SLIME TREATMENT AT MOUNT BOPPY.

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In crushing any material, there is always a certain percentage of impalpably fine powder produced, which makes itself evident, as dust with dry crushing and mud with wet crushing. If the particles of this extremely fine powder are sharp and angular, they settle rapidly in still water, and permit of easy percolation through the interstices between them. But when they have no coherent form, and cannot resist distortion, they form what is approximately a colloidal solution, in which they remain suspended for periods running into weeks. Moreover, when settled these "slimes," as they are called, will not allow any percolation through them. As a general rule, the slime runs higher in gold values than the angular or "sand" portion of the mill product, and has the additional advantage that this gold is much more easily attacked, and dissolved, by KCN solution. Two great problems, however, arise in its treatment—(1) How to bring the gold and KCN into contact, as the slime will not admit of percolation, and (2) how to extract the gold-bearing solution from the colloidal mixture.

The first difficulty is almost universally overcome by adding liquid in such quantity that a fairly thin mud is formed, and agitating this thoroughly, to cause complete homogeneity. Other ways are—(a) By mixing sufficient sand with the slime to make it permeable to the solutions; (b) by drying to drive off any contained water, and so increasing its capacity for absorbing solution; and (c) by forcing solutions through under pressure.

The second difficulty is surmounted when the pulp is siliceous, by adding some coagulent, like lime or alum, which causes the particles to settle, when the clear solution is decanted off, as in South African practice. But when argillaceous, this coagulation is too slow, and so separation has to be effected, by forcing the liquid through a medium which allows of its passage, but prevents that of the slime. This is the filter press method, and is characteristic of Western Australian, and more especially Kalgoorlie, practice, which that at Mount Boppy closely resembles.

Briefly summarising the adaptations of the several slime treatment proccesses, it is seen that — (1) Percolation of mixed sands and slimes labours under the disadvantage that it is slow, and that the gold is dissolved out of the slimes quicker than from the sands, and hence, if the later carry values, treatment must be prolonged, and if they do not, they represent so much diluent, and thus useless material. (2) Drying is scarcely ever resorted to, as dilution is much cheaper, and the leaching problem is as bad as ever. (3) The forcing of solutions through the pulp by pressure is done either by upward percolation in vats, the solution entering at the bottom, and escaping at the top, or by separating the battery slime pulp in filter presses, and forcing cyanide solution through the cakes, as was first done at Kalgoorlie with indifferent success. Both these methods have their efficiencies decreased by incomplete æration, and the formation of channels of unequal permeation and short circuiting. (4) Agitation and decantation, which has the advantage of cheapness of working, the average cost on the Rand being 2s. 3d. to 3s. per ton, with extractions up to 90 per cent. The disadvantages are the enormous size of plant due to the slow settling of even favourable ores, some vats being under treatment three weeks, while the actual solution might only take three hours; and the waste of KCN and water due to the large amount of dilution and washing required. In addition to which it is unsuited to some classes of ores, and the cost of charging and discharging the vats is large, where cheap labour is unavailable. (5) The filter press can treat any class of slime; it is rapid, as treatment rarely exceeds six hours, of which only one hour is spent in the presses, and it furnishes complete æration and washing, with no waste of KCN or water. The disadvantages are the large first cost of plant, and somewhat high working expenses.

The country rock in the Cobar district consists mostly of slate, and this, in crushing, produces a large amount of argillaceous, as distinct from arenacious slime. This fact, combined with the scarcity of water, renders filter pressing imperative at Mount Boppy. The mine produced the largest amount of gold in the State in 1904 and 1905. In the former year 35,378 tons of ore were treated for 21,759oz. fine gold, the average yield thus being 50s. per ton of ore. The total yield being made up of—30 per cent. by amalgamation, 35 per cent. by cyanidation of sand, 25 per cent. by cyanidation of slime, 10 per cent. from concentrates.

