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FROTH FLOTATION APPARATUS

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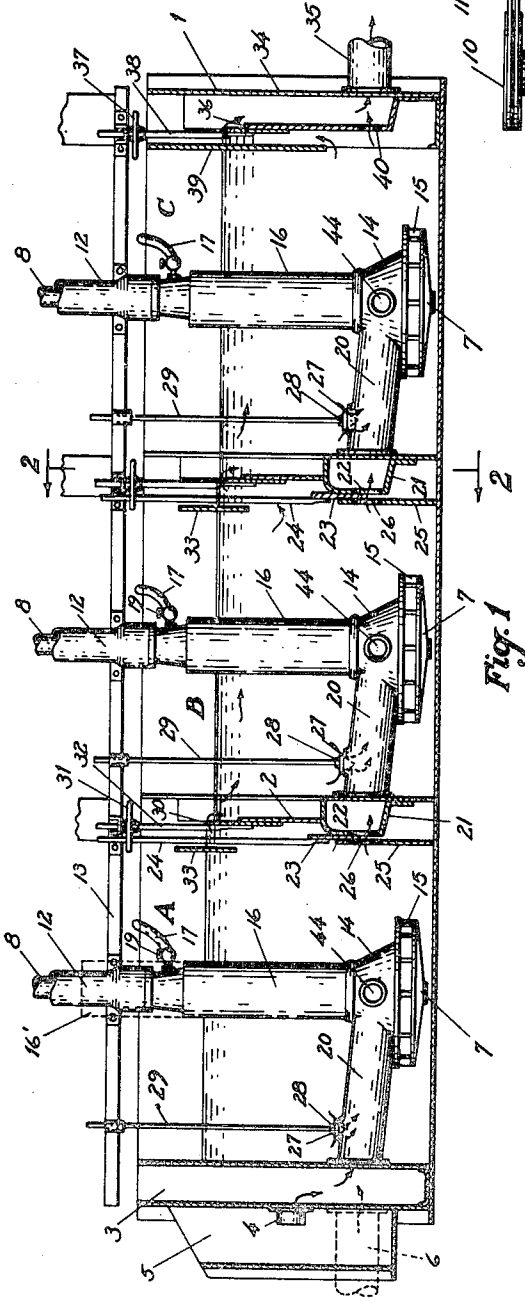


Fig. 1

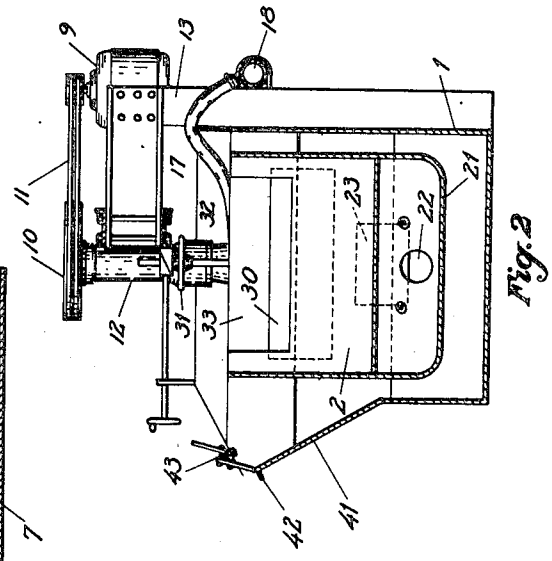


Fig. 2

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## FROTH FLOTATION APPARATUS

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This invention relates to an improved method of and apparatus for flotation treatment of ores and more particularly to improvements in the treatment of ores wherein mechanical agitation is employed and mineral laden froth is formed.

In the present froth flotation apparatus employing a plurality of serially arranged cells having individual agitators or impellers in each cell, the pulp being acted upon is passed from one cell to another through each agitating unit. With this arrangement mineral laden froth and fine particles which have already been conditioned by one cell and are not removed by the usual skimming action are subject to recirculation and a rescouring action when they are caused to be fed to the next cell through its impeller. The action in the following cell on already conditioned material may result in a removing of the agent and air from the mineral particles, thus deactivating or nullifying the conditioning which previously has been accomplished in the preceding cell. As a result it is necessary to add additional reagent to recondition the pulp so that mineral laden froth can again be formed and removed. As a consequence of this it is seen that with this reconditioning action present the efficiency of the flotation apparatus is not as high as it should be.

