Feb. 17, 1953 A. C. DAMAN 2,628,827

APPARATUS FOR AERATING FLOTATION PULPS AND THE LIKE

Filed July 5, 1947 2 SHEETS—SHEET 1

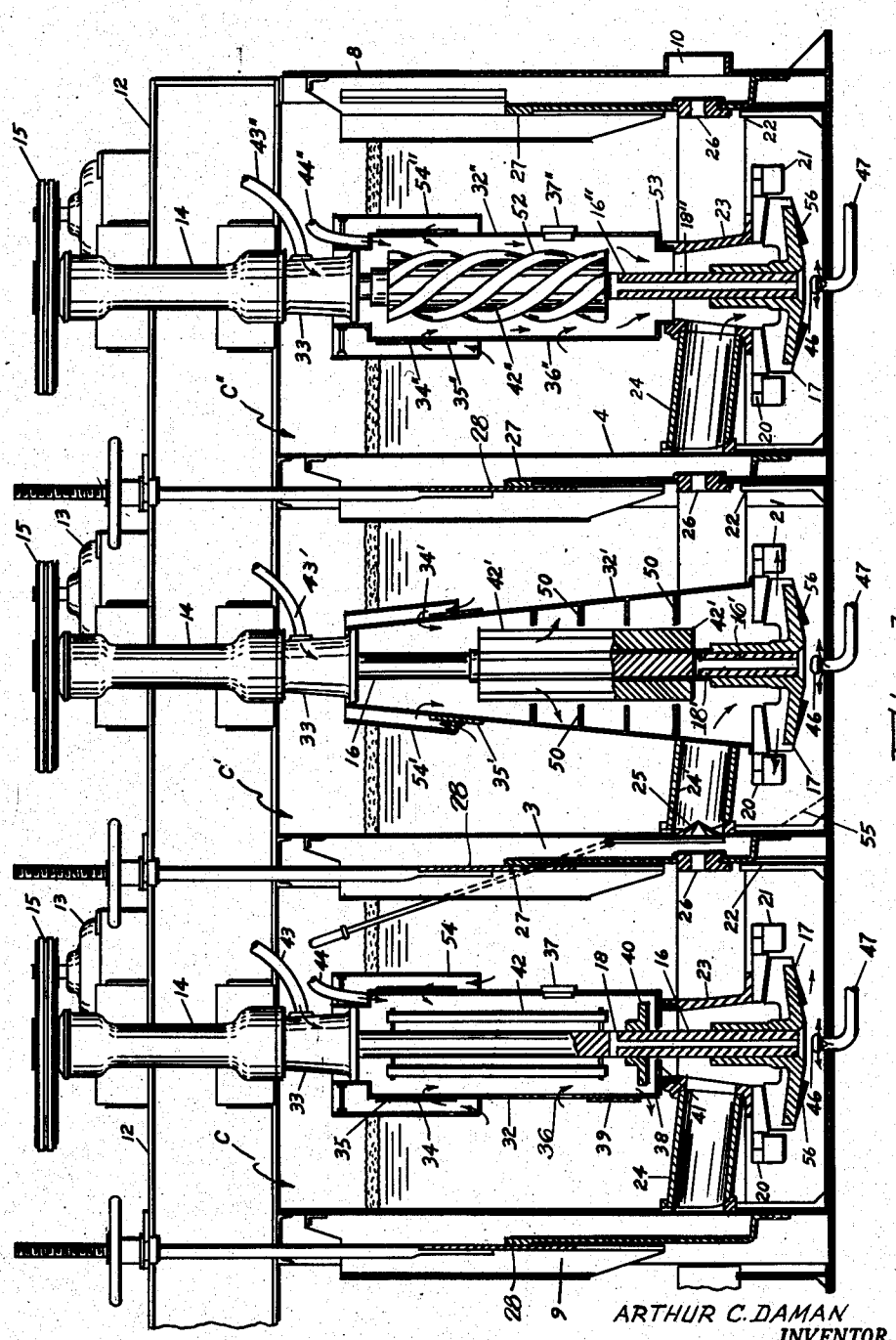

FIG. 1.

