BRITISH COLUMBIA DEPARTMENT OF MINES
Hon. HERBERT ANSCOMB, *Minister*   JOHN F. WALKER, *Deputy Minister*

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Dragline Dredging Methods

Compiled by

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HISTORY AND DEVELOPMENT

A dragline dredge is a placer mining machine comprising two separate units (see Plates I and II). The gravel is dug by a standard dragline shovel which travels over the ground under its own power usually by means of caterpillar tracks (some of the large shovels are "walkers"). The bucket, having a capacity of from one to three cubic yards or more, is suspended from a structural steel boom 50 feet or more in length. The gravel is washed in a separate unit whose equipment is on a barge floating in a pond. For washing the gravel and separating the gold from it, the barge has a revolving screen (trommel) and riffle-tables similar to those used on bucket-line dredges. The dragline shovel digs away at the edge of the pond and casts the gravel into the hopper of the washing plant. The pond consequently advances as the digging proceeds and the barge follows by being warped along by winches with cables anchored on shore. The coarse tailings are discharged from a belt-conveyor, and sand-sluices fill the pond behind the dredge.

"In the early days of placer mining, deposits of gold-bearing gravels were found that could not be hydraulicked or worked by hand. The principal result of efforts to work such deposits mechanically has been the development of the gold bucket-line dredge. The first efforts were mainly unsuccessful but the modern gold dredge is an efficient machine.[1]

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

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

The successful development of dragline dredging equipment and methods has largely taken place in California in recent years. The first plant was a home-made boat built at Oroville about 1932 equipped with a perforated trommel 24 inches in diameter and about 12 feet long whose maximum capacity with a 1/2-yard bucket was

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1 The material in quotation is reprinted from United States Bureau of Mines Information Circular 7013.

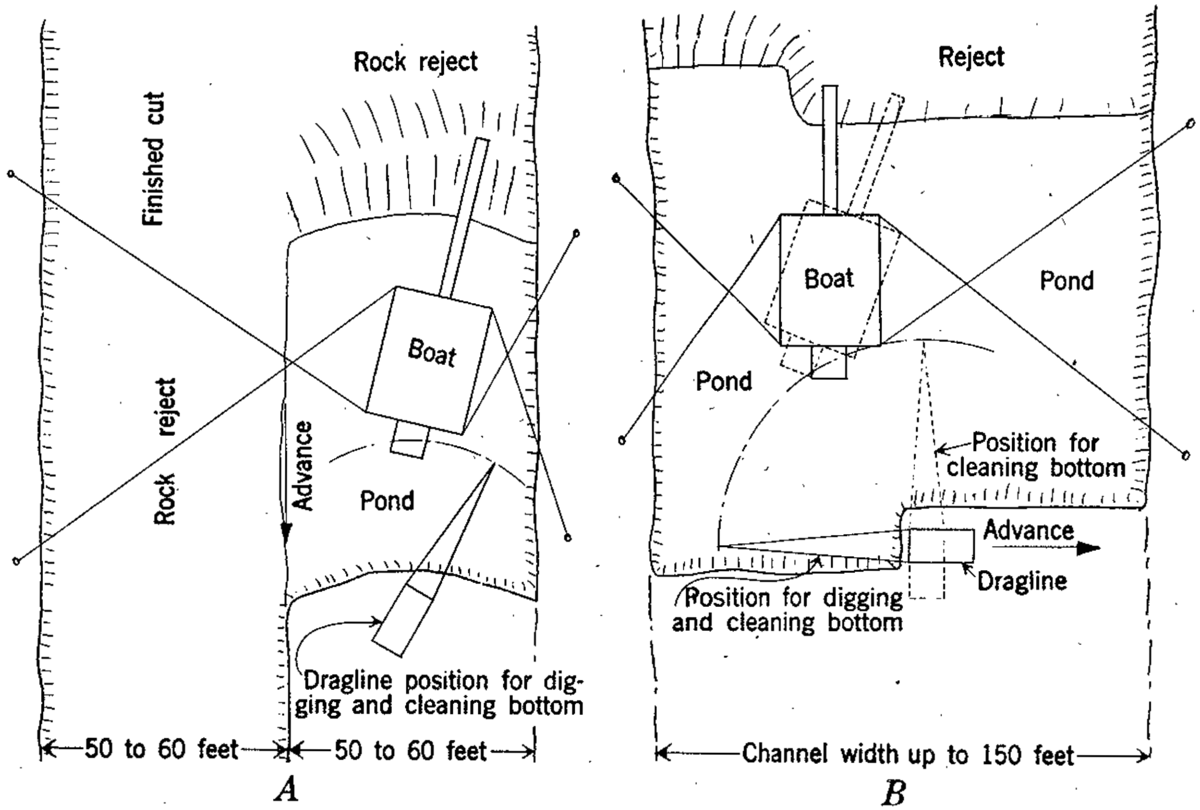

Figure 1.—Typical set-up for floating washer and excavator (not drawn to scale).

Reprinted from U. S. Bureau of Mines Information Circular 7013.

about 200 yards per day. Although the equipment had many mechanical defects, basically it used the principles embodied in the monster dredge installed recently at Dayton, Nevada, which uses a 14-cubic yard dragline and whose washing plant has a capacity of 15,000 cubic yards per day. From modest beginnings dragline dredges have been perfected mechanically and at the same time their limitations discovered so that the proportion of failures has been considerably reduced and their value, in working certain types of placer ground, recognized. There are at the present time more than 200 dragline dredges operating in the Western United States,[1] by far the greatest number being in California. In British Columbia the first dragline dredge began operations in 1941. Credit for being the first to operate in the Province goes to the one which began working on the Similkameen River about 3 miles up-stream from Princeton. A second and somewhat larger dredge operated by North American Goldfields Ltd. is on the Fraser River about 2 miles above Alexandria Ferry and began work about mid-July 1941.

