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P. L. WIGTON

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APPARATUS FOR FLUID SUSPENSION CLASSIFICATION

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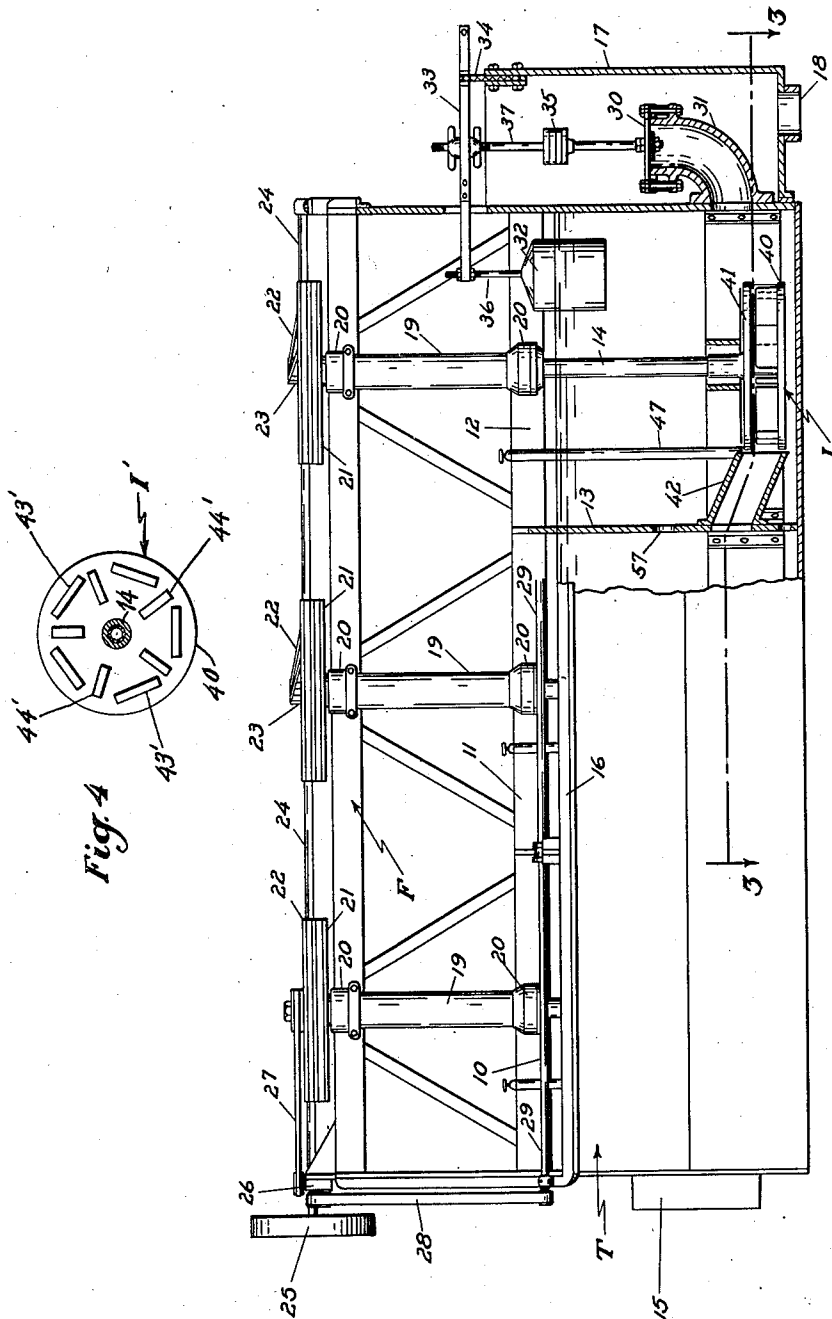


Fig. 1

PAUL L. WIGTON
INVENTOR.

BY

H. A. M. S. M. S.
ATTORNEY

UNITED STATES PATENT OFFICE

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APPARATUS FOR FLUID SUSPENSION
CLASSIFICATION

Paul L. Wigton, Denver, Colo.

