# A Combined Hydraulic and Mechanical Classifier

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IN a Bolivian tin concentrator an appliance was needed to furnish a suitable product for fine jigging from a pulp of the following composition:

| Mesh | Per Cent. |
|---|---|
| + 20 | 8.0 |
| + 40 | 36.5 |
| + 60 | 9.0 |
| + 80 | 10.5 |
| +100 | 5.5 |
| +150 | 4.5 |
| –150 | 25.0 |
| | 99.0 |
| Loss | 1.0 |

In the jigging process, particles of cassiterite as small as 0.1 mm. can be recovered, provided they are not present in excess, that is if the material treated on the jigs contains sufficient coarser sands to keep the interstices between the grains open. Removing the fine material from the pulp by screening, to prepare the jig feed, is impractical, because that means the use of an 80-mesh screen or finer, and is not as effective as hydraulic classification. A screen would eliminate mineral grains from the feed which can be recovered by jigging, and in addition would throw more gangue and low-grade middling on to the jig.

Formerly a one-spigot Richards vortex classifier had been used to accomplish this separation, but the tangential openings through which the hydraulic water enters became clogged by fine vegetal matter with which the water was contaminated, and which it was impossible to remove from the water. Consequently the work of the classifier was imperfect and a good deal of slime was sent to the jig. When designing the plant referred to in this paper it was decided to use a hydraulic classifier as shown in Fig. 1. The essential features had been copied from the Anaconda classifier.[1] This remodeled classifier consists of a truncated pyramidal wooden hopper *A* with an attachment of cast iron

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[1] *Trans.*, vol. 46, p. 277 (1913).

bolted to it at the bottom. The heavier and larger particles settle and pass through the 1¼-in. nipple *C* which is screwed into a flange and laid loose in a recess turned in the casting *B*. The hydraulic water enters through the 1½-in. pipe *D* which is screwed into the casting. The distance of the pipe from the exit of the nipple *C* can be regulated by screwing the pipe up or down, a short hose connection being provided between the valve *E* and the mill water piping to make this flexible.

The work of this classifier was satisfactory if sufficient hydraulic water was used, but under these conditions a good deal of material that should have gone to the jig was carried into the overflow. The difficulty could have been remedied by again submitting the overflow to hydraulic classification in a second pocket, but this was objectionable because it

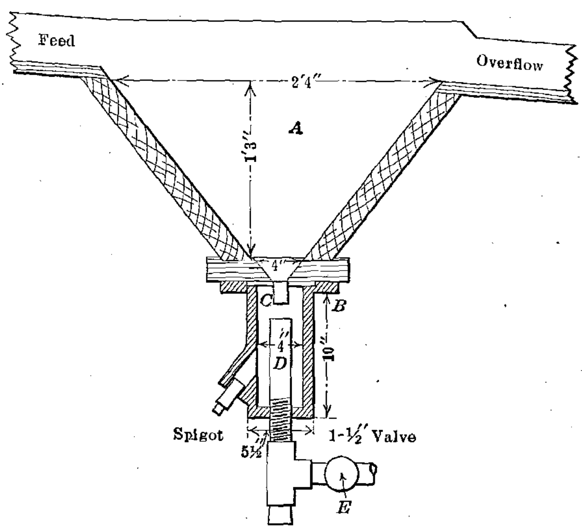


FIG. 1.—SECTIONAL ELEVATION OF HYDRAULIC CLASSIFIER.

would have added another quantity of hydraulic water to the pulp, and would have diluted the overflow too much. The classifier was therefore run with less hydraulic water, so that its sand product contained some slime. The separation effected by the jig was not quite satisfactory under these conditions, since the large amount of fines in the feed made the beds pack in hard banks, producing a low-grade concentrate and causing free mineral to go into the tailing.

The desideratum in this instance was to obtain separation of the part of the sands in the pulp under hindered-settling conditions, or nearly so, without diluting the fine material with too much water. The sand product from a mechanical classifier, although practically free from slime, is the result of free settling of the pulp, and therefore is not as desirable as the sand separated by hindered settling in a hydraulic device. I therefore designed an apparatus which combines the advantages of the hydraulic and the mechanical classifier. Having previously used a paddle-wheel of the Fleming type for dewatering, this machine was selected as a mechanical classifier in preference to the more generally used types on account of its compactness and its low first cost.