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

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

"The excavating machines are built by established responsible companies; mechanical troubles have been largely eliminated. On the other hand, washing and gold-saving equipment have been standardized only in the floating plants in California.

"The most efficient screening and washing device for placer mining is the trommel of the type used on dredges. As far as is known no installations using flat screens for washing and fine sizing of placer gravels have proved successful. Riffles, as used on dredges, are efficient in recovering gold, except fine or flaky rusty particles. Jigs have been used as an auxiliary

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[1] Mining World, vol. 3, No. 10, 1941, p. 14.

to riffles to increase the over-all extraction in some places. There are numerous other gold-saving devices, but, with the exception of the Ainlay bowl, none of these have proven successful in practice, principally because of their limited capacity."

LIMITATIONS OF METHOD

There are certain definite limitations to the use of dragline dredges that apply both to the character of the deposit and the method of working it. To sustain a successful operation the placer deposit should be favourable as to (1) values, (2) depth of gravel, (3) character of the bottom or bedrock, (4) character of the gravel, (5) surface and (6) quantity (yardage). Unusual conditions and those unfavourable in some degree may be overcome to a certain extent by modification in design or method of operation, or they may not be critical if the gold values are sufficiently high.

"Areas suitable for mining by dragline dredges consist essentially of small shallow deposits too small to amortize the cost of bucket-line dredges, too low-grade to be worked by hand methods, and unsuited for various reasons to hydraulic mining. Each deposit is a problem in itself and the type and size of equipment must be selected and the methods of treatment adapted to fit the particular conditions.

"In some instances a balance must be struck between lower operating costs attainable with bucket-line dredges and the lower first costs of plants using a dragline and a floating washing plant. The operating costs per cubic yard at plants of the latter type usually are double that for dredges. Generally the cost at mines using floating washing plants is less than at those with movable land plants of similar capacities which in turn are less costly to operate than mines with stationary plants."

Operations using movable or stationary land plants will not be considered in this report inasmuch as their operating costs are high and furthermore there is at present practically no standardized plant design. On the other hand the design of floating washing plants has been perfected in recent years and has become more or less uniform.

"The character and depth of the gravel and the character of bedrock are determining factors in the selection of a floating type of washing plant. The gravel must be amenable to digging with draglines as these machines are used for excavating. As the depth of gravel increases, larger equipment is needed on floating plants. Deep ponds must be maintained in working higher banks to keep the boat from grounding on the sand tailings, or this material must be disposed of back of the pond. Moreover, long conveyors are needed for stacking the oversize rock.

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

Values

The lowest limit of profitable average values in a deposit cannot be fixed because every deposit and operation varies. An experienced operator should know approximately what recoveries may be expected after tests have been made.

The higher the values, the greater the difficulties that may be overcome; lower values require more favourable conditions. High values are apt to occur under conditions unfavourable for dragline dredging. Coarse gold is quite likely to be associated with heavy gravel and may be erratic in distribution. If most of the values are on bedrock, the distribution is apt to be within narrow limits laterally and the gold be difficult to recover. Gold that is uniformly distributed areally is more likely to occur from the surface down. This is the most favourable condition for draglining.

Depth

Although the depth to which gravel can be successfully worked may be modified by adapting the equipment to special conditions, nevertheless, it is more definite than any of the other limitations imposed by this method of dredging. The lower limit depends on the depth of water necessary to float the plant on the pond. Four feet is sufficient for the usual size plant.

The higher limit of depth ranges ordinarily from 15 to 25 feet but for exceptionally large shovels with booms up to 200 feet the depth dug may be as much as 100 feet. A dragline with a 1 1/4-yard bucket and a 50-foot boom works efficiently at 15 feet depth; beyond this depth there is a sacrifice of speed. Larger draglines with longer booms and more power dig to 25 feet without apparent loss of efficiency. It is considered good practice for the length of the boom to be three times the depth to be dug. The increased output of the larger dragline requires a larger washing plant. This increases the investment and consequently requires a larger reserve of yardage to justify the increased cost. These initial costs are apt to be more than offset by lower production costs.

Since greater depth of gravel increases the yardage in a given area, the deeper deposits are most likely to provide better reserves.

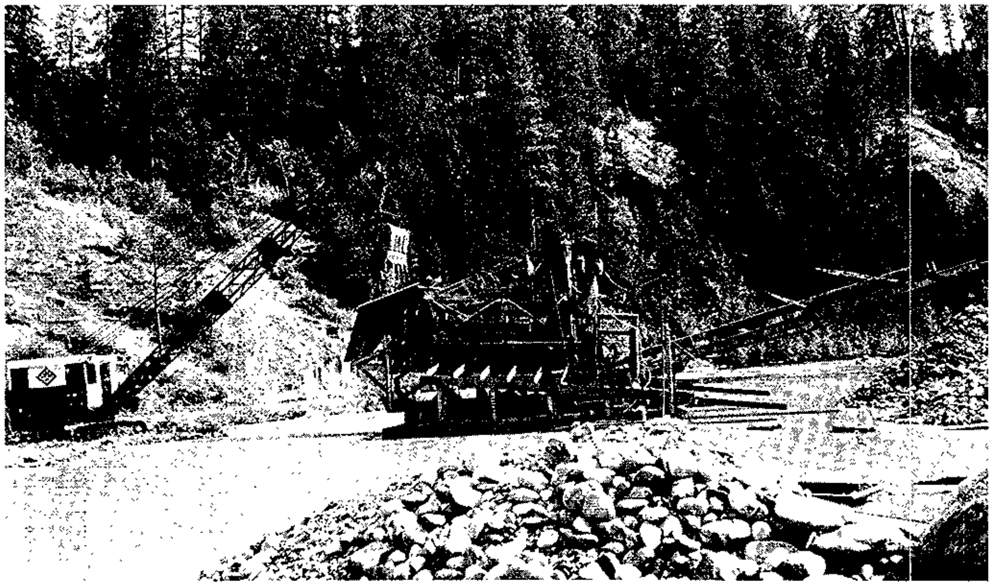

Plate I A. The first dragline dredge to operate in B. C. Operation of A. G. Watkins on Similkameen River about 2 miles up-stream from Princeton.