The sampling-room is alongside the crushers, and is equipped with a small Gate's crusher, delivering ¼-inch and under, and a Little Giant jaw crusher, which further reduces the size to about that of wheat. The sampling floor is of iron, 8 feet square. One pound of ore is taken from each truck, making 1500lb. in 16 hours, when it is sampled down

The battery is driven through a countershaft, geared to the main engine by rope belting. It consists of 60-head, with a wooden frame. The stamps weigh 1100lb. each; height of drop, 7½ inches; drops per minute, 107; screen, 20 holes to the linear inch; duty of stamps, 5 tons each per 24 hours.

The ore as it comes from the mine is treated in the following manner:—

Oxidised Ore.

(1) Brace by tramline to (2).

(2) Grizzleys, bars 3 inches apart, oversize to (3), undersize to (4).

(3) Size D. Gates' crusher, which breaks to 3 inches, thence by elevator to (4).

(4) Small Grizzley, oversize to (5), undersize to (7).

(5) Shaking launders actuated by vibrating jaws of crushers to (6).

(6) Two Blake crushers, which crush to 1 inch, delivering to (7).

(7) Storage bins, thence by inclined tramway to (8).

(8) Battery bins for 40-head, thence by 8 Challenge feeders to (9).

(9) Eight battery bins, fed with water from (37), and delivering to (10).

(10) Copper amalgamation plates, 10 feet long, saving amalgam, pulp by launder to (11).

(11) 40 feet Raff wheel, having 3½ revolutions per minute, delivering through a launder and Butter's and Mein's distributor to (12).

(12) Iron collecting vats 27 feet diameter; 5 feet high, having a capacity of 100 tons, sand to (13), slimes to (16).

(13) Leaching vat, receiving KCN solution from (15), residues to dump and stope, gold solution by launder, through distributor to (14).

(14) Five Zn boxes, gold slimes to (29), weak solution by distributor to (15).

(15) Weak solution sumps, KCN added to requisite amount for standard strength, 0.2 per cent., and elevated by centrifugal to (13).

(16) Sand trap, sand underflow to (11), slimes to (17).

(17) Spitzkasten 50 feet x 15 feet x 10 feet deep, underflow to (12), overflow to (35).

(18) Two Montejus, with 2-inch diameter air pipes, thence to (19).

(19) Three-ton Dehne battery press, cakes to (20).

(20) Vortex disintegrator, receiving slime from (19), and (36) and KCN solution from (34), and discharging to (21).

(21) Storage sump, thence by centrifugal pump to (22).

(22) Three agitators circulated by centrifugals, and fed by weak KCN solution from (34), and by 7 per cent. strong KCN solution, thence by gravitation to (23).

(23) Two Montejus, thence by air at 90lb. per square inch to (24).

(24) Two 3-ton Dehne treatment presses, washed by KCN from (34), residues to tip, gold solution to sump, thence by pump to (25), water wash to (33).

(25) Pressure tank delivering to (26).

(26) Clarifying press washed by weak KCN from (34), thence by distributor to (27).

(27) Three zinc boxes, gold slimes to (29), weak solution by distributor to (28).

(28) Weak solution sumps to treatment presses (24).

(29) Sulphuric acid digester to (30).

(30) Vacuum filter to (31).

(31) Muffle calcining furnace to (32).

(32) Smelting furnace, giving bullion.

(33) Water wash from presses (24), to mixing solution sump, thence by pump to (34).

(34) Weak KCN storage.

(35) Slimes from (15) by launder to (36).

(36) Slime dams, residues to (20), overflow to (37).

(37) Battery water supply.

SULPHIDE ORE.

(1) Brace by tramline to (2).

(2) Grizzleys, oversize to (3), undersize to (4).

(3) Size D. Gates' gyratory crusher, thence by elevator to (4).

(4) Small grizzley, oversize to (5), undersize to (7).

(5) Shaking launders actuated by vibrating jaws to (6).

(6) Two Blake crushers, delivering to (7).

(7) Bins, thence by inclined tramway to (8).