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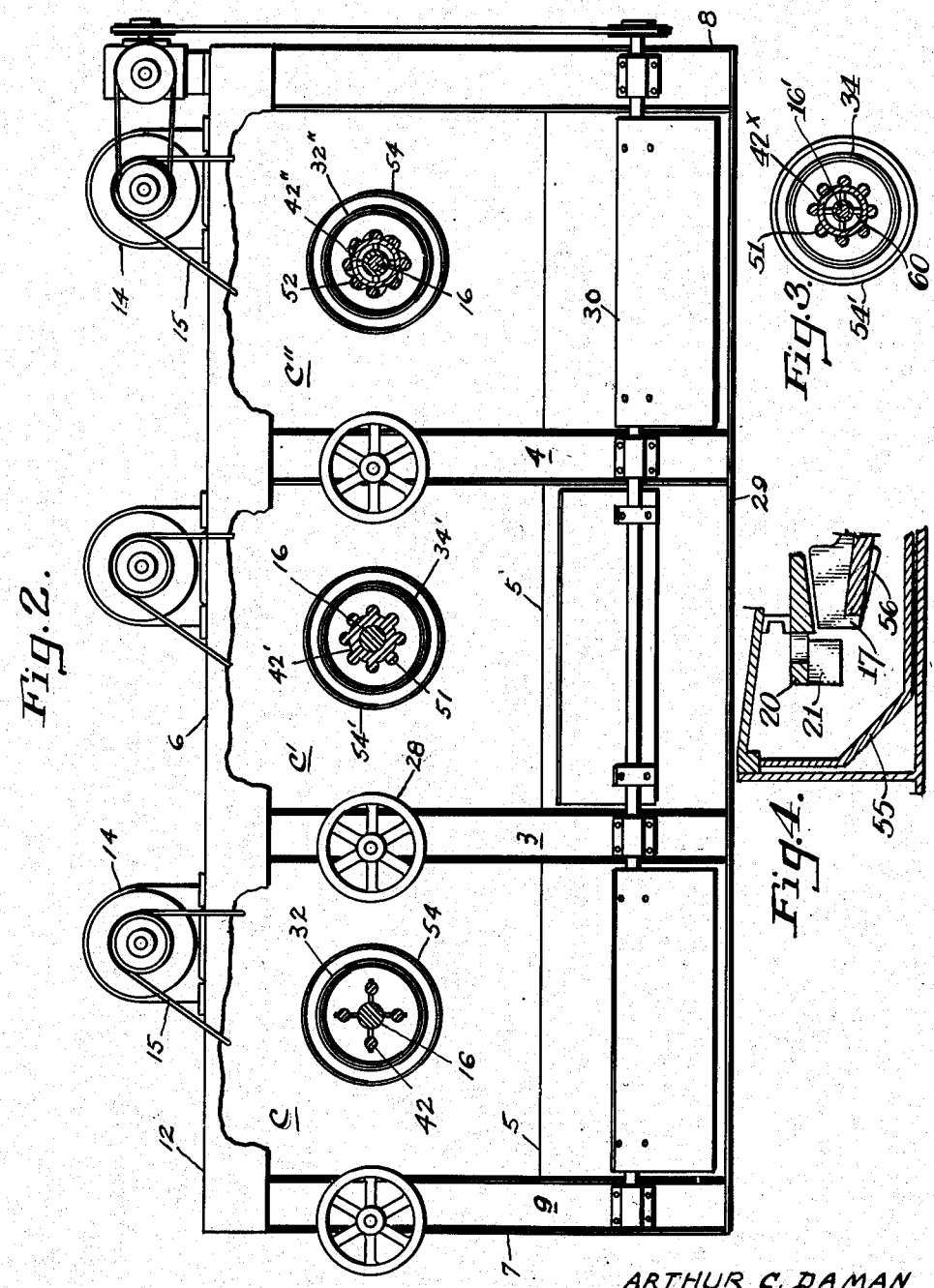


Fig. 2.




Fig. 3.




Fig. 4.