One of the objects of the invention is to so construct and arrange a flotation apparatus embodying a plurality of cells so that once the pulp has been conditioned by any cell and rises to the top as mineral laden froth, it will remain at the top or upper zone of the pulp and not be subject to any reagitation and rescouring action which may cause a nullification of the conditioning already accomplished.

Another object of the invention is to provide an improved method of treating ores which will permit higher recovery of minerals at lower costs.

Still another object is to provide an improved method of treating ores which will eliminate reagitation in and rescouring action of froth and fine pulps once conditioned for removel from a flotation apparatus involving a plurality of serially arranged cells each having agitators.

A further object is to provide a froth flotation apparatus which will permit free flow of conditioned pulp through the upper zones of all the cells until removed, thus permitting the capacity of the apparatus to be increased, together with its efficiency.

A still further object is to provide a froth flotation apparatus which will eliminate any short circuiting of conditioned pulp and thereby permit

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the collection thereof by stage reagent feeding without the possibility of any undesirable rescouring.

Other objects of my invention will become apparent from the following description taken in connection with the accompanying drawings showing improved flotation apparatus embodying structure for carrying out my improved method of ore treatment.

In the drawing:

Figure 1 is a side elevation partially in section of a multi-cell flotation apparatus; and

Figure 2 is a sectional view showing details of construction, said view being taken on the lines 2—2 of Figure 1.

Referring to the figures in detail there is disclosed a three cell flotation machine, but it is to be understood the number of cells may be increased or decreased as desired. The machine shown comprises a tank 1 divided into cells A, B and C by partitions 2. The first cell A is provided with a feed compartment 3 into which pulp is fed through an opening 4 from a feed box 5. In place of this feed box and opening 4 a feed conduit 6 can be provided if desired, which is shown in dotted lines in Figure 1.

In the lower portion of each cell there is mounted an agitating impeller 7, which impeller is driven by a vertically positioned shaft 8 rotated by means of an electric motor 9 and suitable sheaves 10 and belts 11. The shaft 8 is journaled at its top in a suitable bearing 12 carried by super-structure 13 at the top of the tank. This super-structure also has mounted thereon the motor 9, all as shown in Figure 2.

The impeller has associated therewith an overlying flaring hood and extending from its lower peripheral portion are vanes 15 which surround the impeller, all of which is well known construction. Extending upwardly from the upper end of the hood is a column 16 which is arranged to be sealed with the housing of the bearing 12 in order that air or gas may be fed to the column and the impeller under a pressure, which pressure should be less than that created by the hydrostatic head of the pulp in the cell above the impeller. This air is introduced into the top of the column through a pipe 17 coming from a header 18 at the back of the tank as best shown in Figure 2. Associated with the pipe at its entrance to the column is a control valve 19 for regulating the flow of air. By delivering gas, such as air, under pressure to the hood the material passing through the impeller is super-charged with air which results in the air being entrained

in the pulp as small bubbles, thereby causing superior flotation action. This super-charging feature is fully disclosed and claimed in the co-pending application of L. H. Logue, Serial Number 497,749, filed August 7, 1943, Patent No. 2,390,111, granted December 4, 1945, for Aerating apparatus. If super-charging is not desired the sealed column 16 can be replaced by a column 16' shown in dashed lines in cell A of Figure 1. The top of this column is open to atmosphere.

Each impeller has associated therewith a pulp feed intake conduit 20, this conduit entering the impeller through the hood 14. The feed intake conduit associated with the impeller of the first cell A is connected directly with the feed compartment 3, whereas the feed intake conduits of the succeeding cells B and C are arranged to be connected to openings in the partitions 2 so as to receive pulp from the previous cells. As shown in Figure 1 the partitions 2 are so constructed as to provide intake compartments 21 to which the inlet ends of the conduits are connected. Pulp from a preceding cell is fed into these inlet compartments through an opening 22 with which is associated a gate 23 for varying the area of the opening 22. These gates have control connections 24 at the top of the tank so as to be accessible for control at will. Each gate is slidable between the wall of an inlet compartment 21 and a plate member 25 extending upwardly from the bottom of the tank, said plate being provided with an opening 26 aligned with the opening 22 in the intake compartments. It is thus seen with this arrangement heavy particles in the lower zones of the cells can pass to a succeeding cell through the intake conduits and to the impeller of said succeeding cell to be agitated thereby. The amount of pulp transferable in this manner can be controlled by the adjustable gate 23. It is also to be noted that the arrangement is such that the inlet end of the feed intake conduit 20 will be sealed off from atmosphere so that the air introduced into the column about the impeller can remain under pressure and thus be thoroughly mixed into the pulp as it is agitated by the impeller, all in accordance with the teachings in the Logue application above referred to.