As shown in Fig. 2, the device consists of a narrow wooden trough in which the paddle-wheel revolves. Details of the construction of the

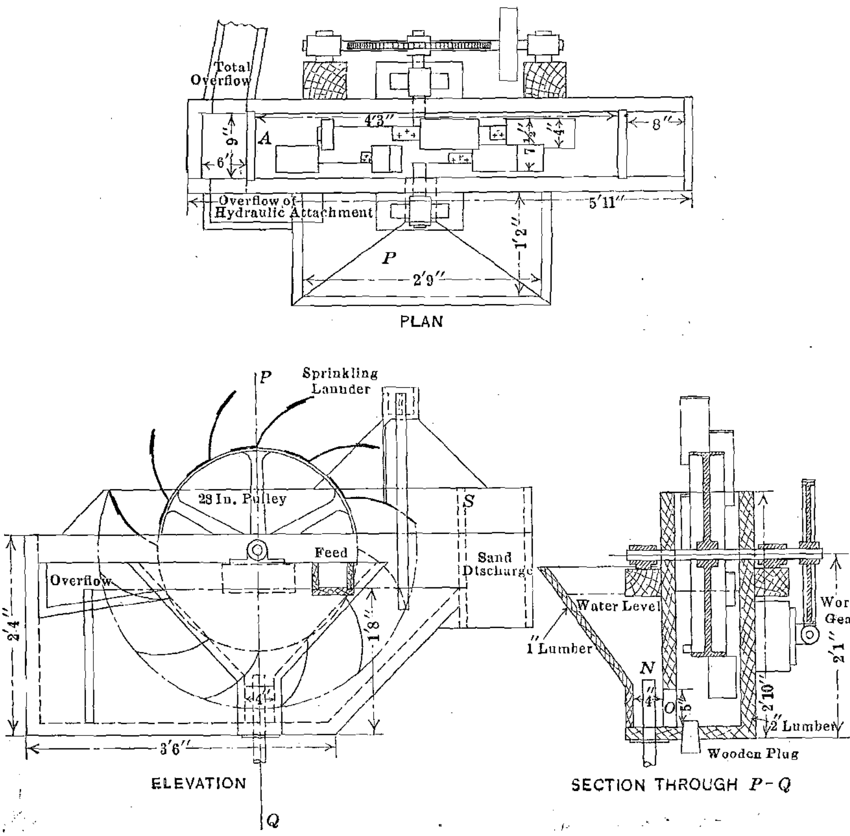


Fig. 2.—Combined Hydraulic and Mechanical Classifier.

classifier can be easily gathered from the accompanying drawing. The tips of the blades are protected by ¼-in. iron strips fixed with two countersunk rivets. The strips last about four months and are replaced at small cost. The blades are cut from ¼-in. plate and bent in the fire. They are fixed to the rim of the pulley by three 1 by ⅜-in. machine bolts. The holes in the rim and those in the blades are bored from a template and spare blades are kept ready so that little time is lost in making renewals. The wheel is driven at the rate of 3 r.p.m. by a simple worm gear—in this case taken from an old vanner—which is directly belted to a line shaft. The feed is introduced into the trough near the bottom at *O*, after having been submitted to hydraulic classification in the pyramidal attachment *P* in which an ascending current of water flows out of the pipe *N*. Consequently the material which is undesirable in the jig feed is floated off with the use of less hydraulic water than needed in an ordinary hindered-settling classifier because the slime that comes with the sand into the trough is separated by the paddle-wheel and flows over at *A*. It is evident that classification in the hydraulic pocket does not entirely take place under hindered-settling conditions, because in that case the sand treated by the wheel could not contain any slime. The amount of hydraulic water used is such that the dilution of the overflow does not exceed the required density and therefore the classification cannot be perfect. However, the most objectionable factor, namely, the presence of slime in the jig feed, is to a large degree eliminated by the subsequent action of the paddle-wheel. The moisture in the sand discharged by the wheel can be regulated in two different ways, (1) by raising the level of discharge, and (2) by increasing the distance between the tips of the blades and the discharge.

The discharge level of the sand product can be varied by inserting strips of wood of different heights into the slots marked *S*. To obtain practical results the sand is discharged at a point 1½ in. above the overflow with 50 to 55 per cent. moisture, but with the level of sand discharge raised to 2½ in. above the overflow, and the discharge edge spaced from the wheel as shown in the drawing, the product contains but 30 to 35 per cent. moisture, but under these conditions the capacity decreases out of all proportion. If the machine is overfed, the sand piles up so high at the discharge that part of it remains lying on the paddles, and falls back into the trough at the other side, finally choking the classifier.

The second method gives a drier and cleaner product, because the sand is piled up in front of the wheel until it reaches sufficient height to slide over the discharge edge, and nearly all the water drains back into the trough. There is no objection to placing the overflow rim in the trough close to the paddles, which makes the machine more compact. I formerly tried to obtain a more thorough settling by leaving a distance of about 10 in. between the tips of the paddles and the overflow, with the only result that the space between became tightly packed with fine sand, and the actual overflow was formed at only ½ in. from the tips.