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## APPARATUS FOR AERATING FLOTATION PULPS AND THE LIKE

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10 Claims. (Cl. 261—87)

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This invention relates to aerating methods used in froth flotation and to aerating apparatus of the mechanical agitation type.

The expansion of our chemical industry has resulted in the production of many new compositions which have proven to be excellent reagents for a variety of flotation treatments. In general, these reagents have been characterized by their ability to form brittle froths, and to some extent at least, the use of such reagents has required a greater degree of gas-mineral contact and mixing, and a more widespread diffusion or dispersion of the aerated product through the pulp body.

It is an object of this invention to provide a simple, economical, and efficient method of aerating a pulp, or a pulp-reagent mixture, as a preliminary step to a froth flotation separation, or the like.

Another object of the invention is to provide simple, durable, and efficient apparatus for improving the aerating action in a flotation cell.

A further object of this invention is to provide a multi-cell flotation machine with a selective control of the recirculation and aeration in each of the cells.

Other objects reside in novel details of construction and novel combinations and arrangements of parts, all of which will be described in the course of the following description.

Briefly stated, the present invention includes the discovery that recirculating pulp and middlings may be drawn from an upper portion of the pulp body in a flotation cell and subjected to a preliminary mixing and aeration in a confined zone, and then returned to the pulp body through the mixing and aerating zone of the impeller, or optionally may be discharged into the pulp body separately from the impeller discharge.

The practice of the invention will be best understood by reference to the accompanying drawings, in the views of which like parts have been designated similarly. In the drawings:

Fig. 1 is a vertical central section through a multi-cell flotation embodying features of the present invention;

Fig. 2 is a top plan view of the machine shown in Fig. 1, partially broken away to better illustrate the aerating features of the machine;

Fig. 3 is a detailed view of a further modified form of agitator embodying the present invention; and

Fig. 4 is a fragmentary vertical section through a modified form of cell bottom liner.

The machine illustrated in Fig. 1 may comprise

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any plurality of cells and is here shown as having a first cell C, an intermediate cell C', and an end cell C''. Preferably, the cells C and C' are spaced to provide a feed compartment 3 between them and a similar compartment 4 is provided between cells C' and C''. The machine comprises a tank having a front wall 5, a rear wall 6, and end walls 7 and 8 respectively, at the feed and discharge ends of the machine. Feed to the machine enters through a feed box 9 in end wall 7 and the final pulp or tailings discharge is through an outlet 10 in end wall 8.

Suitable superstructure 12 is mounted on the top walls of the tank for the support of motors 13, bearing assemblies 14 and suitable power transmission devices 15, by which shafts 16, 16' and 16'' extending into the respective cells are caused to rotate. An impeller 17 is mounted at the lower end of each said shaft and preferably is in the form of a dished disc having a series of radial blades on its upper surface. At the lower end of each shaft, a T-shaped passage 18, 18' or 18'' extends from a position intermediate the ends of said shaft to a point of discharge at the bottom of the impeller.

In the form of the invention shown in the drawings, a hood 20 provided with peripheral vanes 21 overhangs the impeller and is supported by a spider-type baffle assembly 22 seated on the bottom of each cell. The hood carries a hub 23 on its upper portion in the arrangement shown in cells C and C'' which is bolted to the spider assembly, and this hub is apertured to admit a feed conduit 24 connecting with feed box 9 in cell C and with feed compartment 4 in cell C''. The features of the impeller and baffle assembly just described per se form no part of the present invention.

Control of the feed to any of the cells may be regulated, as by the lever-actuated valve 25 shown in cell C', or may be admitted continuously at full volume through the open passages of conduits 24 as in cells C and C''. Solids of the pulp which do not float and tend to settle out of suspension are moved through the sands relief openings 26, while the remaining pulp discharge of each cell is caused to overflow an adjustable level weir 27 as determined by the setting of a flow regulating mechanism 28. Froth collecting on the surface is caused to overflow a discharge lip 29 at the top of front wall 5, which preferably is inclined forwardly in its upper portion to assist the overflow action. Usually, rotary skimmers 30 (Fig. 2) will be used to assist the froth discharge.