The top side of each intake conduit 20, at a point intermediate to its inlet end and the hood, is provided with an opening 27 which is controlled by a conical valve element 28 carried on the lower end of a rod 29 extending downwardly from the super-structure. By means of this opening 27, pulp which may be in an intermediate zone or the top of the lower zone of a cell can be fed into the intake passage and mixed with that coming from a preceding cell. The amount of pulp being fed through the opening can be varied by controlling the conical valve element 28. Thus it is seen that with this arrangement the impeller can be fed, not only with pulp from a preceding cell, but also with pulp from its own cell. Since the pulp being fed from its own cell is from an intermediate zone it will comprise heavier material and it is this material which it is desirable to recirculate through the impeller.

The partitions 2 between the cells A and B, and B and C are constructed to have such height as to not extend above the surface of the pulp in each cell to thus provide overflow weirs. These weirs are made adjustable by means of an adjustable gate 30. The gates are adjusted by means of a hand wheel 31 at the top of the structure which is associated with a rod 32 connected to the gate. The gates 30 are so adjusted that the level of the pulp in each succeeding cell is slightly less than that of the previous cell when the machine is in operation. Thus there will be no possibility of reverse flow through the cells. Ahead of each gate is a baffle 33 extending crosswise of the cell. This baffle is of such width as to extend above the level line of the pulp and also a substantial distance into the pulp so that all pulp passing the baffle and flowing over the gate to the succeeding cell must pass beneath the baffle.

The last cell C of the series is provided with a discharge compartment 34 from the lower end of which leads the discharge pipe 35. The lighter discharged material or tailings may enter the compartment 34 by overflowing an adjustable weir 36, the gate of which is controlled by a hand wheel 37 and a rod 38 connected to the gate. Ahead of the weir is a baffle 39 extending below the liquid level of the cell C so that all discharged material going over the weir must pass under the baffle. Preferably this baffle extends downwardly in the cell farther than baffles 33. The lower end of the discharge compartment opposite the inlet to the discharge conduit is also provided with an opening 40, through which may pass the heavier sands and tailings in the cell C to the discharge pipe.

The front wall of the tank is arranged to have a suitable overflow lip 42 over which froth collected on top of the pulp in the cells may be removed by means of a rotatable skimmer 43, all as shown in Figure 2 and being common practice. Each impeller hood may be provided with additional inlets 44 to which conduits may be connected for delivering certain material to the impeller for retreatment if such is found desirable. My improved method of flotation treatment of ores and the manner in which it is carried out by the above described apparatus will now be described. Previously conditioned pulp to be acted upon by the machine is delivered into the feed compartment 3 forward of the first cell A. From here it enters the feed intake conduit 20 of said cell and passes to the impeller. The pulp may have a collector reagent added to it prior to its entry into the feed compartment, or it may have the reagent added to it during its passage through the intake conduit 20, all of which is well known practice. The main pulp entering the impeller hood is acted upon by the impeller and at the same time the air in the column 16 is entrained into the pulp. The pulp cascades into the impeller and air is drawn into the impeller by its suction influence. Centrifugal action created by the impeller then causes entrainment and entrapment of the air in the circulating pulp.

Upon release of the pulp in the pulp body beyond the zone of influence of the impeller the air, due to the supercharging, rises as small bubbles without appreciable coalescence until it reaches the surface of the pulp body as indicated in Figure 1. The action of the reagents in the aerated pulp causes the mineral to be recovered to respond to this aerating influence and it rises to the surface where it collects in a froth which is pushed across the overflow lip 42 by the skimmers 43. The non-floated solids in the pulp body of cell A will be continuously agitated by the impeller action and some of these nonfloated solids, especially those in the intermediate zone and the top part of the lower zone, will be recirculated through the impeller because of the valve control opening 27 in the feed intake conduit 20. The amount of solids to be recirculated can be controlled by the cone shaped valve element 28.