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This invention relates to apparatus for assorting solids suspended in a fluid, as by a fluid suspension classification, or froth flotation which includes controlled aeration and agitation. The principles of this invention are particularly applicable to froth flotation, though of value for other types of process and apparatus.

In froth flotation of minerals, for instance, a body of pulp which comprises a mixture of liquid and solids, such as water and crushed or ground ore, supplemented by suitable reagents to enhance the flotation effect, is treated by controlled aeration and agitation in the lower portion of the pulp body, to cause the mineral values to be carried upwardly, possibly by air bubbles, to the upper surface of the pulp body. The froth thus formed is skimmed off or otherwise suitably recovered, and then treated, as by thickening and filtration, to recover by the separation a concentrate product more suitable for refining or smelting. For adequate results in froth flotation, it is necessary that an intimate mixture of the pulp, reagents and air or other suitable gas be obtained. For such purpose, it has been customary to rotate an impeller at a relatively high speed in the lower portion of a tank containing the body of pulp, the impeller being adapted to mix together pulp, reagents and air introduced into the pulp near or adjacent the center of the impeller. Such prior practice has not achieved the optimum results, possibly because of insufficient mixing action or inadequate pulp control, or because of coalescence of the air bubbles. In some instances, the air bubbles have been so large as to break the attachment of the particles, such bubbles tending to break more readily at the surface and also produce undue agitation of the upper portion of the pulp body. In other instances, the air bubbles have been insufficient in quantity to carry the larger particles, which were not recovered. Again, insufficient control of the mixing action has in some instances caused the upper portion of the pulp body to be agitated to such an extent as to break up bubbles carrying particles to be recovered.

In general, such prior practice has necessitated the use of undue volumes of air for the amount of flotation work being done, or the use of an undue amount of power to rotate the impeller to obtain effective mixing action.

A close approach to the solution of the problems involved is disclosed in U. S. Patent No. 2,243,302, wherein a compound action of the impeller is obtained by vanes depending from the impeller disc and set at different angles, first to

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draw pulp from the periphery toward the center of the impeller, mix the pulp with air under pressure supplied to the periphery of the impeller, then discharge the mixture from the impeller into the body of pulp. The present invention is an improvement over the disclosed and claimed subject matter of the above patent.

Among the objects of this invention are to provide novel apparatus for assorting solids suspended in liquid; to provide such apparatus by which adequate mixing in a well-defined mixing zone is obtained; to provide such apparatus by which a positive feed of pulp to the mixing zone is maintained; to provide such apparatus by which detrimental agitation of the upper portion of the body of pulp is prevented; to provide such apparatus by which adequate air may be supplied the mixing zone; to provide a novel impeller for apparatus for assorting solids suspended in a liquid; to provide such apparatus in which a positive feed of pulp to the impeller is obtained; to provide such apparatus in which the speed of the impeller may be reduced; to provide such apparatus in which the feed of pulp and other factors insure proper mixing; to provide such apparatus in which the amount of air supplied to the mixing zone can be controlled within rather wide limits; to provide such apparatus which may include a plurality of cells, and in which the action of one cell enhances the action of the other cells; to provide such a method and apparatus which may be carried out in or applied to existing machines by changing or adding a relatively few parts; and to provide such apparatus which is readily constructed and operated. Other objects and novel features of this invention will become apparent from the description which follows.

Apparatus constructed in accordance with this invention may include a tank having one or more cells, with each cell containing a body of pulp. A shaft, preferably hollow, extends downwardly into each cell and has an impeller attached to its lower end for relatively high speed rotation, and conduit means is provided for feeding pulp to the periphery of the impeller. The impeller has upwardly extending vanes, some of the vanes being adapted to draw pulp from the periphery of the mixing zone toward the center thereof, and other vanes being adapted to mix air and pulp and eject the mixture from the mixing zone. The first mentioned vanes are also adapted to redraw ejected material into the mixing zone, preferably a number of times.

A disc rotating therewith is attached to the

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shaft at a point just above the vanes, so as to form the upper boundary of the mixing zone and also to provide a small space for circulation within the mixing zone. The impeller and disc may be formed of suitable material such as cast hard iron or cast steel, and preferably of these materials covered with rubber, either synthetic or natural, because of the resistance of the latter to the abrasive action of the pulp.