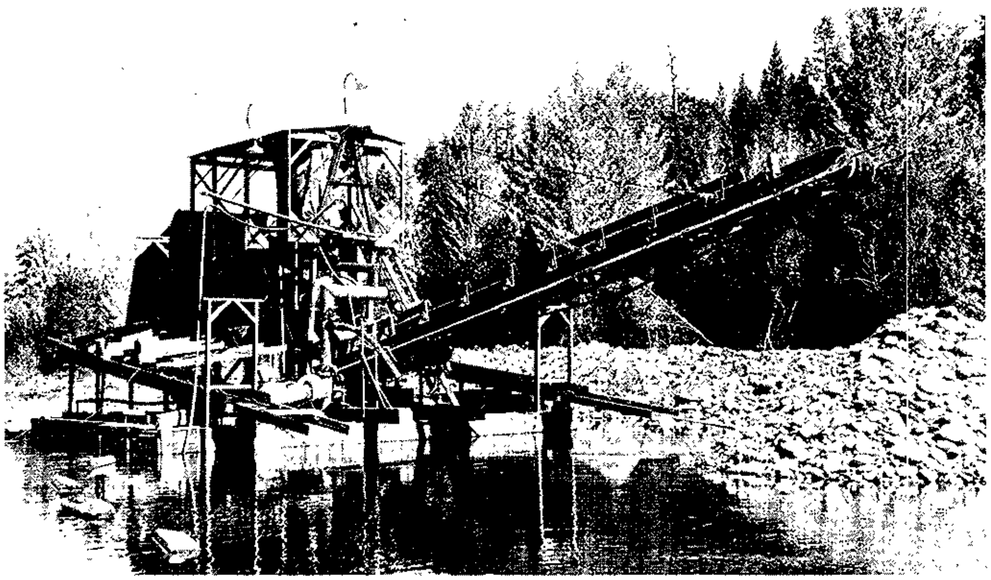

Plate I B. View of washing plant showing the stacker and sluices which discharge at the stern.

Bottom

One of the important points to be considered is the nature of the bottom or bedrock. It is most desirable that it should peel off easily so that from 6 inches to a foot or more may be dug. Thus several passes with the dragline bucket digging a few inches of bottom each time will clean up the higher values usually found near the bottom of the gravel.

On the other hand, in British Columbia, bed-rock is seldom weathered, consequently, depending on the kind of rock, it may be hard, rough, contain deep crevices, and be difficult if not impossible to dig. Under such circumstances the recovery of all the bed-rock gold would be impossible so that the total recoverable gold might not be sufficiently great to justify working the deposit.

However placer deposits in which the gold is more or less uniformly distributed throughout gravel lying above a soft clay or sand bed offer opportunities for easy digging and successful cleaning of the bottom. It is important always to consider that it is not the total gold content of the gravel that counts but the amount of recoverable gold.

Character of the Gravel

There are wide variations in placer gravel. It may be fine or coarse; angular or rounded; sandy or clayey; loose or tight. For dragline digging the most favourable gravel is medium size and sandy rather than clayey; boulders over 18 inches in diameter are troublesome to handle and must be kept out of the washing plant by a grizzly over the hopper. Very coarse gravel is difficult to dig. The handling of boulders represents a loss of digging time and consequently of gold production and must be compensated by higher values. In general, sandy gravel is loose and may not hold up the gold, but such gravel is easy to dig and easy to wash. Clayey gravel is tight and harder to dig and wash. The presence of clay constitutes a special problem as it must be held in the trommel longer by baffles or counter sprays in order that it may be broken up before it gets onto the riffle-tables. Some clay rolls into balls which as they pass over the tables will pick up gold and carry it over the dump. Reasonably clean gravel with about 40 per cent. sand is ideal for dragline dredging.

Surface

The topographical relief of a placer deposit influences the practicability of dredging and the cost of the operation. The surface may be flat and smooth, or rolling, broken or sloping. It may be clear, wooded or bushy. The most desirable surface is flat and smooth without brush or timber. Dredging may be carried on in rolling or broken country if the pond can be carried across the irregularities without too much extra work. A caterpillar tractor with a bulldozer blade and a power take-off is an almost indispensable part of the equipment. With it a road can be levelled for the dragline, barren overburden removed, and dams built across basins or depressions where the ground is too uneven for the dragline conveniently to do the work.

A dredge can ascend a 3 per cent. slope without much difficulty and can descend a slope of 2 degrees with about the same effort. Steeper grades, as much as 5 per cent., can be managed in an emergency but at greater cost and loss of time.

The clearing of wooded land may cost as much as $100 an acre for densely wooded, heavy timber. This is a heavy charge against a shallow placer deposit and for that reason cleared land has a distinct advantage.

Quantity

The deposit must be large enough so that the recoverable gold will yield a profit after paying off the investment. Estimating the size of a deposit is a problem that requires experience and an ample safety factor. The most favourable deposits have a large volume of gravel which necessitates a larger initial investment but which enables lower operating costs to be attained.

The plant of a dragline dredge is built for easy portability and it may be moved at comparatively small cost from one small area to another providing the distances are not too great and the expense of moving reasonable. The cost of moving the plant must be added to the total cost of operating the different small areas.

SAMPLING AND RECOVERY

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

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

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

"The entire amount of gold contained in any placer deposit rarely is recoverable by standard washing plants either on dredges or on the types described in this paper. This is due mainly to the physical condition of the gold and its relation to gangue minerals in the deposit. Often fine and rusty gold and that embedded in gangue material is not caught in riffles or quicksilver and is lost. Therefore, the method of estimating the amount of recoverable gold in a bed of gravel that most nearly approaches the method used to work the deposit is considered the safest method of estimation.

