DEPARTMENT OF MINES & MINERAL RESOURCES

1502 West Washington
Phoenix, Arizona 85007
255-3795 Toll-free in Arizona 1-800-446-4259

JIG RECOVERY SYSTEMS

Circular 52, April, 1995
by H. Mason Coggin, Director

Jigging is one of the oldest processes used to separate heavy minerals from the lighter gangue. This technology was used in Cleopatra's time to separate wheat from chaff. A jigging sieve was described by Agricola in De Re Metallica in the 16th century.

How the Jig Works

The jig consists of a cell containing water with a screen on the top. Steel or stainless steel shot is placed on the screen. A rubber diaphragm located at the bottom of the cell is driven up and down by a walking beam and eccentric mechanism.

On the up, or expansion stroke, the water column is forced through the shot bed causing the shot bed to dilate and differential particle sorting to take place, based on Stokes Law of Hindered Settling. This allows the heavier particles on or near the shot bed to settle through the shot while the lighter particles are carried onto the tails. On the down stroke these heavier particles are pulled down through the bed and discharged through the hutch concentrate valve at the bottom of the cell.

Feed rate, depth of bed, pulsation frequency, stroke length, and make-up water are the main variables used to adjust the jig for optimum recovery. These basic features of the jig system are shown in Figure 1.

History

Although jigs were extensively used in coal and base metal recovery at the turn of the century, it was not introduced to the gold placer mining industry until 1914. From that time until 1942 jigging became the most popular method of placer gold recovery. Beginning with the gold mine closing order of 1942, production from placer gold mining and jigging all but disappeared until the gold price was released in 1975. Gold mining has had a most remarkable revival in the last two decades, but the practice of jigging has lagged.

In 1914 J.W. Neil installed a large-scale test jig on the Yosemite dredge in California. Subsequent testing of the Neil jig by Natomas Consolidated resulted in the conversion of their sluice dredges. At first jigs were placed on the end of the sluices as a final cleanup. The next year they were moved to the head of the sluices. The following year sluices were being removed from many of the dredges and jigs were installed as the only recovery system. The improved recovery from jigging resulted in the profitable reworking of the tails from some previously mined deposits that had been considered marginal.

Conversion by other companies was slow. It was not until 1932 that the Bulolo Gold Dredging Company initiated testing. This test work resulted in the immediate conversion of their largest dredge then operating in New Guinea. The Bendalari Jigs became the dredge's sole means of primary recovery. With the success of this operation, the company began to convert all of their dredging operations to jigs.

To remedy the design and installation problems of the original Bendelari Jigs, the Bulolo engineers designed a new machine that they called the Pan-American Placer Jig. The new design, adapted for use on board a dredge, was compact and could accommodate a great deal of wave movement on a small barge operating in an active dredge pond.

The success of this new design was so great that Bulolo converted their dredges in New Guinea and Columbia. Observing the high recovery of these installations, Yuba Consolidated Goldfields, Ltd. converted all of their California Fisher and Baumhoff operations to jigging plants in 1936 and 1937.

These efforts marked the last technological advancement in gold dredging. With the L-208 closing order of WWII all placer gold mining in

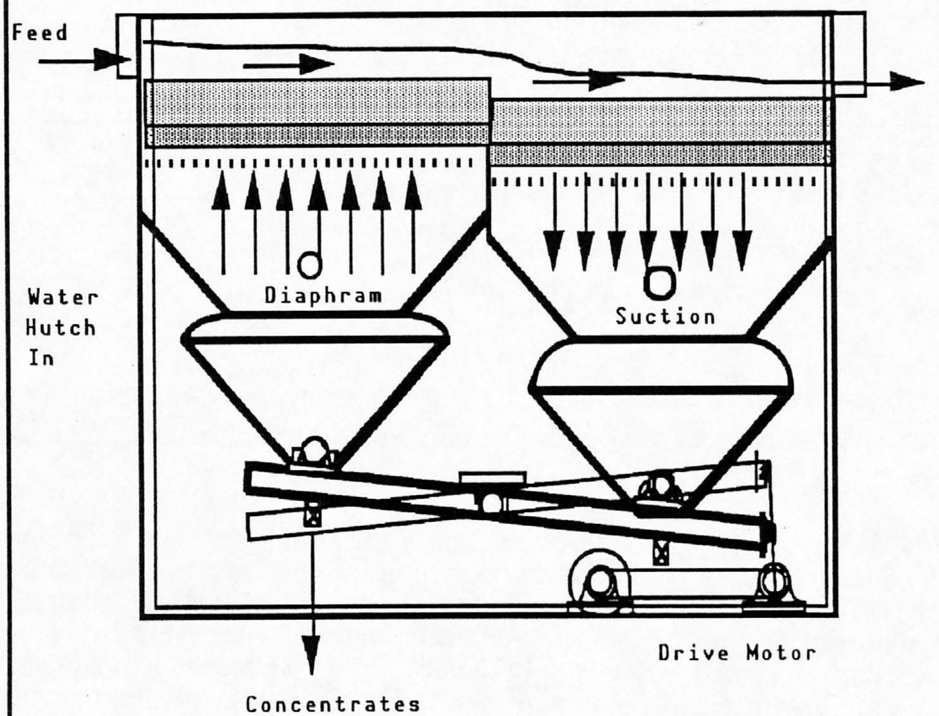

Figure 1. Section of a modern placer jig.