One advantage of vanes extending upwardly from the impeller disc or base and a well-defined mixing zone, lies in the prevention of downward flow by gravity of the material out of the mixing zone and air-interference, thus assuring that thorough mixing will be obtained without loss of partially mixed material, which tends to occur when the vanes depend from a disc and are spaced from the bottom of the tank.

Further features and details of apparatus embodying this invention will become apparent from the following more detailed description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a front elevation, partially in section, of flotation apparatus constructed in accordance with this invention;

Fig. 2 is a fragmentary vertical section, illustrating a modification of the apparatus of Fig. 1;

Fig. 3 is a partial horizontal section, taken along line 3—3 of Fig. 1; and

Fig. 4 is a partial horizontal section taken along line 4—4 of Fig. 2.

As illustrated in Fig. 1, apparatus to which the principles of this invention may be applied may comprise a three cell flotation machine, although the machine may include any number of cells. The machine includes a tank T divided into three cells 10, 11 and 12, respectively. A partition 13 divides each cell from the next adjacent cell, and crushed or ground material, such as ore or the like, is introduced into the first cell 10, along with water and suitable froth flotation reagents. The constituents or pulp within the tank are mixed and agitated in the lower portion of each cell by an impeller, such as impeller I of cell 12, which is driven by a hollow shaft 14. The pulp passes from cell to cell, with the valuable particles to be recovered—such as gold, silver, or copper bearing ore—being carried upwardly by air bubbles from the lower portion of the cell to the top, and collected in a froth. The froth may be recovered from each cell, or the froth from the last cell reintroduced into the first or second cell, in a rougher-cleaner operation, and the froth recovered from only the first or second cell. In either instance, the froth product is conveyed to the next apparatus in the mill, such as a thickener supplying a filter.

Normally, the flotation machine will be fed pulp from a conditioner in which the crushed or ground ore, water, and reagents are mixed, but usually without attempt at aeration or flotation. Thus, the pulp from the conditioner may be fed to a box 15 and flow into the lower portion of cell 10. Air may be introduced into the lower portion of each cell through the hollow shaft 14, and the froth carrying the ore particles to be recovered and produced by the agitation and aeration in each cell, may be recovered in a launder 16 and conveyed to a concentrate thickener. The tailings or other discharge product from the last cell 12 are discharged into an outlet box 17, and thence through an outlet 18, to be conveyed to a subsequent treatment, or if a waste product, to a settling pond or the like.

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The impeller shaft and a drive for the shaft of each cell, is suspended from or mounted on a superstructure or framework F, above the tank T. Each shaft may be mounted in and extend through a vertical housing 19 attached to framework F. Inside enlarged portions 20 of each housing 19 are suitable bearings, such as rotary thrust bearings, for which lubrication may be provided by suitable fittings of a conventional type. Keyed to the top of each shaft is a drive pulley 21, driven from a suitable source of power by belts 22 or the like. Individual motor drives may be provided for each shaft or each adjacent pair of shafts, in the case of a machine having a relatively large number of cells, or belts 22 may be driven from a common source of power, such as pulleys 23 mounted on a line shaft 24, as shown. Shaft 24 is driven by a motor or the like, through a belt engaging a line pulley 25. From the shaft for cell 10, a pulley and bevel gear arrangement 26 may be driven by a belt 27, and connected by a belt 28 with a froth paddle line shaft 29. The paddles connected to shaft 29, which are conventional in construction, keep the froth in the upper part of the cell moving into the overflow launder 16.

The overflow of tailings into outlet box 17 may be controlled by a diaphragm 30 which is adapted to seal the open upper end of an L 31 in accordance with the pulp level in cell 12. The position of diaphragm 30 is determined by the position of a float 32, which is connected thereto through a second-class lever 33. The lever may be pivoted about a relatively flexible support 34, formed of impregnated fabric or the like, to reduce vibration of the control mechanism, and also to reduce "hunting" of the diaphragm 30. A weight 35 counterbalances the buoyancy of float 32, and adjustable connections, as shown, on rods 36 and 37, connecting the lever with the float and the diaphragm, respectively, permit regulation of the float position and the leverage exerted on the diaphragm.