"Gardner and Johnson[1] have discussed sampling and estimation of gold placers. The most common methods of obtaining samples at the placers discussed here are from pits or shafts. These are dug by hand or with a dragline shovel.

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

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1 Gardner, E. D. & Johnson, C. H., "Placer Mining in the Western United States," Part I, Information Circular 6786, 1934, pp. 26-46.

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

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

"Prospecting of a gravel bed by the Wyandotte Gold Dredging Co. has been described by Magee.[1] Shafts 3 by 6 feet in cross-section were sunk by hand to the false bed-rock. A windlass was used in the deeper pits and water was pumped out by a gasoline engine-powered pump when necessary. The distance between rows across the channel was 500 feet and between shafts in the rows about 200 feet; 30 pits were sunk on 75 acres.

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

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

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

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

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

"Sampling, as practiced by E. T. Fisher Co., Atlantic City, Wyo., has been described by Ross and Gardner[1] as follows:

> 'The deposit was sampled by driving pipes through the gravel. A single row of holes 150 to 300 feet apart was put down first along the centre line of the channel. Rows of holes 1/2 mile apart were then drilled across the deposit; holes in the rows were 20 to 60 feet apart. The spacing depended upon surface indications. The holes extended through the decomposed bed-rock to solid rock and averaged 14 feet in depth.
>
> 'The sampling device was a 4-inch casing with a Keystone cutting shoe. The diameter of the shoe was slightly less than that of the pipe; the samples were retained in the pipe when it was withdrawn. The casings were driven down to refusal with a locally made pile driver. This consisted of a 275-pound hammer, a 20-foot, 4-legged, pole derrick, and a Chevrolet automobile engine and transmission shaft. The cable for raising the hammer ran through a sheave at the top of the derrick to a drum on the transmission shaft. The whole assembly was on a pair of skids and was moved forward by its own power; the end of the cable was attached to a deadman. The sampling outfit cost $300 to build.
>
> 'The casings were pulled by means of a set of wire blocks having 4 and 5 sheaves. The cable from the blocks was wound on the drum by the engine. About half the time it was necessary to start the casing with jacks set against a clamp put around the top of the pipe. Three sets of casings were used. A pulled casing was laid on saw horses and the gravel removed in 6-inch sections by means of a special spoon; each section of gravel was panned.
>
> 'The crew consisted of three men. The man in charge panned while the machine was being moved up and the next pipe driven. All three men pulled the casings. A total of 140 holes was put down in 2 1/2 months' time at a cost of $2,200 excluding traveling expenses. The cost per foot was $1.12. From 4 to 7 holes were driven daily when full time was spent in sampling. Four holes were lost because the pipe hit boulders. In these cases new holes were driven alongside.

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

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

'Two men sank a shaft each day, while the third washed the gravel. The cost of sinking the shafts and washing the gravel was $1.50 to $4 per cubic yard of gravel.

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

FLOATING PLANTS

"Gravel is washed in a revolving screen; the undersize is distributed to a bank of cross tables on each side of the trommel, from which it discharges into banks of longitudinal sluices on each side, and finally flows to the pond at the rear of the boat. Gold is collected in Hungarian-type riffles installed in the sluices. The oversize is discharged from the trommel to a stacker belt and piled at the rear. Figure 2 shows (diagrammatically) the essential features of a typical floating plant.

Hulls

"Hulls are constructed of wood or steel; the smallest one visited was 17 by 35 feet and 3 1/2 feet in depth; the largest was 50 by 50 1/2 feet and 2 1/4 feet in depth; the customary size is 30 by 40 by 3 1/2 feet for boats with a capacity of 100 to 130 cubic yards per hour." According to Lord[1] the average boat for a 3-cubic yard shovel is 34 by 48 by 3 1/2 feet made up of 6 pontoons each 34 feet long and 8 feet wide. "The size is very important; in addition to being able to carry the load, the hull should be large enough to give as much stability to the plant as practicable in order to minimize swaying and tipping caused by intermittent dumping of gravel into the hopper. Swaying interferes with the efficiency of the sluices, and sudden tipping causes sand to bank in places and upset the even flow over the riffles. The latest practice is to use steel pontoons about 8 by 30 by 3 feet in size, fastened together by bolting them to steel members laid across the deck. The first cost of the steel pontoon is greater than that of wood; the steel hull, however, has a much longer life. When the plant is dismantled and moved to a new site, the pontoon sections are separated and moved along with it. An ultimate saving of steel over wood hulls is claimed by manufacturers. Hulls made of wood are constructed on the site and abandoned when the operation is finished.

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

Hopper

"A hopper, usually about 15 to 15 1/2 feet above the surface of the pond, is constructed at the front of the boat. This is made of metal supported by steel or wood underpinning; it slopes downward, terminating in a metal chute that conveys the gravel to the feed end of the trommel. Manufacturers recommend that the hopper

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1 Lord, W. S. Mining World Vol. 3 No. 10, 1941, p. 14.