A spray is provided to remove the adhering grains of sand from the blades of the wheel, and after having cleaned the blades, the water falls on the pile of sand lying in front of the wheel and gives it a final wash. The slower the wheel revolves the cleaner will be the sand product, because then every blade brings up slightly more sand than it can deliver, and part of the material falls back into the trough to be shoved up again by the next blade. Therefore the sand is repeatedly turned over before being discharged, which materially assists in removing the slime.

The classifier can easily handle 60 tons per 24 hr. of dry pulp with a specific gravity of 3.5 to 3.8. Screen tests made on the products are shown below:

| Mesh | Sand Product Per Cent. | Overflow, Per Cent. |
|---|---|---|
| + 20 | 11.0 | 0.3 |
| + 40 | 42.0 | 5.4 |
| + 60 | 13.5 | 12.5 |
| + 80 | 16.3 | 11.0 |
| +100 | 8.0 | 9.3 |
| +150 | 2.5 | 11.5 |
| −150 sand | 4.2 | 48.2 |
| slime | 1.4 | |
| | 98.9 | 98.2 |
| Loss | 1.1 | 1.8 |

These figures show that there is no separation at a definite screen size, but this can not be expected when classifying a pulp that contains particles of cassiterite with a specific gravity of over 6.5 and particles of gangue with a specific gravity less than 3.0. The plus 60-mesh material in the overflow is all very low-grade, and the minus 80-mesh in the sand product is the richest material in this product.

The jigging practice has considerably improved with the better adapted feed and the grade of the concentrate has been raised from 66 per cent. metallic tin to an average of 70 per cent. and more. The concentrate from the jig, which is of the Harz type making a concentrate on three sieves, has the following composition:

| Mesh | Per Cent. | Metallic Tin, Per Cent. |
|---|---|---|
| + 20 | 20.9 | 71.7 |
| + 40 | 55.3 | 72.2 |
| + 60 | 10.4 | 71.0 |
| + 80 | 4.6 | 65.6 |
| +100 | 2.7 | 66.2 |
| +150 | 3.6 | 70.1 |
| −150 | 1.3 | 68.3 |
| Total and average | 98.8 | 71.36 |
| Loss | 1.2 | |
| | 100.0 | |

The feed to the classifier contained in this instance 3.5 per cent. tin, the sand product or feed to the jig was not assayed, but carried probably somewhat more cassiterite than the original pulp.

When working on a richer feed of about 13 per cent. tin, the concentrate from the jig contains a much larger percentage of fines, as is shown below:

| Mesh | Per Cent. | Metallic Tin, Per Cent. |
|---|---|---|
| +20 | 10.0 | 71.8 |
| +40 | 36.5 | 72.1 |
| +60 | 16.5 | 72.7 |
| +80 | 12.0 | 72.0 |
| +100 | 6.5 | 69.8 |
| +150 | 7.0 | 69.2 |
| −150 | 10.0 | 70.3 |
| Total and average | 98.5 | 71.98 |

I will now explain why in this case jigging is used for the treatment of a pulp that could be handled by tables. When dressing an ore assaying less than 5 per cent. tin on tables it is impossible, even with the best classification, to obtain at one operation a concentrate assaying better than about 63 per cent. tin, whereas a jig gives a product of a considerably higher grade, and once it has been properly adjusted does not need much attention, even with a varying amount of feed. When working on richer material, a table does not produce a concentrate of more than 66 per cent. In tin dressing the grade of concentrate produced is of paramount importance, on account of heavy freight charges to the smelters and the reduced smelting charges on high-grade products. It is therefore advisable in every case to recover as much concentrate as possible on jigs.

The whole construction of the classifier could, of course, be improved, especially as regards the form and overflow of the hydraulic attachment, but since the machine does the work expected of it, it is not worth while to make changes. The power required to drive the wheel is under 1/6 hp. The only attention required is to lubricate the bearings occasionally and to adjust the water valves, if the quality of the feed varies. The machine has been working since the beginning of July, 1915, and at the date of writing (November, 1915) the tips of the paddles have just had to be renewed. One paddle has broken near the rim of the pulley, but this was probably due to poor material or perhaps because the paddle after bending had been cooled too quickly.

After writing this I noticed the classifier proposed by A. E. Drucker in the *Mining and Scientific Press* of Oct. 16, 1915, which is essentially the same as the paddle-wheel with hydraulic attachment. There is no reason why the latter machine could not be used with advantage to prepare the feed for a regrinding mill.