The impellers utilized for agitation and aeration may be identical in each cell, or may vary from cell to cell. As in Figs. 1 and 3, an impeller I may be installed in one or more cells, or a slightly different impeller I', as in Fig. 4, may be installed in one or more cells. It will be understood, of course, that the impellers installed in the three cells may be identical or both may differ from the others. Also, other and/or slightly different impellers may be utilized, depending upon the treatment characteristics of the pulp in each cell.

The apparatus of Fig. 2 is similar to the apparatus of Fig. 1, comprising a flotation machine divided into three cells, 10', 11' and 12', although the machine may include any number of cells, as before. Aside from impellers I', and a feed arrangement described hereinafter, the various parts and operation thereof are the same as corresponding parts of the flotation machine of Fig. 1. In general, features of the machine of Fig. 1 may be substituted for features of the machine of Fig. 2, and vice versa.

The impellers I and I' operate in a somewhat similar manner to the impeller disclosed in U. S. Patent No. 2,243,302, but with certain differences, including air preferably drawn down the hollow shaft 14 by the suction effect of the impeller, a mixing and agitating zone produced between base 40 of the impeller and a disc 41 attached to the shaft and rotating with the impeller, and vanes

extending upwardly from base 40, as described in more detail hereinafter.

In accordance with this invention, the pulp is directed to the periphery of the impeller along a confined path, as through a chute 42 of Figs. 1-3, leading from the lower portion of the previous cell, or through similar means in the case of the first cell which is fed from the conditioner. Chute 42 is preferably inclined downwardly, and at least the outlet end thereof is also inclined in the direction of rotation of the impeller, to insure a positive feed of pulp to the impeller or mixing zone. Pulp passing from the chute to the impeller is moved or forced into the mixing zone defined by the impeller and disc 41, through the action of slicing or substantially chordal vanes 43 or 43' of impeller I and I', respectively, as in Figs. 3 and 4. Each vane 43 or 43' extends upwardly from base 40 of the impeller, being cast, or attached thereto in a suitable manner, as by welding, and each vane 43 is disposed with the leading end extending substantially to the edge of the base. The trailing end of each vane 43 terminates at a point on a radius of the base to which the vane is perpendicular. The end of each vane 43' is spaced from the edge of the base of the impeller, and each vane 43' is perpendicular to a radius of the base which bisects the vane.

As pulp is forced into the mixing zone and moves toward the center thereof, air is mixed therewith and the mixture of air and pulp is directed against disc 41, which contributes to the mixing action, and is also discharged by centrifugal force through the action of mixing vanes 44 of impeller I, as in Fig. 3, mixing vanes 44' of impeller I' of Figs. 2 and 4, acting in a somewhat similar manner. Vanes 44 are parallel to but spaced slightly from a radius of the base and extend to the periphery of the impeller. Vanes 44' lie along a radius of the base, but are spaced further inwardly than slicing vanes 43'.

The mixing action of the vanes 44 and 44' is also enhanced by disc 41, since the materials being pumped or moved by the vanes is agitated or whirled about and continually swirls back and forth, as it were, between the disc 41 and base 40 of the impeller, such action aiding in obtaining a more perfect mixing and dispersion of air bubbles throughout the pulp. The space between the tops of vanes 44 and 44' and the disc, which may be varied to suit operating conditions, permits a slight overflow across the tops of the vanes, thus tending to circulate pulp and air from the space ahead of one vane 44 or 44' to the space ahead of the next vane 44 or 44'. This also increases the mixing action, since the flow is preferably just enough to add to the turbulence and agitation of the products in the mixing zone. Due to the effectiveness of the mixing action, it is possible to reduce the speed of the impeller below that which would be necessary if the impeller merely agitated the pulp, thus decreasing the power required and/or permitting a greater volume of pulp to be treated per cubic foot of introduced air. As will be evident, the foregoing is a relatively valuable result of utilizing the method and apparatus of this invention.