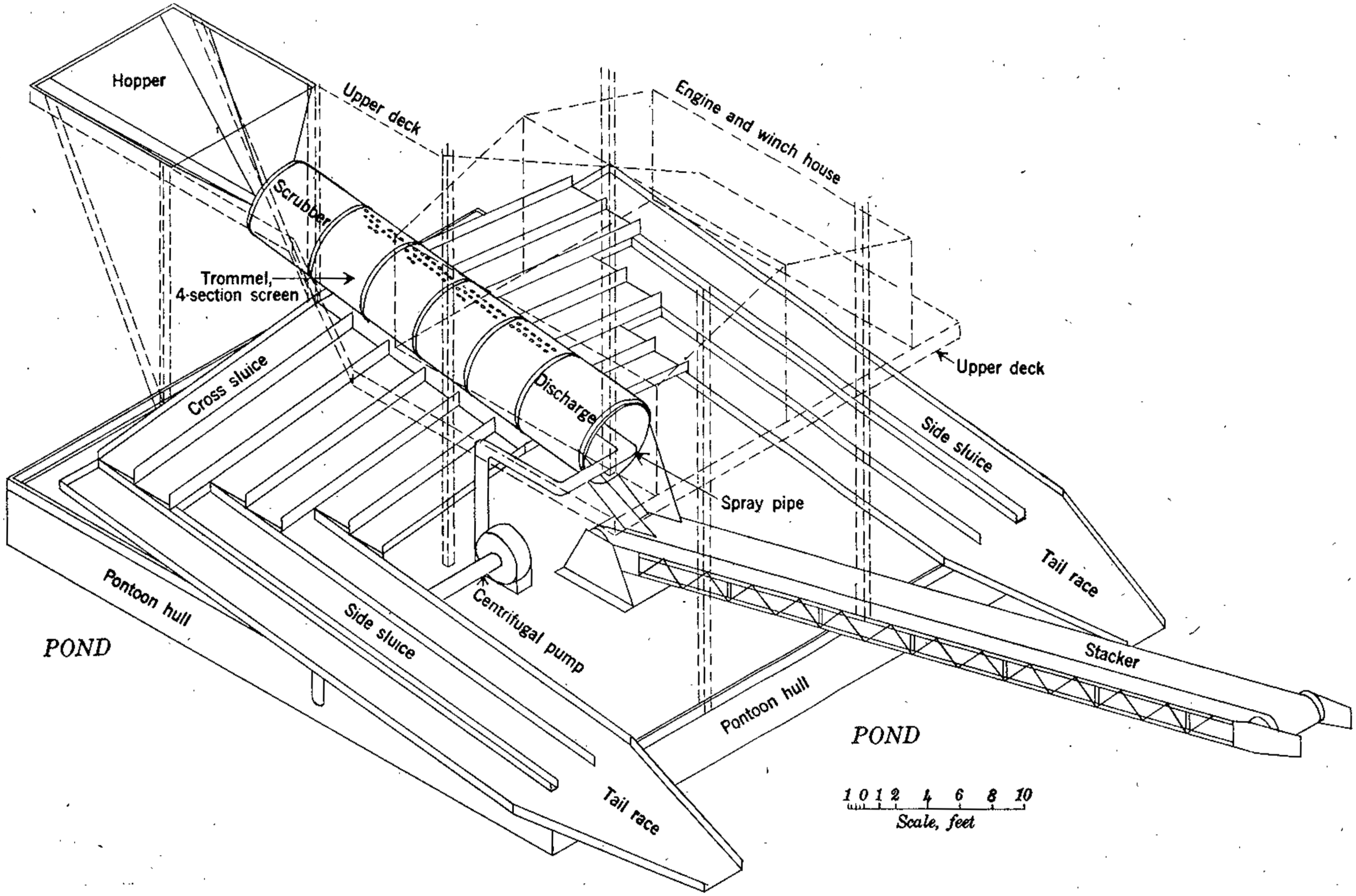


Figure 2.--Essential features of a floating washer and gold-saving plant.

Reprinted from U. S. Bureau of Mines Information Circular 7013.

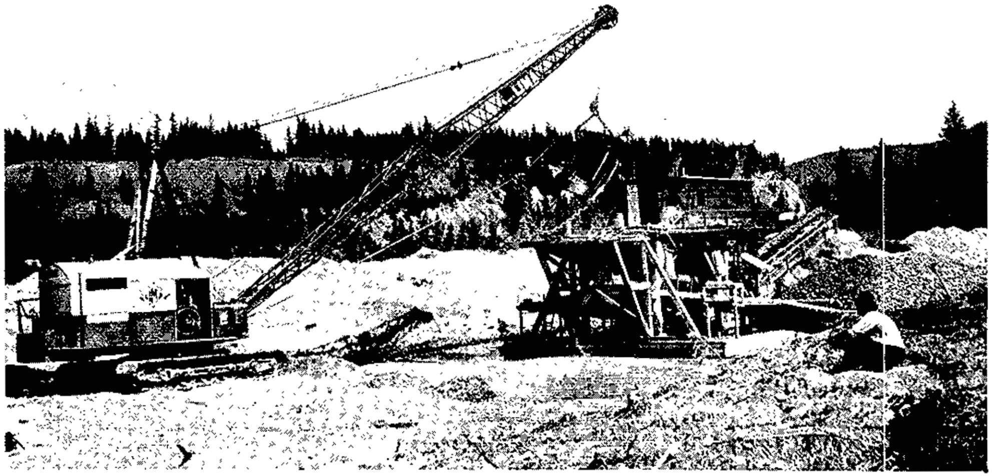


Plate II A. Operation of North American Goldfields Ltd. on low Fraser River bench up-stream from Alexandria Ferry. Tailing piles lie behind the shovel, between it and the Fraser River, and back of the washing plant.