In order to produce a more widespread and intense aeration, and to prevent the formation of a high density middlings zone beneath the froth bed which otherwise would impede the concentration, I provide structure extending from the top of hub 23 in encompassing relation to the shaft 16 to an elevation at least equal to and preferably substantially above the froth bed, as shown. When the first cell of the machine is used to float a large volume of concentrate as in cell C of the drawings, I prefer to use a stationary shell 32 interposed between hub 23 and a collar member 33 underhanging the bearing assembly 14.

Shell 32 has one or a plurality of intake openings 34 in its upper surface and the effective size of these openings may be varied by a sliding gate 35. Another set of openings 36 is provided intermediate the ends of shell 32, and plugs 37 are provided to close these openings when desired. A bottom opening 38 also is provided in shell 32 and this opening is controlled by another gate 39. This arrangement permits intake of pulp into the upper and intermediate levels of the shell while the bottom opening 38 functions as a discharge outlet, due to the pumping influence of a runner 40 mounted for rotation with shaft 16, and a partition 41 preventing any appreciable intake of pulp at the top of hub 23.

An agitator 42 is mounted for rotation with shaft 16 and extends a substantial vertical distance through shell 32. This agitator comprises a series of spaced, vertically extending bars or rods mounted in end plates or rings which are attached to the shaft for rotation therewith, as by pins extending through drilled holes in the shaft. In the mining and milling industry, an assembly of this type is commonly termed a "squirrel-cage" assembly and such terminology will be used in the specification to designate such structure.

An aerating gas of suitable composition is introduced into collar 33 by a plurality of conduits 43 and 44. The gas from conduit 43 descends interiorly of the path of the blades of the squirrel-cage agitator 42 while gas from conduit 44 flows exteriorly thereof through the shell for mixing with the recirculating pulp entering through openings 34 and 36. While the rotation of the agitator tends to cause a centrifugal movement of the material, the foraminous character of the agitator causes a considerable amount of surging with the result that gas from both the inner and outer streams is intrained in the gravitational descent of the pulp through shell 32.

However, sufficient gas is present around the shaft at the intake of T-passage 18 to enter freely therein and discharge beneath impeller 17. Also, the action of runner 40 in effecting the lateral discharge of pulp through opening 38 creates a certain amount of back pressure that assists the gas discharge through passage 18. For some treatments, an even greater volume of gas may be required beneath the impeller and nozzles 46 may be connected with a suitable source of supply (not shown) by conduits 47 for this purpose.

In the next or intermediate cell C', a somewhat different aerating arrangement is provided as this cell usually produces a less voluminous froth and tends to form a greater high-density middlings zone. The enclosure 32' is of frustro-conical shape and extends upwardly to collar 33 from the hood 20 on which it is supported. This enclosure is suitably apertured for connection with a feed conduit 24' which is substantially identical with the feed conduits 24 previously described. This enclosure has top openings 34' preferably controlled by gates 35', but otherwise is imperforate throughout its lengthwise extent.

Interiorly, the enclosure supports a plurality of annular baffles or partitions 50 spaced from but adjacent the periphery of a rotary agitator 42', and arranged at different levels in the enclosure.

The agitator 42' preferably is formed as a one piece casting of substantially cylindrical shape, but with a series of ribs 51 extending vertically at spaced intervals about its periphery. The interior passage of agitator 42' may be machined for a friction fit with shaft 16 as shown in Fig. 2, or may be of greater diameter as shown in Fig. 3, in which case the agitator 42x will be held by pins 60 in the same manner as the agitator 42 of cell C. In this way, a central passage is provided for flow of gas downwardly through as well as around the agitator.

Because the interior of the agitator 42' does not provide an adequate gas delivery passage, only one gas supply line 43' is provided for delivery of gas into enclosure 32'. This gas entrains in the pulp entering opening 34' to a large extent and thereafter is mixed with pulp at each level of baffles 50 due to the restriction of the descending passage at these points. This arrangement produces a high degree of beating and intermixture so that by the time the pulp has descended below the last baffle 50 it is thoroughly aerated. However, sufficient gas is still present to flow through T-passage 18' and discharge underneath the impeller.

