DESIGN, CONSTRUCTION AND TESTS
OF A
NEW APPARATUS FOR
WASHING GOLD FROM GRAVEL

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Design, Construction and Tests of a New Apparatus for Washing Gold from Gravel.

While some statistics are available, there seems to be but little known, and particularly on the part of the general public, of the extent to which gold is present in the sands and gravels of the earth's surface, or what is known as "placer deposits." In such deposits the gold is combined mechanically with the sand and it only requires a thorough washing to separate the two.

One of the original methods used to recover gold from the placers was by panning it. A portion of the sand was thrown into a shallow...
pan, and standing on the banks of a stream the operator would wash the contents of the pan until the gold—being heavier—would sink to the bottom and could be recovered. This process was slow, and as it required about one hundred and fifty pans to the cubic yard, did not pay unless the sand was very rich in gold. Plate I shows the method employed in panning to bed-rock to test the richness of the bank, and the lower view shows the method of panning the gravel at the bottom of a stream.

In many places there is not enough gold in the gravel to make this slow process a profitable one, and some means must be devised by which a large amount of gravel can be treated. There are two principle ways...
of accomplishing this end, depending on the quantity of water available. Where water is scarce or distant some form of dry placer miners is often used, but where the supply of water is plentiful and under considerable head the hydraulic process is the more rapid and profitable.

The dry washers — as they are commonly called — vary from the small one operated by one man and carried on a man's back to quite extensive plans run by steam or horse-power. The small ones are used either to locate rich deposits and then called "prospect machines" or a man may be unable to buy a more extensive plant and use this small one to work the richer ground.

In Arizona, New Mexico and similar regions
there are many men who roam over the placer deposits with a hand machine, making from two to five dollars a day.

Plates II and III show the details of one make of these machines; Plate II, showing it all ready for operation, while in Plate III the top cover is removed to expose the riffle. This machine is two feet wide, six feet long and weighs about five hundred pounds. Its capacity is from fifteen hundred to two thousand pounds per hour and the concentrates recovered from the riffle after a day's run weigh from fifteen to twenty pounds. The gold is recovered from the concentrates by panning or by amalgamating, according to conditions.

The hopper of this machine is provided
with a screen with three-quarter inch openings, and anything larger, passes down over the riffle cover and off with the tailings. All material passing through the screen drops between a pair of jaws and then onto the riffle. The bottom of the riffle-box (which is also the top of the bellows) consists of a screen plate covered with a carpet, and strips forming the riffles clamped across this. The jiggling motion together with the wind cause the most of the gravel to pass off the riffle, while the gold and some sand lodge behind the bars. These are removed in cleaning up.

The larger washers are built on much the same principle as the above with the
essential difference that they use water instead of wind to separate the gold.
The "hydraulic" process of recovering gold from gravel has been used very extensively, and where there was an abundance of water under sufficient head, very profitably. It required on an average of two thousand gallons of water to the cubic yard of gravel, and this should be under a head of at least two hundred feet. A long sluice-way is necessary, with ample dumping ground. The sand and gold is washed from the banks into and carried rapidly through the sluice by the force of the water. The gold deposits remain in pockets in the sluice.
Plate IV shows this method of operating.
as employed on a placer near Prescott, Arizona, where a four and a six inch stream of water are used. This plant can be operated only during the rainy season on account of the scarcity of water, and this fact led the owners of the placer to rig up an outfit shown in the three views on Plate V. It is a machine that uses but little water and requires no extensive dumping grounds.

These views on Plate V are from photographs which were all taken from the side and so do not show the steam shovel which digs the gravel from the bank and delivers it to the washer. This latter machine consists of a screen which revolves in water and so washes the gravel,
and a series of riffles similar in some respects to the one on the small dry washer. These separate the gold from the sand and the tailings are carried to the dump by means of a bucket conveyor. The machine as shown is digging from the left hand bank and the tailings are deposited to the right. When the length of the cut is reached the tractors are moved over close to the cut bank and the machine comes back, cutting further into the left hand bank and making a new row of tailings on its right hand side. Plate VII shows three photographic views of the reservoir with the pump house and pipe line for supply of water to the machine which was operating on a level above the
reservoir. The lower view also shows the cut made by the machine in its passage, and the deposit of fine sand and mud left by the water in its return to the reservoir from which it was taken. By making this arrangement for the water, it can be used over a number of times, and a much smaller quantity is needed.