(8) Battery bins for 20-head, thence by four Challenge feeders to (9).

(9) Four battery boxes, fed by water from (37), and delivering to (10).

(10) Copper amalgamating plates, saving amalgam, pulp by launder to (11).

(11) 17-inch diameter Raff wheel, by launder to (12).

(12) No. 1 Spitzlutte, underflow to (13), overflow to (15).

(13) No. 1 Wilfley table saving concentrates, residues to (14).

(14) Ivanhoe pan producing amalgam and fine sand, the latter to (19).

(15) No. 2 Spitzlutte, taking overflow from (12), and sending overflow to (17), and underflow to (16).

(16) No. 2 Wilfley saving concentrates, residues to (14).

(17) No. 3 Spitzlutte, taking overflow from (15) and (17), sending it underflow to (18), and overflow to (19).

(18) No. 3 Wilfley, saving concentrates, middlings to (14), tailings to (22).

(19) No. 4 Spitzlutte, taking overflow from (17), and sending its overflow to (20), and underflow to (21).

(20) No. 4 Wilfley table, saving concentrates and sending tailings to (22).

(21) No. 5 Wilfley table, saving concentrates and sending tailings to (22).

(22) Slime distributor to (23).

(23) Eight canvas slime tables, 9 feet long by 6 feet wide, saving concentrates, residues by centrifugal pump to (24).

(24) Collecting vats for sands, slimes overflow meets oxide slime and treated with it.

(25) Leaching vats for sands from (24), residues to dump and stope, gold solution through same boxes as oxidised sand gold solution.

The slimes treatment plant consists of—1 puddler, 1 pulp storage sump, 3 agitators, with 3 four-foot Morris centrifugals attached, 4 Montejus, 3 Dehne filter presses of 3 tons capacity, 2 smaller clarifying presses. The plant also includes the necessary adjuncts to an air-compressor, several pumps, a pressure tank for the clarifying presses, and the zinc boxes, H_2SO_4, and digesters, drying and smelting furnaces of the extractor house.