In the final cell of the series, a smaller volume of solids remains in the pulp due to the removal of concentrate in preceding cells, and consequently a less intense agitation is required. For this reason, an enclosure 32'', similar to enclosure 32, but omitting the bottom opening, is mounted at the top of hub 23 and has its upper end fitted in collar 33. The agitator 42'' of this form is a hollow cylinder having spiral ribs 52 on its exterior surface to impart a high velocity spiraling descent to the pulp and with its interior surface spaced from shaft 16'' and supported by pins for conjoint rotation therewith. Preferably, gas is introduced interiorly and exteriorly of agitator 42'' as by lines 43'' and 44''.

Due to the narrowing of the passage through enclosure 32'', as shown at 53, the descending pulp stream is caused to back up and forms a vortex at the outlet, with the result that large quantities of gas are entrained and mixed with the previously aerated pulp as it passes into hub 23 and onto the impeller. At the same time, excess gas in the lower portion of enclosure 32'' flows into T-passage 18'' and discharges beneath the impeller for further mixing within the impeller enclosure.

Any amount of pulp may be recirculated by regulation of the effective size of top openings 34'' under the control of gates 35'' or by changing plugs 37'' in the other series of openings 36''. After the primary mixing in enclosure 32'', the plup is mixed additionally by the action of the impeller and then discharges into aerated pulp from beneath the impeller for further mixing before assuming a rising course in the cell.

In the several forms of agitator construction just described, the enclosure member preferably extends to or above the froth level in the cell. Such arrangement prevents direct entrainment of froth at the top of the enclosure, but the up-

per side openings of the several enclosures are so near the froth bed that froth might be drawn down and through such openings. To prevent such action, I provide the annular baffles 54, 54' at the froth level of the cell which extend for a sufficient depth below the forth bed to eliminate the possibility of any vortex condition which would draw froth from the surface through said openings. In the operation of a multicell machine embodying features of the present invention, such as the three cell machine illustrated in the drawings, incoming pulp enters through feed box 9 and feed conduit 24 to pass directly onto the impeller. The provision of the vanes 21 at the periphery of the impeller serves to break up the aerated pulp as it discharges across the periphery of the impeller and at the same time aerated pulp thrown out from beneath the impeller mixes with the aforesaid discharge to further aerate the pulp and to impart an elevating component to the mixture.

At the same time, recirculating pulp is drawn through the openings 34 and any of the unplugged openings 36 for mixing with the air descending through the agitator in the manner previously described. As this mixture reaches the bottom of the enclosure, it descends onto the rotating surface of the runner 40 and is thereby forcefully ejected through the bottom opening 38 in a course substantially parallel to the impeller discharge. As a result, the aerated pulp of this stream moves laterally into the ascending pulp column and further mixing of the two aerated bodies occurs. Froth collecting at the top of the cell is removed by the action of the skimmers 30 into suitable launders (not shown) and may be passed on to subsequent treatment or returned to selected cells of the machine in a rougher-cleaner operation, if preferred.

The continual withdrawal of a portion of the pulp in the upper portion of the liquid body and below the froth level for recirculation through the agitator unit serves to prevent any formation of a high density middlings zone as otherwise would tend to occur in most treatments. Also, by a selective control of the gates 35 and 39 and the plugging or opening of openings 36, any given amount of recirculation may be attained. Due to the fact that a double gas delivery is provided for the agitator unit, a selective control of aeration may be obtained, and if preferred, one type of gas may be introduced as through the conduit 43 and another type of gas may be introduced through conduit 44, as for example, air and $CO_2$.

Froth forming in this first cell is caused to overflow the lip on the front wall and discharges into a suitable launder (not shown). Additional pulp overflows weir 27 under control of flow-regulating mechanism 28 and enters into feed compartment 3 while heavy sands not rising to the level of the weir are caused to pass through the sands relief opening 26 to enter feed compartment 3. The discharge from this compartment to the feed conduit 24' of cell C' is regulated by a valve 25 so that more or less feed can be delivered to the impeller in accordance with the recirculating requirements of this cell. Gas is introduced through nozzle 46 at the bottom of cell C' and is subjected to mixing by the bottom vanes on impeller 17 until it clears the periphery of the impeller and begins its ascent through the cell. At such time, it is struck by the pulp discharge from the top surface of impeller 17 passing the vanes 21 of the hood and this mixture rises through the cell to form the froth at the top of the cell.