The mixture of air and pulp produced in the mixing zone is thrown out at a point spaced from the chute 42, but re-enters the mixing zone by again being moved therein by the slicing vanes 43 or 43'. Thus, as the impeller rotates, there is a continuous recirculation into the mixing zone, so that an extremely intense agitation and aeration is produced, with the result that all of the

entering pulp receives treatment, and there are substantially no dead spots in the cell. As the mixture of air and pulp is thrown out of the mixing zone, air bubbles—and particularly those carrying the ore concentrates which are to be separated from the gangue or valueless rock particles—rise to the top of the pulp body and form the froth bed. The remainder of the discharged pulp is recirculated through the mixing zone, as described above.

So that the pulp above the mixing zone will remain in a relatively quiescent state, to prevent disturbance of the bubbles which might cause them to break and thereby drop the ore particles, a plurality of radially extending baffles 45 may be secured to the corners of the cell and united about the shaft in the manner shown in Fig. 3. As in Figs. 1 and 2, the baffles are spaced slightly from disc 41, and substantially conform in shape to the outer periphery of the disc and impeller, the lower portions of the baffles assisting in the recirculation by retarding any tendency for the pulp adjacent the bottom of the cell to swirl around with the impeller. Further to produce a quiescent condition which will produce the least amount of disturbance to the bubbles rising to the froth bed and carrying with them the ore particles to be recovered, a grid or screen may be placed atop the baffles. Disc 41, which confines the mixing zone, also assists in insuring that the pulp in the upper portion of the cell will not be unduly agitated by the aeration and agitation in the lower portion of the cell.

The impeller is rotated at a suitable peripheral speed, such as 1400 to 1600 F. P. M., and the suction effect of the pumping vanes 44 and 44' will draw air down through the hollow shaft 10 into the center of the impeller, the shaft being provided with holes, or the like, to permit an induced flow of air into the mixing zone. In some instances, it may be desirable to provide an additional supply of air, such as in treating heavy pulp or pulp that is difficult to mix. Such additional air may be supplied by a pipe 47, as in Figs. 1 and 3, extending downwardly to a point adjacent the periphery of the mixing zone or impeller. Air from pipe 47 is discharged into the fresh pulp introduced by chute 42, preferably from a point just behind the chute. Discharge of air at such point tends to assist the flow of pulp through the chute into the mixing zone, and also tends to premix the air with the pulp.

In some instances, it may be desirable for air pipe 47 to lead directly into chute 42, and in certain instances for air pipe 47 to be the sole air supply. In other instances, it may be desirable to provide an air pressure pipe 48, as in Fig. 2, which leads to a space 49 within housing 19, adjacent the upper end of the hollow shaft. Air under pressure may pass into the interior of shaft 14 through slots 50, and space 49 may be sealed by packing 51 at each end thereof. Air pipe 48 is utilized when the suction effect of the pump vanes is not relied upon alone to introduce air into the mixing zone. Such supply of air may be of advantage where the pulp is difficult to mix adequately, or where a greater volume of air per cubic feet of pulp is required, than would be produced by the normal suction of the impeller.

To transfer the pulp from cell to cell, and to control the level of the pulp in cells 10 and 11, as in Fig. 2, a pair of partitions 54 and 55 may provide a weir compartment leading from the lower portion of cell 11 to a weir or opening 56 in partition 13, and a feed compartment leading

to chute 42. Flow through opening 56 may be controlled in any suitable manner, as by a weir gate or slats, to maintain the pulp in cell 11 at a predetermined desired level.

If the level of pulp in all of the cells is to be maintained the same, then partitions 54 and 55 and weir 56 may be omitted, but a return flow hole 57, as in Fig. 1, may be provided in the partitions to insure that changes in the pulp level in one cell will be communicated to the next. The flow through hole 57, while sufficient to maintain the desired pulp level, is not sufficient to affect adversely the operation of the apparatus. It will be understood, of course, that any suitable type of discharge control may be used. For instance, a weir gate or slats may be utilized instead of diaphragm 30 and its associated parts, for controlling a series of cells or individual cells.

From the foregoing, it is apparent that this invention provides a new and useful apparatus for assorting solids suspended in a fluid, such as by froth flotation. A mixing zone of the type defined by the base 40 of the impeller and the disc 41, is an important feature of this invention, particularly when combined with another important feature of the invention—the positive and controlled feed of fresh pulp to the periphery of the impeller or mixing zone. Such features insure that all of the pulp will be treated and thoroughly aerated. It will be apparent that the apparatus of this invention may be produced readily, as by slight changes in a normal flotation machine, such as merely installing an impeller and disc, baffles, and feed chute, constructed in accordance with this invention.