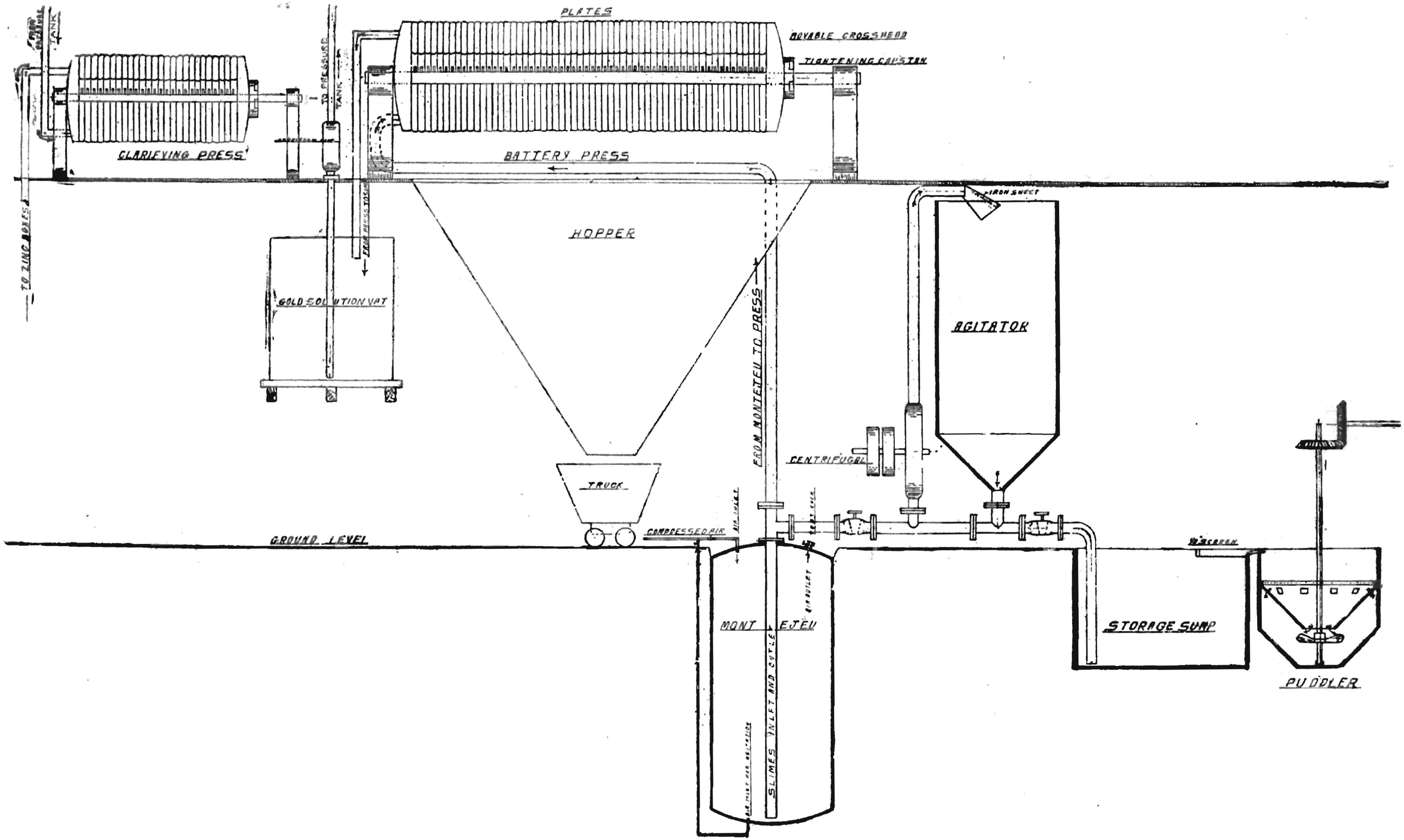
The contents of the trucks from the slime dams are tipped into the puddler, known as a "Vortex disintegrator," whose top is on the ground level. It consists of a steel cylinder 6 feet diameter and 5 feet deep, with an inverted conical bottom, and fitted with an inverted conical diaphram, with a hole in the centre to admit a vertical shaft to which a propellor is attached, and with holes round the periphery to allow circulation of the mixture. A constant supply of .04 per cent. KCN solution is here introduced, and the pulp is drawn down the inside cone, thoroughly mixed and disintegrated, and then circulated up through the holes at the periphery, to overflow through a quarter inch screen to a storage sump, from which it is periodically pumped to the agitators, one of which its contents just fill. The agitators consist of steel cylinders 5 feet diameter, 12 feet high, tapered at the bottom to an opening connecting with the 4-foot Morris centrifugal circulating pump on the one hand and to the outlet to the Montejus on the other. The mixture in these agitators consists of a little over one part of water to one of slime, that quantity being just sufficient to fill one Monteju, and later one press; in this proportion the fine materia will remain in suspension for 40 minutes without agitation. In the agitators sufficient 7 per cent. cyanide solution is added from a storage tank to bring the strength of the solution, which has fallen by dilution to .02 per cent., up to .12 per cent. The pulp remains in the agitator for three hours, during which time it is continually circulated by centrifugal pumps having pressure chambers fed by KCN solution to keep grit out of the bearings, the KCN being used to prevent dilution of the solutions. The material is continuously drawn out through a 5-inch diameter pipe at the bottom, and discharged on the top of the agitator against an iron plate, which breaks it up into fine spray, and thoroughly ærates it. This is much more economical, and quite as efficient as agitation by compressed air.

At the end of the agitation, the centrifugal pump is thrown out of gear, and the solution is allowed to gravitate to the Monteju. This consists of a steel drum, similar to an air receiver, but placed with its axis vertical. On top it has a 5-inch pipe for the entry and discharge of the pulp, a 1-inch high pressure air-cock, and a test and air outlet cock. On the bottom is a high pressure air pipe by which air can be introduced to keep the pulp from settling, should it be necessary to let it remain long in the Monteju. During the charging the top cock is open, to allow the air occupying the Monteju to escape, and the height of the liquid can be gauged by putting a rod through the cock.