The heavier solids in the lower zone of the body of pulp in cell A, which do not rise to the top of the pulp body surface, are passed through the openings 26 and 22 into the feed intake conduit 20 leading to the impeller of the cell B, from where they are agitated by the impeller of said cell and also aerated in the same manner as described with respect to cell A. The lighter solids of the aerated pulp with the small bubbles dispersed therein will rise to the top of the body of pulp in cell B and there will be established a froth at the top of said body, which froth carrying the mineral concentrate is skimmed off by the skimmers in the same manner as the froth is in cell A.

None of the lighter solids which have risen to the top zone of the body of pulp in cell A will be passed into the feed intake conduit 20 of cell B and be acted upon by the impeller. It is only the heavy solids which remain in the lower zone of cell A that pass to the impeller of cell B. The lighter solids in cell A will remain at the top of the liquid and be free to pass over the adjustable gate in the partition 2 between cells A and B. Thus there will be no reagitation and circulation of these finer particles. The flow of these finer particles is indicated by arrows in Figure 1. The gate 30, associated with the partition between cells A and B, is maintained at such a level that the level of the pulp in cell A will be higher than in cell B. This condition is created in cooperation with the proper adjustment of the gate 30 associated with the partition 2 between the cells B and C.

It is thus seen that with the overflow arrangement between the pulp bodies of cells A and B, all the finer particles together with slimes will remain in the upper zones of the two pulp bodies and these particles and slimes will not be subject to any rescouring operation by either the impeller in cell A or the impeller in cell B. In prior practice all of the pulp from cell A which reaches cell B is caused to be passed through the impeller in cell B. Consequently much pulp was reagitated and rescoured, which has been found to be unnecessary, and, in fact, disadvantageous to the best efficiency as to ore treatment. This reagitation and rescouring of the prior art practice has a tendency to deactivate or nullify the conditioning which previously took place. Also there is a possibility that the reagent and air which is placed in the pulp will be removed. With the improved method the fine particles, which are conditioned ores and rise to the upper zone of a cell, will always remain in said upper zone either of the cell in which the conditionng took place or in a succeeding cell.

In addition to the heavier material which passes from the lower zone of the cell A to the cell B through the intake conduit 20 leading to the impeller of cell B, there will be added heavier pulp from cell B, particularly the intermediate zone and the top part of the lower zone of the pulp body in cell B. This additional material will enter the conduit 20 of cell B through the opening 27 in the top of the conduit. The added material is regulated by the valve 20.

Since the structure and relationship between the cells C and B is the same as between the cells B and A, the pulp in cell B will pass to the cell C in the same manner as the pulp from the cell A passes to the cell B. The heavier material in the lower zone of the body of pulp in cell B will enter the intake conduit 20 in cell C and be acted upon by the impeller in said cell. At the same time air will be entrained in the pulp by the action of the impeller. No fine particles which have risen to the upper zone of the pulp body in cells A, B or C will be subject to agitation by the impeller in cell C. The lighter material in the upper body of cell B can pass to the body of pulp in cell C by overflowing the gate 30 associated with the partition 2 between cells B and C. The level of the pulp body of cell C is maintained slightly lower than that of cell B by proper control of the gate associated with the discharge compartment 34. Thus there can be a flow between the upper zone of the body of pulp in cell B to the upper zone of the body of pulp in cell C. Because of the valve control passage 27 in the intake conduit 20 to the impeller of cell C, heavier particles in the intermediate zone of the body of pulp in cell C are recirculated into the impeller so as to be reaerated to obtain lighter particles capable of rising to the surface of the pulp body as froth so that it can be skimmed off.

