffles may be used alone...
the table-stacker dredges standard steel-shod woode...
iron riffles are mostly used. The grades of the m...
1 to 1½ inches to the foot.

UNDERCURRENTS

Some flume dredges are provided with undercurr...
spaced bar or plate grizzly with small openings...
bottom of the flume near its lower end. The...
through this grizzly is conducted over short table...
with screen, expanded metal, or punched plate lai...
ting or burlap; small special transverse riffles a...
amalgamation plate may be used in conjunction...
of these undercurrents is governed by their constr...
tion, the character of the deposit, and the charact...
gold.

One flume dredge, formerly operated in the...
reported that 20 per cent of the gold was recove...
current. The saving is usually less, and in some c...
currents have been discarded because of the low...
Northern Light flume dredge a test made dur...
showed that 82.54 per cent of the gold recovered...
upper 25 feet of the flume, 10.93 per cent in the...
per cent by the undercurrent, and 2.8 per cent...
beyond the undercurrent grizzly. This tail sluic...
punched screen, ⅝-inch holes, laid over burlap.

SCREENS

Dredges provided with screens not only have...
better washing and disintegration of the materia...
out the heavier stones improve conditions for sa...