The principle of the Monteju is the same as that of the ordinary wash bottle, high pressure air entering by a small pipe at the top, pressing on the surface of the pulp, and forcing it up a large outlet pipe, which reaches almost to the bottom. When full the valve from agitator to Monteju is closed, and that from the latter to the filter press opened, the air at 90lb. to the square inch is turned on, and the slime is forced into the presses on the floor above.

At Kalgoorlie these Montejus have been mostly discarded for plunger pumps, which are from 40 to 60 per cent. cheaper, since it is necessary to waste one whole Monteju of high pressure air at every filling of the press, besides additional air for agitation. Moreover, the agitation in the Montejus causes the coarser particles to settle to the bottom, and so to be sent up to the presses first, and deposit on the sides and lower portions of the cakes, causing subsequent unequal resistance to pressure and short circuiting of solutions.

The presses are of German make, being manufactured by Dehne. There are three on the plant, each of which makes 50 cakes 40 inches by 40 inches by 2 inches, or a total of 75 cubic feet, which is equivalent to 3.15 tons of dry slime, as the cakes contain 24 per cent. of moisture. The presses—whose application to slime treatment was first suggested by the use of a similar contrivance with sugar cane in Queensland, although previously used in other metallurgical processes, and first put into practice at the Lake View Consols, Kalgoorlie, in 1898, are of two kinds, one with an outlet channel in the press; the other, with drain cocks and an outside channel. The Dehne presses belong to the latter class, and have the disadvantage of renewal of cocks and the labour of closing and opening them, but any broken cloth is immediately detected and shut off, while with inside discharge the whole of the cloths must be examined on the completion of the pressing. The Dehne press consists of two fixed end-supporting standards, connected by two 5-inch diameter steel rods, which have to bear the whole weight of the full press. On one end is a fixed, and on the other a movable crosshead with a 2-foot travel, along which it is moved by a rack and pinion. In between the crossheads come the frames or plates which are of three different kinds, but are all supported on the steel rods by projecting lugs cast on them. As seen facing towards the movable crosshead all the plates have square lugs on the left-hand bottom and right-hand top corners, through which are bored four holes, two in each lug, and known as the slime inlet and solution inlet in the bottom and solution outlet and air outlet in the top lug. All the faces are machined, so that when the plates are butted and screwed up, these holes form continuous pipes, which have branches to the various plates, where desired.



Mt. Boppy Slimes Plant—General elevation, press and accessories.

(1) The "high pressure" or "solution plate" (Fig. A), distinguished

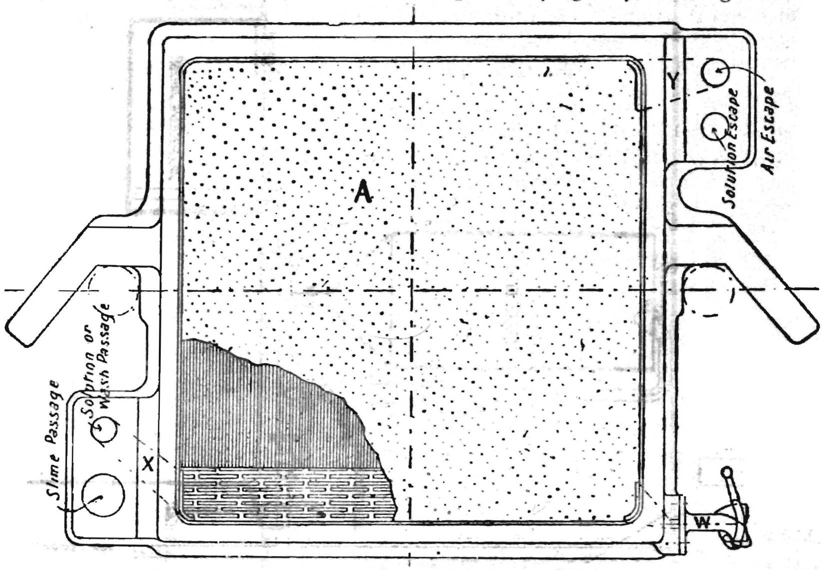


Fig. A.—Solution Plate for Filter-Press.