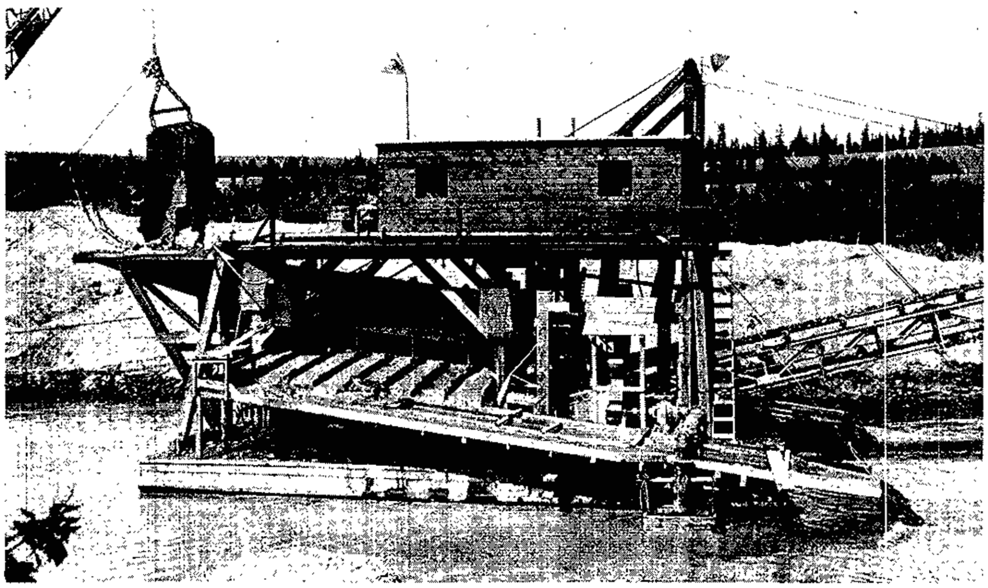


Plate II B. Side view of the washing plant showing bucket dumping into the hopper, riffle tables discharging at the stern, enclosed engine room and control house on upper deck, and stacking belt leading off to the right.

be lined with 2 to 4 inches of wooden plank, over which is laid a wearing sheet of steel plate shaped to the hopper. The wearing sheet may be renewed economically without renewing the entire hopper; the wood serves as a cushion."

Water nozzles are arranged at the discharge end of the hopper and by proper arrangement partly wash the gravel and feed it into the trommel. It is claimed that half the washing should be done in a well designed hopper. The rest of the required water is supplied by a spray pipe in the trommel.

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

Trommel

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

"Most of the screens of the trommels are 16 to 20 feet long, made up of 4- or 5-foot sections. Usually, each section is made up of four rolled-steel plates forming the periphery of the shell. The blank sections are tied together endwise across the screen area with four heavy railroad rails, the base flanges of which act as the longitudinal butt straps and to which the replaceable screen section plates are bolted. Peripheral butt straps about 4 inches wide and half an inch thick cover the joints between abutting sections of screens to which they are bolted.

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

"Screens usually are perforated with holes with a minimum diameter of 3/8 inch along most of their length. Depending on the maximum size of gold nuggets found during testing, the last section of screen may be perforated with holes 1/2, 5/8, or 3/4 inch in diameter. When flat or elongated nuggets are found, one or more of the last sections sometimes are perforated with slots.

These are formed by punching or drilling two holes, 3/8 inch in diameter or larger, near each other and cutting out the intervening metal.

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

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

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

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

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

<u>Sluices and Riffles</u>

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

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

"The slope of the tables should be adjusted to the character of the material handled. The slope is increased when fines tend to pack in the riffles or when the gravels contain an undue proportion of sand." A common slope is 1 1/2 inches to the foot.

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

If the gold is fine and flaky, not easily amalgamated, or if there is an excessive amount of black sand it is probably advisable not to use the usual wooden riffles. A firm, short-piled slightly-corrugated Brussels carpet has been found to be an effective gold-saver for the fine, flaky gold that is found along the bars and benches of the Fraser River. The carpet is used without the protection of expanded metal screen with the distinct advantage of not collecting too much black sand which needs to be handled in the clean-up. This type of riffle is used by the dredge operated by North American Goldfields Ltd. at Alexandria Ferry on the Fraser River.

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

It is possible that placer gold jigs may displace riffles for use on floating washing plants. Jigs work well on fine gold and on concentrates which carry values not entirely freed from its matrix; or if platinum or other precious metals are present in appreciable quantities. Jigs will often increase the percentage-recovery per cubic yard.

A proper installation requires rougher and cleaner jigs, sand pump, grinding mill and amalgamator plates or an amalgamating barrel. One further advantage is that no time is lost for the clean-up.

Description of Jasper and Stacey Mine

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

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

"The undersize from the trommel distributing boxes goes to a bank of three 30-inch-wide by 3-foot-long double-deck riffle tables on each side, and thence to two 42- by 42-inch Bendelari jigs on a side. The jigs have 5-foot head room, a 1 3/8-inch stroke, and pulsate at the rate of 124 per minute. A bed of

250 pounds of No. 10 shot is used in each jig. The overflow from each pair of jigs passes over two 5-foot sluices and thence through 30-inch by 45-foot longitudinal sluices to a dewatering tank. The sand is raised by a bucket elevator to a steel sluice, from which it is discharged onto the rock pile at the edge of the pond.

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

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

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

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

EXCAVATING EQUIPMENT

Dragline Shovels

"Diesel-engine power units are used on 18 of 24 draglines (examined by Gardner and Allsman in California) that serve floating washers; four are powered with electric motors and two with gasoline engines.

"Dragline excavators serving floating plants range in size from 1 1/4- to 3-cubic yards bucket capacity; the 1 1/4- and 1 1/2-cubic yard sizes are more common. A common practice is to buy a dragline equipped with a bucket 1/4-cubic yard smaller than the rated capacity of the machine to provide reserve power for contingencies, prolong the life of the unit, and reduce repairs.