This was only an experimental plant — though a very profitable one — and the different parts were assembled in rather a crude fashion. The excellent results obtained led the owners of the Sterling Placers, situated along the banks of the Hassayampa River about twenty-five miles south of Prescott Arizona, to determine to perfect and build a similar plant.
The writer was at this time employed as engineer and designer by this company, and had charge of the design and much of the construction of the machine as it was built. With the exception of Plate VIII, IX + X the following plates are from photographs and detailed drawings made by the writer and used in the construction of the machine. The cuts and tracings are at the company's shop office in Harvey, Illinois. The geological construction of their land and also the location of the river and gravel to be worked are shown on Plates VIII and IX. The area of these gravel is about eight miles in length by about four miles in width, and is from five to fifteen feet deep along the river. The gravel
VERTICAL SECTION SHOWING ORIGINAL DEPOSITION OF GRAVEL UPON TUFFA ROCK BEFORE RIVER CHANNEL WAS CUT THROUGH
along the river runs from ten to fifty cents per cubic yard, while that along the foot-hills runs from one and one-half to two dollars per cubic yard. The water for washing the gravel is taken from the Haciyampa River, which runs about one hundred miner's inches of water, but sometimes double that amount during the winter months. The operation of this plant is clearly shown on Plate I, which shows what might be called the theoretical working condition. The river and pumping station are in the distance, and the pool or reservoir and second pump are near the machine. The shovel is of the complete circle type and delivers the gravel from in front or the side onto the hopper of the washer. The fuel
is carried on a truck between the shovel and the washer.

It is this washer which is referred to in the subject of this thesis, and of which the following description treats.

The gravel is dumped by the shovel on a grid of 1\(\frac{1}{2}\) x 5 inch bars as shown on Plate XI, and at H on Plate XII, where it is washed by the water which flows from the flat cast iron pipe (see Plate XI and O-Plate XII). The section of this pipe is shown on Plate XI, and it is so arranged that the lip may be raised or lowered, or the opening closed to any required width. This pipe surrounds the grid on three sides. It is supplied by a five inch pipe (see K-Plate XII), and delivers about 500 gallons of water for each cubic yard of material dumped.
SECTION AT A-B.

SECTION AT C-D.

IMPROVED METHOD WATER APPLICATION
SIDE ELEVATION.

Fig. 1—MACHINE FOR SEPARATING GOLD FROM PLACER GRAVELS.
on the grid by the shovel.

Stones too large to pass through the space between the bars of the grid (about 10 inches) over the top of the hopper lie upon the bars until the water impinging upon them in its passage has washed from them all clinging particles. After this is finished, a mechanism engaged in operation by an attendant drags off the large stones from the bars and drops them on the dump side of the machine. This prevents the passage of these stones through the machine and so saves considerable wear. The gravel, sand, and water pass from the grid down the hopper (H - Plate XII) and into the revolving screen (S - Plates XII + XIV) which is driven by the engine R.

The axis of this screen lies horizontal, and
by means of a gear rim bolted to the discharge end it is caused to revolve upon a pair of 24 inch rollers at each end. The detail of the screen is clearly shown on Plate XVI, which is a reproduction of the assembled shop drawing used in its construction.

The screen as shown consists of three separate screens—one within the other. The inner one is 3 feet in diameter, made of longitudinal bars with a variable space (about 2 inches) between them. The middle screen is 6 feet in diameter, made of ¼ inch steel plates, with openings or mesh of ⅞ x ⅛ inches. The outer screen is 7 feet in diameter, made of ⅜ inch steel plates with openings of ⅛ x ¼ inches. This outer plate is
FIG. 3—REVOLVING SCREEN.
readily removable and can be changed for a plate of other mesh if the character of the gravel should require.

All stones that will not pass between the bars of the inner screen or cylinder are carried through by the spiral flights (steel castings) and dropped in the buckets of the elevator or conveyor, to be deposited in the dump pile. Such material as passes between the bars of the inner screen are received by the middle cylinder, and anything too large to pass through its meshes is also carried along by the spiral flights and deposited in the buckets. Whatever passes through the middle screen is received by the outer screen and the same process of separation takes place.
This constant stirring gives ample opportunity to wash all gold and sand from the stones. The water, fine sand and the gold pass through the outer screen and are caught in the tank beneath (E - Plate XII). This deposit is then drawn through a 6 inch suction pipe (Plate XII) to an ordinary 8 inch centrifugal pump (B - Plate XIII + XV). The water, with the gold and sand, is then passed through the pump and up the pipe T to the top riffle F.

There are three of these riffle boxes, made of cast iron bars cast across the bottom, leaving spaces about one inch wide and one inch deep. They are somewhat similar to the riffle on Plate III and being slightly inclined the water flows over
the bars, while the gold settles and is saved. The water passes from two to four inches deep over the riffle surface. The coarsest gold is deposited in the top riffle, but the fine dust is saved by mercury placed in the lowest riffle.