by a knob on the upper part of the top lug, consists of a square frame of cast-iron, enclosing two perforated plates kept apart by a piece of iron with vertical corrugation. These plates support the filter-cloth, but allow the solutions to pass through them, and down the corrugated sheet, which gives place to a crimped sheet for 5

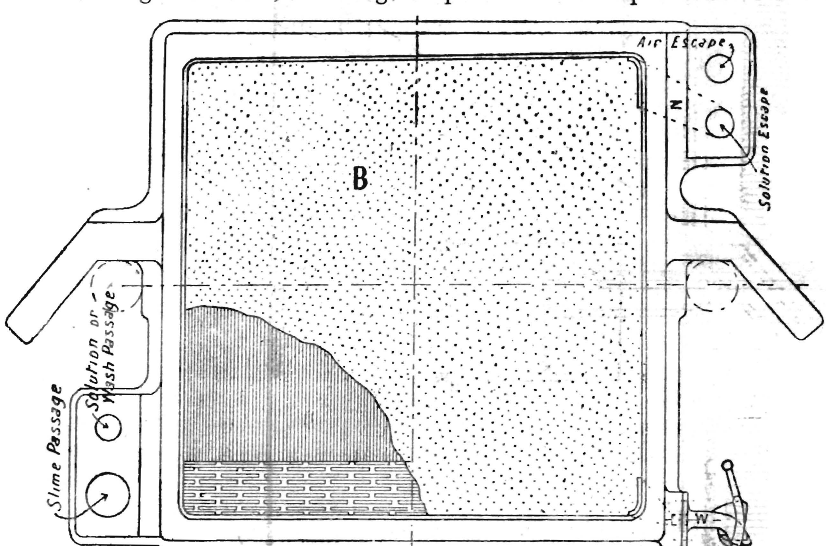


Fig. B.—Air Plate for Filter-Press.

inches at the top and bottom, so as to allow the lateral flow of the solutions to the outlet cock W. The frame is also connected to the solution or wash passage (see X) in the bottom, and the air escape passages (see Y) in the top lug.

(2) The "low pressure" or "air plate" (Fig. B) is distinguished by a knob on the lower portion of the top lug, and has perforated and corrugated plates, and discharge cock (W) similar to the "high pressure" frame, but is only connected to the solution escape (see Z). Both of these plates have filter cloths on both sides, brought together about every foot to keep them in place.

(3) The third is the "Dummy" "open plate" or "slimes plate" (Fig. C), in which the cake is formed, and consists of the frame

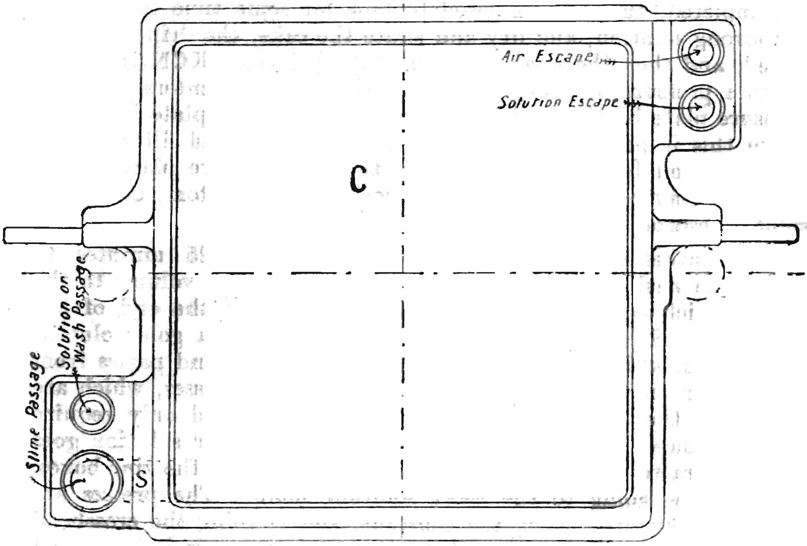


Fig. C.—Open Plate or Slimes Plate for Filter-Press.