A part of the pulp in the upper portion of the cell enters between baffle 54' and enclosure 32' to enter the openings 34' which may be selectively controlled by gates 35' and there entrains air introduced through conduit 43' and collar 33 until it is subjected to the beating action of agitator 42'. The provision of the successive baffles 50 at different elevations arrests the decent of the pulp-gas mixture and it is thus subjected to an intense beating by the agitator 42' until it clears the lowermost baffle 50 and entrains in the pulp stream entering from conduit 24'. The action within the impeller enclosure is the same as previously described with reference to the impeller of cell C.

The pulp discharge from cell C' is across another weir 27 to enter feed compartment 4, and again heavier sands are caused to pass through the sands relief opening 26 into compartment 4. The intake to feed compartment 24 of cell C'' is not controlled in this form of the invention, although it will be understood that a valve similar to the valve 25 may be provided, if desired. The action within the impeller enclosure in cell C'' is the same as that obtained in cell C and a portion of the ascending pulp is caused to enter between baffle 54 and enclosure 32'' to pass through openings 34'' controlled by gates 35''. The agitator 42'' in this cell is a spiral ribbed type which produces a pronounced lateral component in its rotation so that an in and out action quite comparable to that obtained in cell C' results from the gravitational movement of the pulp-gas mixture past the agitator.

A restriction 53 at the bottom of enclosure 32' serves to create a back pressure resulting in substantial entrainment of gas through the T-shaped passage 18'' in the shaft in a manner similar to which the gas is entrained in the corresponding passages of the shaft in cells C and C'. This provides an additional supply of gas underneath the impeller and in most instances, the supply through nozzle 46 will be unnecessary, although as an optional arrangement, both supplies have been incorporated in the present machine. The final discharge from the machine is across a weir 27 and through a discharge compartment to the outlet 10 and heavy sands not rising to the weir are caused to pass through the sands relief opening 26 and thence through the outlet 10.

From the foregoing description, it will be apparent that a high degree of aeration of both the pulp feed and the recirculating pulp is attained in each of the cells and due to the structural differences of the agitator unit in each cell, the extent of pulp recirculation may be closely controlled to satisfy the requirements of the froth discharge of each such cell.

As illustrated, cell C' is an intermediate cell and will be representative of any number of such cells that may be required when more than three cells are used. However, it will be understood that if a greater or lesser amount of aeration is required in the recirculating material, for example, when such cells are the cleaner cells of a rougher cleaner operation, either the form of agitator shown in Fig. 1, or the form shown in Fig. 3 may be substituted for the agitator unit 42 of such intermediate cells or a portion thereof.

The machine illustrated is essentially the standard machine of U. S. Patent No. 2,423,456 except for the inclusion of the agitator units in the

several cells. With respect to such inclusion, it should be noted that in the forms shown in cells C and C'', it is only necessary to remove the conventional hollow column or standpipe extending between hub 23 and collar 33 with the substitution of the agitator unit and appurtenances to convert a conventional machine into a unit utilizing features of the present invention.

When the form of enclosure shown in cell C' is to be used, the entire agitator assembly must be inserted as a new unit and will include the structure supporting the impeller hood 20 and its associated vanes 21. Likewise, it should be understood that the agitator units of cell C, C', and C'' may be installed in other types of machines where the stationary support is provided above the rotary impeller onto which the agitator unit can be mounted for stationary support.

In the preceding description, I have referred to the use of various types of aerating gases and cited as an illustration air and $CO_2$. It will be understood that any of the various gas supply conduits may be connected with any suitable aerating gas supply, such as the aforesaid compositions, or others now being used in the froth flotation art. Therefore, where the term "aerating gas" is used, it is intended to apply broadly to all the forms of gas being used for such treatments.