the U.S. was stopped. Few of the dredges survived the scrap drives of the war. When L-208 was rescinded at the end of WWII, a few of the survivors were refitted, but inflation and the fixed gold price halted the construction of new dredges for North American placer gold mining. Placer gold mining was almost forgotten until 1975 when the price of gold was allowed to float on the world market. Somehow, during this long sleep the success of the jig was forgotten.

The Cleveland Circular Jig was designed to treat the tin bearing sands off the coast of Indonesia. Feed is entered through the center and as it travels outward to the tail weir the velocity is decreased with obvious advantage. At the present time these jigs are manufactured in Europe. One manufacturer has even developed a hydraulic stroke for the diaphragm that is claimed to be superior to the mechanical eccentric drive.

Circular jigs have not been generally accepted in gold mining, probably because of their high cost, large capacities, and low (20:1) recovery ratios that were developed for the offshore tin industry.

The concentration of free gold in a gold placer is very small and a high concentration ratio is required to make an economic concentrate. There is a great deal more tin in a tin placer than gold in a gold placer. To be economic the ratio of enrichment for tin placers need only be 10 or 20 times.

One of the few modern operators using circular jigs was WestGold in their offshore operation at Nome, Alaska. These jigs were already onboard when the dredge, Bima, was purchased.

Jig Operation

Although great improvements have been made in their design, riffles have inherent metallurgical limitations. The gold must settle and be trapped behind the riffle in a swift current of water. The current's velocity must be great enough to transport crudely classified material across the riffles. The slower the velocity the better the tendency for the gold to settle and be saved. This lower velocity, however, has less carrying capacity and will allow black sand and other heavy minerals to pack behind the riffles leaving no trap for the gold. If the amount of water and the slope of the riffle are increased to provide sufficient velocity to clean the riffle, gold particles that were previously trapped will be remobilized and lost. Sudden surges in feed may also dislodge gold. If the velocity is too low during the down cycle, black sand will again pack behind the riffle.

In either case the first gold lost by the riffles is presumed to be the fine (- 200 mesh) gold. Flat gold or light gold because of its poor setting ability will also be lost.

Jigging avoids these limitations. The best can be adjusted to permit settling and trapping of the gold at all times. Once trapped, the gold is removed from the stream and the losses from packing and surging are eliminated. The jig can be adjusted to remove a large percentage of black sand and the balance can be eliminated on tables or further jigging. The pulsations of the jig move material across the jig to the tail, and consequently, less water is required to move material. Conditions at the top of the jig bed are quiescent at the top and bottom of each stroke. This provides a better opportunity for the gold to settle.

The jig has few limitations, but it is a gravity machine and therefore can recover only the gold that will settle by gravity in the jig bed. Some of the finest gold will be lost, but in most deposits this loss is below the economic limits of present technology. In the majority of placer deposits the total amount of fine gold is difficult to quantify. If the deposit was formed as alluvial, colluvial or eluvial, the finest gold has already been eliminated by the poor sluicing provided by nature. There are a few exceptional deposits in which the gold has been liberated by oxidation of gold-bearing sulfides, or is still locked up within

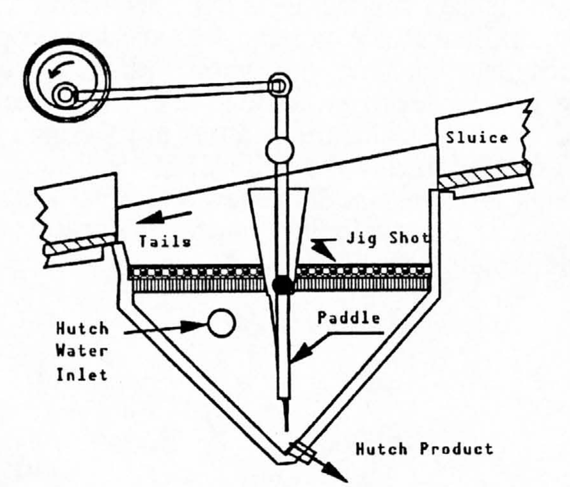

Figure 2. Neil Jig, about 1907 (after Taggert)

the sulfides or oxides that were deposited with the gravels of the deposit. These deposits present problems that involve milling methods and the economic advantages of a placer operation are voided.