While different embodiments of this invention have been described in detail, it is to be understood that such embodiments are susceptible of considerable change and that other embodiments of the invention which are not described in detail may exist. Furthermore, the principles of this invention are not limited to aeration or froth flotation, but apply equally as well to other processes and apparatus, such as conditioning. In the latter instance, an air supply would normally be unnecessary. However, the mixing and recirculation action carried out in the mixing zone, and the positive feed thereto, are features of apparently great value thereto.

When a given cell is used for retreatment as in rougher-cleaner operations, froth from one cell will be conducted into another cell through a chute substantially of the same shape as chute 42 but of smaller dimension, and preferably, this or other feed will be discharged at the periphery of the impeller in the manner illustrated.

It will further be understood that various other changes may be made without departing from the spirit and scope of this invention.

What is claimed is:

1. Apparatus for assorting solids suspended in a liquid, which comprises a rotating impeller having upwardly extending vanes for mixing air, solids and liquid in the lower portion of a body of pulp consisting of solids suspended in liquid; a rotating disc spaced above said vanes; conduit means for supplying pulp to the periphery of said impeller; and means for supplying air to said impeller, said impeller being adapted to move said pulp from its periphery toward the central portion thereof, to mix air, solids and liquid, and then to eject the mixture of air, solids and liquid.

2. In apparatus for assorting solids, as defined in claim 1, said impeller including a disc and said

vanes including a plurality of slicing vanes attached to the upper surface of said disc and extending chordally, each such vane being disposed with one end at or adjacent the periphery of said disc and its other end spaced from said periphery and at a point substantially on a radius of said disc to which said vane is perpendicular, and a plurality of additional vanes disposed substantially parallel to a radius of said disc and extending inwardly from a point adjacent the periphery thereof.

3. In apparatus for assorting solids, as defined in claim 1, said impeller including a disc, and said vanes including a group of substantially equally spaced vanes disposed chordally and attached to the top of said disc, each of said vanes being spaced from the periphery of said disc and extending a substantially equal distance to either side of a radius of said disc to which said vane is perpendicular, and a second group of equally spaced vanes attached to the top of said disc, each vane extending from a point adjacent the center of said disc outwardly to a point further from the periphery of said disc than any of said first group of vanes, the vanes of said groups being equal in number and disposed alternately with respect to each other.

4. Apparatus for fluid suspension classification comprising a tank containing a body of pulp consisting of solids suspended in liquid; a hollow shaft extending into the lower portion of said tank; an impeller having upwardly extending vanes for mixing air, solids and liquid and attached to the lower end of said shaft, said shaft being adapted to convey air therethrough to said impeller; a baffle spaced above said vanes and secured to said shaft; and conduit means for feeding pulp to at least one point on the periphery of said impeller.

5. Apparatus for fluid suspension classification as defined in claim 4, including means for supplying air under pressure to a point adjacent the periphery of said impeller.

6. Apparatus for fluid suspension classification as defined in claim 4, which includes means for supplying air under pressure to said hollow shaft.

7. In apparatus for assorting solids, a hollow shaft extending to the lower portion of a body of pulp consisting of solids suspended in liquid; an impeller rotated by said shaft and provided with upwardly extending vanes for producing a pumping action to draw air through said shaft to said impeller; a baffle rotated by said shaft and spaced above said vanes; conduit means for supplying pulp to the periphery of said impeller; and means for conveying additional air to a point adjacent the periphery of said impeller.

8. In fluid suspension classification apparatus, a hollow shaft extending to the lower portion of a body of pulp consisting of solids suspended in liquid; an impeller rotated by said shaft and provided with upwardly extending vanes for inducing a flow of air through said shaft to said impeller, for producing a flow of pulp from the periphery toward the central portion of said impeller, for mixing air, solids and liquid, and for ejecting the mixture of air, solids and liquid; a baffle rotated by said shaft and spaced above said vanes; and conduit means for supplying feed pulp to the periphery of said impeller.