In operating agitators 42, 42' and 42'' in certain types of pulps, undue wear may occur on the rods or ribs, depending on the type of agitator used. Where such excessive wear is known to be prevalent, it will be desirable, particularly in agitators of the type shown in cells C' and C'', to form the rib structure separate from the cylindrical body portion and then attach such ribs to the body by soldering or brazing to permit easy removal when excessive wear has made a change in the rib structure necessary.

With respect to the various gas supply conduits 43, 44 and 47, prior reference has been made to the use of such structure for gas introduction only. However, it should be understood that such conduits might be utilized in feeding reagent or pulp to the machine, as well as the aforementioned gas. Particularly in the case of the lower conduit 47, it may conveniently be used for the return of a middlings concentrate from other cells to a given cell, as when rougher cleaner operations are employed. Similarly, when it is necessary to introduce reagent directly into the cell rather than by prior conditioning, such reagent may be conveniently fed through the various conduits 43, 44, 43', 43'' or 44' to thus obtain additional reagent mixing with the recirculating pulp which usually requires the addition of some reagent to effect the necessary flotation.

In Fig. 4, I have shown an inclined baffle wall 55 in place of the upright wall 22 usually provided. For certain purposes, it may be desirable to provide a more pronounced upward component to the pulp and/or other matter moved outwardly along the bottom by the action of the vanes 56 on the bottom surface of the impeller. This will result in a more intense mixing of the matter so elevated with the aerated pulp discharge passing across the periphery of the impeller and through the various spaces between vanes 21 of the hood structure.

It will be apparent from the foregoing description that the accompanying drawings are intended to represent a typical practice of the invention, but not to limit the scope of the invention except as defined in the hereunto appended claims.

What I claim and desire to secure by Letters Patent is:

1. In aerating apparatus, a cell for pulp having an overflow establishing a liquid level therein and means for aerating and agitating the pulp comprising structure providing a substantially tubular passage closed at its top and having an upper intake opening for pulp below but adjacent the liquid level and a mixing chamber below the passage, a vertically-disposed rotary agitator having blades extending throughout substantially the vertical extent of said passage and defining with the passage inner and outer courses for gravitational descent of material admitted through the intake opening, means for introducing streams of gas to said inner and outer courses, means for feeding pulp to the mixing chamber for mixing with matter descending through the passage, and a rotary impeller below the chamber in a position to receive the mixed material by gravity.

2. In aerating apparatus, a cell for pulp having an overflow establishing a liquid level therein and means for aerating and agitating the pulp comprising structure providing a substantially tubular passage closed at its top and having an upper intake opening for pulp below but adjacent the liquid level and a mixing chamber below the passage, a vertically-disposed rotary hollow agitator having blades extending throughout substantially the vertical extent of said passage and defining with the passage inner and outer courses for gravitational descent of material admitted through the intake opening, means for introducing streams of gas to said inner and outer courses, means for feeding pulp to the mixing chamber for mixing with matter descending through the passage, and a rotary impeller below the chamber in a position to receive the mixed material by gravity.

3. In aerating apparatus, a cell for pulp having an overflow establishing a liquid level therein and means for aerating and agitating the pulp comprising structure providing a substantially tubular passage closed at its top and having an upper intake opening for pulp below but adjacent the liquid level and a mixing chamber below the passage, a vertically-disposed rotary agitator having blades extending throughout substantially the vertical extent of said passage and defining with the passage inner and outer courses for gravitational descent of material admitted through the intake opening, means for introducing streams of gas to said inner and outer courses, means for feeding pulp into the outer course for mixing with matter descending through the passage, and a rotary impeller below the chamber in a position to receive the mixed material by gravity.

4. In aerating apparatus, a cell for pulp having an overflow establishing a liquid level therein and means for aerating and agitating the pulp comprising structure providing a substantially tubular passage closed at its top and having an upper intake opening for pulp below but adjacent the liquid level and a mixing chamber below the passage, a vertically-disposed rotary squirrel-cage agitator having blades extending throughout substantially the vertical extent of said passage and defining with the passage inner and outer courses for gravitational descent of material admitted through the intake opening, means for introducing streams of gas to said inner and outer

courses, means for feeding pulp to the mixing chamber for mixing with matter descending through the passage, and a rotary impeller below the chamber in a position to receive the mixed material by gravity.