Since it is desired to have only the heavier material pass from one cell to the succeeding cell through the impeller of said succeeding cell, it is desirable for proper operation to have the openings 22 and 26, through which this heavier material passes, of fairly large size so that a substantial amount of material can pass through. Once fine particles of aerated material are carried into the upper zone of a given cell, they will remain in said upper zone of said cell or the upper zone of a succeeding cell until removed. The conditioning thereof will not be nullified by subjecting the fine particles to any subsequent impeller action. Consequently there cannot occur what is called "short circuiting" of the aerated froth. The method of entrainment carried out in the illustrated machine also insures that there will be maximum aeration and the aeration will be on pulp which has not already been so agitated and aerated as to rise to the upper zones. By having a free flow through the tops of the cells, which is in the same direction as the flow of the pulp through the impellers of the cells, it is possible to obtain a higher capacity for the machine. There also will result a higher recovery of concentrate as there is no removal of reagent from the finer particles because there is no reagitation and rescouring. Also, by maintaining the lighter particles in the upper zones of the cells and not subjecting them to a reagitation by the impellers, it is possible to collect additional mineral by stage reagent feeding, that is, feeding additional collector reagent into each cell as the pulp passes through. There will also be less impeller wear for a given capacity because the impeller in each cell will only act upon the heavier material and not be required to act upon any material which has been so aerated as it can rise to the upper zone.

Being aware of the possibility of modifications in the particular method and apparatus described without departing from the fundamental principles of my invention, I do not intend that the scope of the invention be limited in any manner except in accordance with the appended claims.

What is claimed is:

1. In froth flotation apparatus having at least two cells and a wall interposed between the cells having an upper passage for the interchange of pulp between the cells, a rotary impeller in each cell, a hood covering the impeller, means including at least one conductive member for delivering gas under pressure into each cell from an

outside source of supply, a feed conduit inclining downwardly from a wall of the cell and delivering pulp onto the impeller through the hooded enclosure, at least one said conduit extending to a point adjacent the wall between the cells, an adjustable weir defining the passage in said wall for regulating the pulp discharge from a first cell into the main pulp body in a second cell of the plurality, and a submerged baffle spaced from the weir in the first cell to prevent a surface flow of pulp or froth to said weir, the improvement which comprises an enclosed, enlarged intake compartment connected to the upper end of the feed conduit and having a portion extending above the conduit and sealing the end of the conduit from direct upward travel of entrained gas, there being a passage into a lower portion of said intake compartment from the preceding cell of the plurality, and an adjustable member for varying the effective size of said passage.

2. In froth flotation apparatus having at least two cells and a wall interposed between the cells having an upper passage for the interchange of pulp between the cells, a rotary impeller in each cell, a hood covering the impeller, means including at least one conductive member for delivering gas under pressure into each cell from an outside source of supply, a feed conduit inclining downwardly from a wall of the cell and delivering pulp onto the impeller through the hooded enclosure, at least one said conduit extending to a point adjacent the wall between the cells, an adjustable weir defining the passage in said wall for regulating the pulp discharge from a first cell into the main pulp body in a second cell of the plurality, and a submerged baffle spaced from the weir in the first cell to prevent a surface flow of pulp or froth to said weir, the improvement which comprises an enclosed, enlarged intake compartment connected to the upper end of the feed conduit and having a portion extending above the conduit and sealing the end of the conduit from direct upward travel of entrained gas, there being a passage into a lower portion of said intake compartment from the preceding cell of the plurality, and a gate mounted for sliding movement to selectively open and close said passage and having a control portion extending above the top of said weir.

3. In froth flotation apparatus having at least



two cells and a wall interposed between the cells having an upper passage for the interchange of pulp between the cells, a rotary impeller in each cell, a hood covering the impeller, means including at least one conductive member for delivering gas under pressure into each cell from an outside source of supply, a feed conduit inclining downwardly from a wall of the cell and delivering pulp onto the impeller through the hooded enclosure, at least one said conduit extending to a point adjacent the wall between the cells, an adjustable weir defining the passage in said wall for regulating the pulp discharge from a first cell into the main pulp body in a second cell of the plurality, and a submerged baffle spaced from the weir in the first cell to prevent a surface flow of pulp or froth to said weir, the improvement which comprises an enclosed, enlarged intake compartment connected to the upper end of the feed conduit and having a portion extending above the conduit and sealing the end of the conduit from direct upward travel of entrained gas, there being a restricted passage into a lower portion of said intake compartment from the preceding cell of the plurality, a recirculating opening in the feed conduit intermediate its ends, and a valve for regulating the admission of recirculating pulp to said conduit.

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