Cables

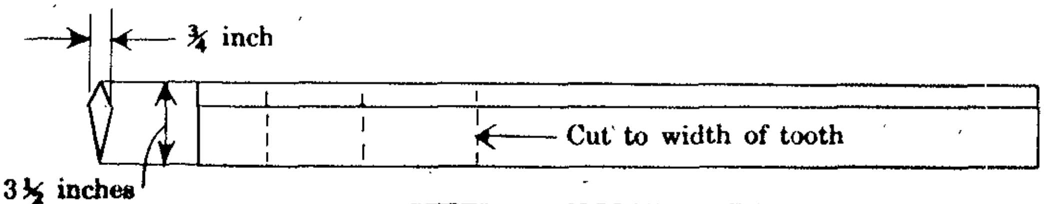
"Shovels are equipped with a hoist and a boom support cable; occasionally some of the smaller shovels are equipped with a cable-type crowd. The dragline, in addition to hoist and boom cables, requires a drag cable. Usually, cables recommended by the excavator dealer are used; they are constructed to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

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

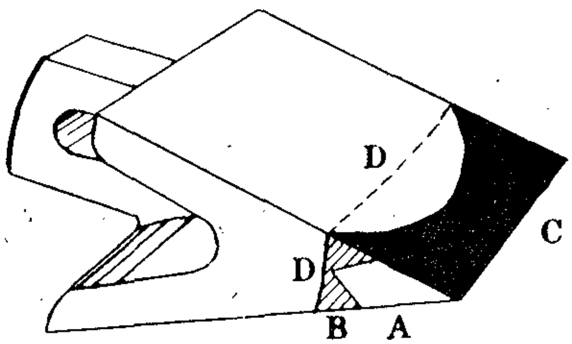
"According to available data, the average length of service for hoist cables on draglines was from 150 to 900 hours, the average being about 500 hours for all operations listed. The life of drag cables ranged from 150 to 400 hours, with an average for all of about 200 hours.

Teeth

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

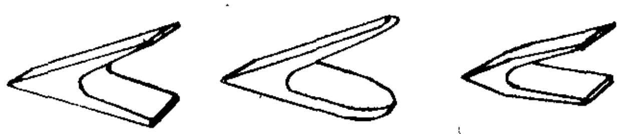


STEEL APPLICATOR BAR



REBUILT TOOTH

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



TYPICAL REPOINTS FOR TEETH

Figure 3.--Methods of rebuilding dipper and bucket teeth.

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"The life of teeth varies because of the wide range in hardness and abrasive qualities of the gravel at different mines.

"Several methods of rebuilding and prolonging the life of teeth are in use. Some operators reconstruct the entire point from welding rod. Another method is to weld on repointers; when these are used, care is taken not to wear into the stock of the tooth or it will have to be rebuilt before the repointer is applied. The use of applicator bars has found favor with many operators; these may be bought from several manufacturers of steel products and are highly recommended by them. The bars are of manganese steel or some other suitable steel, and come in lengths of several feet; they may be cut into sizes the width of a tooth. These are welded on and filled out to size with welding rod. A surface of hard facing applied to the point is proving to be economical in prolonging the life of teeth at some places. Figure 3 shows a typical applicator bar and its application to a tooth with hard facing added. Typical repointers are also shown.

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

Bulldozers

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

POWER

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

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

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

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

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

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

WATER

"Water is used primarily for disintegrating and washing the gravel and flushing it through the sluices. In addition, a relatively large amount is used during a clean-up.

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

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

"The amount of water required to maintain a pond sufficient for a floating washer depends upon the relative porosity of the gravel and bed-rock. The minimum requirements appear to be about 35 to 50 miners' inches,[2] although 20 miners' inches were used at

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[1] These are U. S. gallons equal to 0.833 of an Imperial gallon.

[2] 1 miners' inch equals 9.3 Imp. gallons per minute.

one small plant working in tight gravel and with a limited water supply; 100 to 150 miners' inches was found to be used at a few operations, owing mostly to the abundance of water.

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

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

LABOUR

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

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

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

TABLE 1 - Cost of plants and operating costs at placer mines using floating treatment plants

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

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

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COSTS

Cost of Plants

"The cost of plants (in California), where data were available, is given in Table I. Principal factors governing variation in cost of floating plants have been whether equipment is new or second hand and the daily capacity. The cost of washing plants varies less with increases in capacity than does the cost of excavation."

Note: The table on the preceding page represents costs of equipment and operation in California in 1936 and 1937. Both would be higher at present.

The following table lists the approximate (American) costs of plants, quoted by H. S. Lord in The Mining World for October 1941.

Dragline	$1\frac{1}{2}$ cu. yd.	2 cu. yd.	3 cu. yd.	5 cu. yd.	12 cu. yd.
Boat Capacity	1200-1500	2000-2500	4000-5000	5000-6000	10-12,000
Dragline	$25,000	$36,000	$53,000	$ 90,000	$250,000
Boat	20,000	28,000	50,000	100,000	200,000
2 Buckets	3,600	4,400	5,200	9,000	20,000
Welder	1,000	1,000	1,000	1,000	1,000
Field Shop	1,000	1,000	1,500	3,000	10,000
Tractor and Bulldozer	7,000	10,000	10,000	10,000	10,000
Trucks, etc.	2,000	2,000	3,000	5,000	10,000
Totals	$59,600	$82,400	$123,700	$218,000	$501,000

Cost of Mining

"Table I gives costs of mining per cubic yard at placer mines where floating washers are used. The costs are based upon estimated yardages, since actual measurements rarely are made.

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

It should be pointed out that the crew for a small plant is almost as great as for one handling 5000 yards per day. There is however a slightly greater power cost for the larger plant. Consequently if at any operation the yardage handled be increased by 1000 yards a day the cost per yard will decrease proportionately. Furthermore other factors such as type of ground worked and lost time through break-down or in handling boulders have a pronounced effect on the per unit cost. It is important therefore that the plant be kept running as steadily as possible in order to wash the maximum daily yardage possible.

More specific costs are given in the following summaries:

Wyandotte Gold Dredging Co.[1]
Oroville District, Cal.

April 5, 1935 to Jan. 1, 1936 (557,764 cubic yards mined) Dragline with 1 1/4-yard bucket on a 50-foot boom digging to a depth of 9 1/2 feet, bed-rock is decomposed granite.

		Cents per cu. yd.	
Barge:	Payroll	2.51	
	Maintenance	0.90	
	Fuel, oil, supplies	0.32	
	Shop	0.01	
	Total		3.74
Shovel:	Payroll	1.40	
	Maintenance	1.60	
	Fuel, oil, supplies	0.32	
	Total		3.32
General:	Prospecting	0.22	
	Clearing	0.99	
	Water, insurance, etc.	0.77	
	Total		1.98
	Total operating expenses		9.04 cents

This does not include depreciation and property payments.