5. In aerating apparatus, a cell for pulp having an overflow establishing a liquid level therein and means for aerating and agitating the pulp comprising structure providing a substantially tubular passage closed at its top and having an upper intake opening for pulp below but adjacent the liquid level and a mixing chamber below the passage, a vertically-disposed rotary agitator in the form of a hollow cylinder having ribs on its exterior surface extending throughout substantially the vertical extent of said passage and defining with the passage inner and outer courses for gravitational descent of material admitted through the intake opening, means for introducing streams of gas to said inner and outer courses, means for feeding pulp to the mixing chamber for mixing with matter descending through the passage, and a rotary impeller below the chamber in a position to receive the mixed material by gravity.

6. In aerating apparatus, a tank for pulp, a rotary impeller in the lower portion of the tank, a tubular enclosure extending from a point near the impeller to a point adjacent the pulp level in the cell, structure mounted for rotation within the enclosure and having a spirally-ribbed surface arranged to impart an in and out movement to material falling by gravity through said enclosure, and means for introducing at least one aerating gas into said enclosure.

7. In a froth flotation cell, having an upper overflow lip for froth discharge and a tailings discharge outlet spaced from said overflow lip, shaft-supporting means at the top of the cell, including a bearing assembly, an impeller carried at the lower end of the shaft and extending substantially to the bottom of the cell, a cover member overhanging the impeller and having a central hollow portion, a feed conduit for delivering incoming pulp onto the impeller through said hollow portion, an enclosure member extending between the cover member and the bearing assembly in encompassing relation to the shaft and having a lower surface providing a restricted passage between the enclosure and the hollow portion of said cover member, there being at least one opening into the enclosure for admission of pulp from the upper portion of the cell at a point below the froth overflow level, means for delivering gas under pressure into the upper portion of said enclosure, and an agitator mounted on the shaft within said enclosure for conjoint rotation therewith so as to subject the pulp and gas to a beating action prior to its discharge through the restricted passage into the impeller enclosure.

8. Structure as defined in claim 7 in which there is a passage extending from the bottom of the agitator through the shaft to a point of discharge beneath the impeller for the discharge of excess gas from said enclosure.



9. In a froth flotation cell, having an upper overflow lip for froth discharge and a tailings discharge outlet spaced from said overflow lip, shaft-supporting means at the top of the cell, including a bearing assembly, an impeller carried at the lower end of the shaft and extending substantially to the bottom of the cell, a cover member overhanging the impeller and having a central hollow portion, a feed conduit for delivering incoming pulp onto the impeller through said hollow portion, an enclosure member extending between the cover member and the bearing assembly in encompassing relation to the shaft and having a lower shouldered surface providing a restricted passage between the enclosure and the hollow portion of said cover member, there being at least one opening into the enclosure for admission of pulp from the upper portion of the cell at a point below the froth overflow level, means for delivering gas under pressure into the upper portion of said enclosure, and an agitator mounted on the shaft within said enclosure for conjoint rotation therewith so as to subject the pulp and gas to a beating action prior to its discharge through the restricted passage into the impeller enclosure, and the shaft having a passage extending upwardly from an opening at the underside of the impeller and terminating in laterally-extending intake openings under the agitator, whereby excess gas in the enclosure is discharged through said shaft and underneath the impeller.

10. In aerating apparatus, a tank for pulp, a rotary impeller in the lower portion of the tank for agitating pulp in the tank, a tubular enclosure extending from a point near the impeller to a point adjacent the pulp level in the cell and having at least one intake opening in its upper portion for gravitational movement of pulp through the enclosure and onto the impeller, a ribbed impeller mounted for conjoint rotation with said first impeller and cooperating with the walls of said enclosure to cause an in and out movement of the pulp descending onto said first named impeller and to assist the action of the first named impeller in accelerating the downward circulation of pulp through the enclosure, and means for introducing at least one aerating gas into said enclosure.

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