without any plates or filter cloths. It is connected only to the slime passage. (See. S).

Starting from the fixed crosshead, into which the slime and other passages deliver, the frames are arranged:—1st, open plate; 2nd, high pressure; 3rd, open plate; 4th, low pressure plate; the cycle being repeated to the other crosshead, which has also an open plate against it. The Dehne presses are closed by turning a capstan nut with square thread, on each of the supporting rods, which force the movable towards the fixed crosshead. As the motion of each nut is independent of the other, crossheads are frequently broken by unequal screwing, besides occasioning a large amount of leakage. To avoid this, hydraulic closed presses are becoming the rule in Western Australia, some of the old hand-presses being converted. Another method of closing is by rotating a screw, placed transversely to the press, one end of which has a left and the other a right hand thread; these gear into the longer arms of two bell crank levers, the smaller arms of which press against the crosshead.

After screwing up the press, all the drip cocks are opened, and the air at 90lb. to the square inch is turned on to the Monteju and forces the slime into the press. As the pulp enters the "Dummy," to which alone the slime passage is connected, it finds itself between the filter cloths of the high and low pressure plates, through which the solution immediately passes, the slime being caught on the cloths and the cakes gradually built up. The solution escapes from the cocks into a launder or drip tray, which also catches the leakage from between the plates. When the cake is completed, the air is allowed to flow for some time to displace the strong solution, and dry and ærate the cake, the drip-cocks are closed, and then the weak solution of .05 per cent. KCN is turned on at a pressure of 100lb. to the square inch, and enters the high pressure plate by the wash inlet passage, giving the plate its name. From this it passes through the perforated iron and filter cloths, and cakes on both sides of it, into the low pressure plates, from which it may escape either by the cocks at the bottom, or by the solution escape at the top as desired.

The cakes are 2 inches thick, and take 20—25 minutes to form; the wash passes for $1\frac{1}{2}$ hours, and is equal in volume to the cakes, which contain 24 per cent. of moisture at the end of the operation. From the presses the solution goes to a gold solution sump, from which it is pumped to a pressure tank and passes from this, under 18 feet head, through two clarifying presses, which are similar to the other presses, but much smaller, and only require cleaning once in several days. From here the clear solution goes to the extractor house and by a distributor through the zinc boxes, the overflow going to the weak solution sump. The presses are discharged by unscrewing the capstans, and running the crosshead back, when the plates are pulled one by one towards it by a man on each side of the press and the cakes dropped, or pushed into a hopper below, delivering to the trucks, which are hauled by endless rope to the dump.

To return to the coarser slimes which settle in the large spitzkasten, and which constitute one-half of the whole amount treated. They are from time to time flushed out by either or all of three openings, into a 6-inch pipe, which delivers to two of the Montejus, from which it is forced through an ordinary filter press known as the "Battery Press" to get rid of its superfluous water which would unnecessarily dilute the cyanide, and cause excess of the stock solution. From the Battery press the cakes go to the puddler, and are treated thenceforward in the same way as the slimes from the dams.

The precipitation boxes are of wood, in eight compartments; there is enough copper present to just coat the Zn. The boxes are cleaned up once a fortnight, the zinc from six of the eight being dissolved by strong H_2SO_4 in a wooden vat, and a pivoted iron digester provided with fume hoods.

The gold slimes are dried in a muffle calcining furnace, and smelted in the ordinary way, the bullion being 800 fine.