9. In fluid suspension classification apparatus as defined in claim 8, means for supplying additional air adjacent the periphery of said impeller.

10. In fluid suspension classification apparatus, a hollow shaft extending to the lower portion of

a body of pulp consisting of solids suspended in liquid; means for supplying air under pressure to said hollow shaft; an impeller secured to the lower end of said shaft and rotated by said shaft, said impeller being provided with upwardly extending vanes for moving pulp from the periphery thereof toward the central portion thereof, for mixing air, solids and liquid, and for ejecting the mixture of air, solids and liquid; a baffle secured to said shaft in spaced position above said vanes; and conduit means for feeding such pulp to the periphery of said impeller.

11. In aeration apparatus, a rotating impeller driven by a vertical shaft and comprising a substantially horizontally disposed disc provided with upwardly-extending vanes, some of said vanes being disposed generally radially and other vanes being disposed generally chordally of said disc; and a substantially horizontally disposed baffle above and spaced from said vanes and rotated by said shaft.

12. Apparatus for fluid suspension classification comprising a tank containing a body of pulp consisting of solids suspended in liquid; a hollow shaft extending into the lower portion of said tank; an impeller comprising a disc attached to the lower end of said shaft and carrying vanes on the upper side thereof and a baffle attached to said shaft and spaced from the upper edges of said vanes, said vanes being adapted to move pulp toward the center of said impeller, to mix air, solids and liquid, to eject the mixture of air, solids and liquid, and to recirculate pulp from said body for further mixing in said impeller; a conduit leading from a point outside said body of pulp for conveying feed pulp to a point adjacent the periphery of said impeller; an air conduit terminating at a point adjacent the periphery of said impeller and also adjacent said feed conduit on the side of said conduit approached by successive portions of the periphery of said impeller during rotation of the same; and baffle means within said tank and extending above said impeller for producing a more quiescent state in said body of pulp.

13. For aeration apparatus, a device for mixing air, solids, and liquid, comprising upper and lower spaced rotatable discs; and a plurality of upwardly extending vanes attached to the lower disc but spaced from the upper disc, said discs and vanes being constructed and arranged so as to move pulp from the periphery of said discs toward the central portion thereof, to mix such air, solids, and liquid, and to eject the mixture of air, solids, and liquid.

14. For aeration apparatus, a device for mixing air, solids, and liquid, comprising a lower rotatable disc having two groups only of upwardly extending vanes attached thereto, each group of vanes being substantially equally spaced about said disc with one group of vanes extending substantially radially of said disc and the other group of vanes extending substantially chordally of said disc; and an upper rotatable disc disposed above and spaced from said vanes, said device being adapted to be supplied with air centrally of said discs.

15. For aeration apparatus, a device for mixing air, solids, and liquid, comprising a lower rotatable disc having two groups only of upwardly extending vanes attached thereto, each group of vanes being substantially equally spaced about said disc with one group of vanes extending substantially radially of said disc and the other group of vanes extending substantially chordally of said disc; and an upper rotatable disc disposed above and spaced from said vanes, said device being adapted to be supplied with air at a position along the periphery thereof.

16. For aeration apparatus, a device for mixing air, solids, and liquid, comprising a lower rotatable disc having two groups only of upwardly extending vanes attached thereto, each group of vanes being substantially equally spaced about said disc, with each vane of one group extending chordally from a radius of said disc, to which said vane is perpendicular to a point at or adjacent the periphery of said disc, and each vane of the other group extending inwardly from a point near the periphery of said disc and parallel to the radius of said disc to which the adjacent vane of the first group is perpendicular; and an upper rotatable disc disposed above and spaced from said vanes.

17. For aeration apparatus, a device for mixing air, solids, and liquid, comprising a lower disc having two groups only of upwardly extending vanes attached thereto, each group of vanes being substantially equally spaced about said disc with each vane of one group extending a substantially equal distance to either side of a radius of said disc to which said vane is perpendicular and each vane of the other group extending radially from a point adjacent the center of said disc; and an upper rotatable disc disposed above and spaced from said vanes.

PAUL L. WIGTON.