1 Magee, J. F., Dragline Dredging, C.I.M.M. Trans. vol. XL 1937 p. 123.

Lincoln Gold Dredging Company[1]
Klamath River, Cal.

March 15 to Sept. 3, 1939 (485,910 cubic yards handled), Dragline with 2-yard bucket, depth of ground 20 feet of which 8 to 10 feet was stripped by separate shovel.

	Cents per cu. yd.	
No. 1 Dredge Unit		
Dragline payroll	0.937	
Dragline fuel & oiling	0.812	
Dragline maintenance	1.07	
Dredge payroll	0.911	
Dredge fuel and oiling	0.567	
Dredge maintenance	0.366	
Depreciation	0.794	
Taxes	0.243	
Total		5.702
No. 2 Unit - used for stripping includes payroll, fuel, maintenance, depreciation and taxes.		
Total		2.16
Tractor units for stripping		
Payroll, fuel, maintenance depreciation and taxes		3.065
Administration and general expenses		1.95
Total		12.877 cents

Note that this is the total operating cost per cubic yard but excludes royalties and exploration.

[1] Austin, V. Operating Costs on the Klamath River, E. and M. J. vol. 141, No. 9, 1940, p. 57.

San Andreas Gold Dredging Co.[1]

Jan. 1 to Dec. 31, 1939 (744,584 cubic yards mined). Dragline with 2-yard bucket on a 60-foot boom digging an average drift of 11 feet but as much as 20 feet at times. Average mined per hour of actual running time - 134 cubic yards.

	Cents per cu. yd.	
Dredge operation - including labour, fuel, water, supplies, renewals, repairs	8.05	
General expenses - supervision, office, etc.	0.62	
Indirect expenses - insurance, taxes, etc.	0.60	
Royalties - including 10 per cent. of gross gold, mineral rights purchased.	2.53	
Prospecting and moving dredge, abandoned leases.	1.64	
Total costs	13.44	
Allowance for depreciation	1.70	
Total costs including depreciation	15.14	cents

In this operation much of the gold was in the bed-rock and consequently from 2 to 4 feet of slate bed-rock was taken up by cleaning from three angles, parallel to the cut and by two cross cuts. Furthermore large boulders were cast aside and handled by a bulldozer and consequently the yardage per hour was considerably less than that of other operations using the same size dragline under more favourable digging conditions.

1 Thurman, C. H., Dragline Gold Dredging, The Miner, Sept. 1941, p. 29.

H. S. Lord in The Mining World for October 1941 lists the following costs as having applied to a 3-cubic yard plant that handled 1,243,000 cubic yards in 333 working days under fairly favourable conditions.

	Cents per cu. yd.	
Payroll	2.64	
Repairs	0.86	
Gas, oil and fuel	0.69	
Other expenses	0.30	
Compensation etc.	0.23	
Insurance and taxes	0.09	
Cable	0.07	
Welding material	0.06	
Freight and express	0.03	
Total field cost	4.97	
Depreciation	2.01	
General office expense	0.40	
Total	7.38	cents

In the above statement no items are included for interest on investment, income taxes, depletion, prospecting, moving expenses or royalties. These vary widely but must be included in the total cost per yard mined.

NORTH AMERICAN GOLDFIELDS LTD.

The North American Goldfields Ltd., Box 67, Quesnel, B. C., hold placer leases covering a low bench on the east side of the Fraser River and extending for about 1 1/2 miles up-stream from Alexandria Ferry.

The surface of the bench is about 10 feet above the high water level of the Fraser River. The gravel, which is dug to a depth of 9 or 10 feet is loose, fairly porous, contains little clay and has few, if any boulders larger than 12 inches across. Bed-rock lies at a depth of 15 feet or more. The gravel contains fine, flaky gold in the upper part with little in the gravel which lies below the depth dug. The surface may be underlain by from 2 to 5 feet of barren silt which is stripped off by a D7 caterpillar.

The shovel is a 2 1/2-cubic yard Lima dragline operating a 2 1/2-yard Page bucket on a 60-foot boom. The shovel is run by a 260 H.P. Cummins Diesel engine. The hoist cable used is a 1-inch diameter, and the drag, 1 1/8 inch.

The washing equipment is carried on a boat 40 by 32 feet, built on the ground from Douglas fir. Because there are no large boulders the bucket dumps directly into a hopper, having no grizzly, which feeds the gravel to a trommel 54 inches in diameter and 26 feet long. There is a 5-foot blank section at each end of the trommel. The screen section is 16 feet long having 3/8th inch holes spaced wider apart at the front end. It revolves at 14 R.P.M.

The stacker belt is 50 feet long and 30 inches wide running at 150 feet per minute and driven by an electric motor at the outer end.

There is about 800 square feet of riffle-tables having a grade of 1 1/2 inches to the foot at the head end and using a hard surface, slightly-corrugated Brussels carpet.

The power plant is a 100-h.p. International Diesel engine belt-connected to a drive shaft which operates the trommel and pump and direct-connected to a generator which supplies power for the electric motor running the stacker.

The dredge works two 10-hour shifts per day and operates from 16 to 19 hours a day. Gravel dug averages about 130 cubic yards per hour of operating time. The riffles are cleaned up once a day when the shovel and dredge are shut-down for greasing and oiling. The total crew comprises 2 shovel runners at \$1.25 an hour, 2 greasers at 55¢ per hour, 2 dredge operators at 65¢ an hour, 1 bulldozer operator (on day shift) at \$1 an hour, 1 clean-up man (on day shift), 1 office man, and the superintendent.

The plant represents a cost of about $90,000.

There are other low benches along the Fraser River having similar physical characteristics to the one being mined. These are potential dredging areas which need, however, to be thoroughly sampled for values and total yardage before mining is warranted.

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