Flotation, for example, may be applicable in the recovery of fine gold that will be lost even by jigs. Without specific research on the increased recovery from flotation and the costs involved for each specific property, it is doubtful if flotation would recover more gold values than it would cost. A 1933 installation of six full-size flotation machines, treating 300 tons per day, was made on one of the dredges operating on the American River in California. After three months of operation the recovery of gold by flotation was only 2 cents per ton on heads to the cells of 3.5 to 9 dollars per ton.

Design Considerations

Placer jigs present a different set of problems from those encountered in the concentration of base metals. The ratio of the specific gravities is higher and the feeds are not as well classified as those in hard rock milling. The hard rock jigs are generally much longer and narrower. To work with the lower specific gravities, close classification is essential and the longer jig beds provide for slower setting. With these advantages the load per square foot for the placer jig can be increased without appreciably affecting the recovery. This allows a lower cost unit to be produced per ton of material jigged.

When jigs were first considered for placer mining, several different designs were available from coal washing and base metal operations. These jigs were heavy, cumbersome, and occupied considerable space. On a dredge, floor space is a critical design consideration. The Neil Jig, was modified to take up no more floor space than the actual jigging surface.

The Bendelari Jig, which followed the Neil design, was actuated by a plunger sealed with a rubber diaphragm located below the jigging surface. This allowed the floor space requirement to be defined by the jigging surface.

Pan-American Placer Jig

In the Pan-American Jig, the hutch is an inverted cone that moves by means of an eccentric cam and a walking beam. A rubber diaphragm between the cone and the jigging screen provides a positive displacement of the hutch water to insure jig bed pulsations. Concentrates discharge freely through the metered outlet in the bottom of the cone. A large volume of water is added in the hutch to provide an upward flow through the screen during the up stroke while maintaining the flow of concentrate out the bottom. This provides a zone in the hutch, below the screen, where the flow is neither up nor down. Gold particles settling through this zone are accelerated by the velocity of the flow to the discharge.

Hutch water flow also aids in the suspension of the pulp as it passes over the screen providing for additional separation in the ragging. In the final design, the weight and volume of the machine was cut to a minimum for further cost reduction and volume efficiency.

The Pan American Placer Jig is designed to hold a certain volume of steel shot on the screen as bedding. The restriction, through the spaces between the shot, reduces the amount of concentrate and provides for maximum recovery at a high concentration ratio.

The 42" x 42" duplex cell arrangement has become a defacto standard in the industry. In this arrangement two cells are set in series with a drop between the cells. The rollover of the material as it passes over this drop between the cells further increases gold recovery. Material, which may have been riding on the top in the first cell, is rolled to the bottom of the flow and adjacent to the bedding. The effectiveness of this toss is demonstrated at each jig screen cleaning. Particles of coarse gold that escaped the first cell will be found in the first few trays of the second cell.

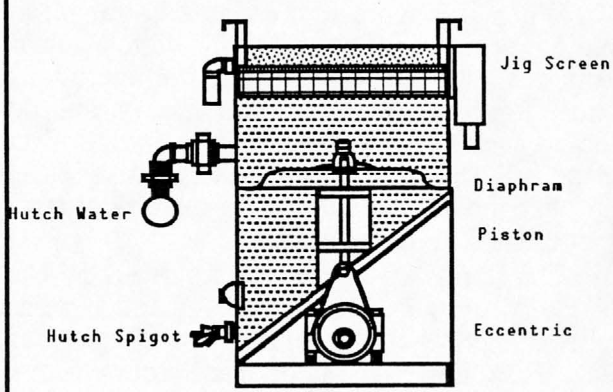

Figure 3. Bendelari Jig (after Taggert)

Testing Tailing Losses

Nowhere in the art and science of sampling are results harder to obtain and less reliable than in the sampling of gold placer tails. The volume of material is so great and the effect of one small gold particle so dramatic, that only relative results can be obtained. The following example will illustrate this point.

For a placer operation with average heads of \$3.00 and recovery of 90 percent, the tail will carry \$0.30 in gold. This is equivalent to about 500 minus 80 mesh particles per yard. An 80 mesh particle is smaller than a speck of ground pepper and has a value of about \$0.0005. If three of these particles were found in a single pan of tails, the loss would be reported as \$0.30 per yard.

Summary

The jig is again a popular choice for processing placer gold deposits. Operators who have experimented with sluices, spirals, cones, and centrifuges are now changing to jigs. One reason for this may be the great number of manufacturers who are answering the demand for jigs. In most cases these manufacturers have acquired one of the original Pan American Jigs and have copied them as original patents ran out years ago. These designs have proven to be efficient and effective collectors of gold. Innovations in jig design that were tried during the first half of the century are being tested again. Some new and better technology may be developing, but for the present, the old designs are still the best.