The water and sand passing over the riffles flows into the tank C and is then elevated by the centrifugal pump D through the 6 inch pipe M and deposited upon the dump. This completes the separation so far as the machine is concerned. The riffles are supported on a gudgeon at each end and can be cleaned up by simply tipping on edge and catching the contents as they flow down.

To go more closely into the details of
design used, in the machine, it will be noticed from the various drawings that it is built entirely of steel and iron. The main frame is built of 15-inch beams and channels, and is 27 feet wide by 30 feet long. It is supported near each corner by a cast iron truck (Plate XVII). This requires four rails arranged as shown on Plate XVIII. By using this form of truck the machine more easily adjusts itself to inequalities in the road-bed and can be made to turn shorter curves.

This frame carries a fifty horse-power boiler, and four 8 x 8 inch engines, two of which are directly connected to the two centrifugal pumps; the third rotates the screen and the fourth drives the elevator. The pumps are
Height to Clear Hopper, from rail, 14 feet.
of the ordinary style, except that while they have 6 inch openings the casing is the same as for an eight inch pump. This is done to get the water up to the required speed without having to run the engine so fast. Details of the casing are shown on Plate XIX and of the piston on Plate XX.

The work of the pumps during the tests was very satisfactory and by means of a float in tank C connected to butterfly valves in the steam pipes the speed of the engines was so regulated that the water level in the tanks was maintained near a given point. This prevented the tanks from becoming empty and allowing the engines to race or the pumps to lose their priming. Flap valves were provided for the ends of the
Piston for Left Hand Pump.

For Sand and Gravel.

8" Centrifugal Pump Details.
discharge pipes, but after the jumpr was running these could be thrown clear back by a mechanism provided for that purpose. The discharge pipe M was provided with a gate valve about 12 feet from the upper end, through which the water could be discharged provided it carried too much sand for the jumpr to lift to the end of the pipe.

The general appearance of the conveyor or elevator is shown on Plate XIII, and the detailed cross section together with a sketch of the bucket is given on Plate XXI. Every other bucket was provided with a pair of rollers which ascended on the top side of the frame and returned in the Z bar on the lower side. The flange of the Z bar was
Distance from track to top of bucket must not be more than 10".

Sterling Placer Co.
Harvey, Ill.

Drawing No. 757c June 29, 47

R. A. Duker
cut away for about 10 feet at the bottom to allow for the sag of the chain. The buckets were mounted upon two steel chains as shown on Plate XIX, one bucket being bolted to each of the flat links.

By means of a series of chains the buckets were driven from the top of the elevator (see Plate XXIX), these chains transmitting the power from the engine. A take-up at the top end of the conveyor served to tighten the chain, and the sag of the upper side was supported on an idler about half way up the conveyor. The entire length of this structure was 40 feet, and it was supported at the bottom by a cast-iron foot resting on gudgeons, and at its
Jeffrey Steel Link Chain.

No. 566. Full Size 1/2 inch Link. 6,000 pounds Working Strain. 60 cents per foot.

A Full Size Blue Print of other Sizes furnished upon application.
Jeffrey Mey-Oborn Chain Link.

No. 103. Full Size.
Working Strain, 2,200 Pounds.
65 cents per foot.

Attachments
A7, F2, K1, K2, G6.
center and at 12 feet from the upper end by guy's leading to the head of a derrick. The foot of the conveyor was so constructed that by changing the length of the supporting guy's the top end might be raised or lowered.

The derrick is constructed of four wrought iron pipes 4 inches in diameter, with both ends secured by heavy castings. Cross-stays, made of 2 inch pipe, join these pipes at two points, and make the whole a very firm and rigid construction. The ruffles swing from an I beam attached to two of these pipes.

This machine has not yet been in actual operation. Such tests as were possible were conducted in the erecting
shop, and a number of slight changes were made. During these tests, gravel and sand were dumped into the machine and every thing made as near like working conditions as possible. When every thing was under way, with water and sand running over the riffles a known quantity of fine gold would be thrown with the sand as it entered the top riffle. About half an hour after this was done the machine would be stopped and the contents of the riffles cleaned up and panned. After each test almost every particle of the gold was recovered, and that mostly on the top riffle. It is quite possible that in a twelve or a twenty-four hour run, the second
and perhaps the third ruffle would be called upon to save their share of the gold, or it may be proved that one or two ruffles are sufficient.

At other times the machine was run either with water and sand, or dry, for several hours and sometimes for all day in order to get things in working shape and to discover any weak points in the construction.

The entire weight of the machine is something over sixty tons and it required two flat cars to transport it to its destination, the Sterling Placers in Arizona. It is now in process of erection. Its normal capacity is rated at one cubic yard of gravel handled and washed.
per minute, but the machine is capable of washing, and has been run at the rate of three cubic yards per minute.