

May 31, 1960

C. A. HOLLINGSWORTH ET AL

2,938,629

CONCENTRATION OF COMMINUTED MATERIALS

Filed July 28, 1955

3 Sheets-Sheet 1

FIG. 1

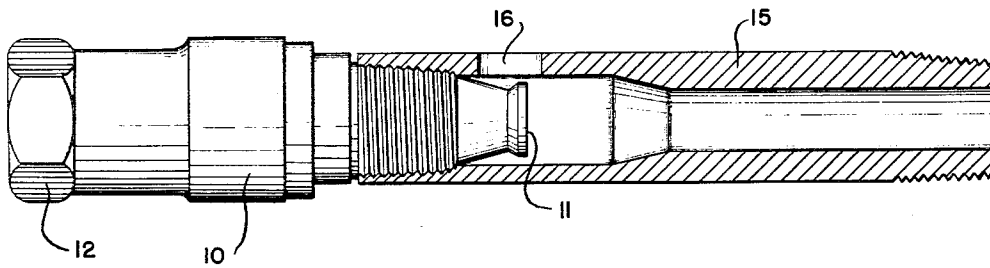


FIG. 2

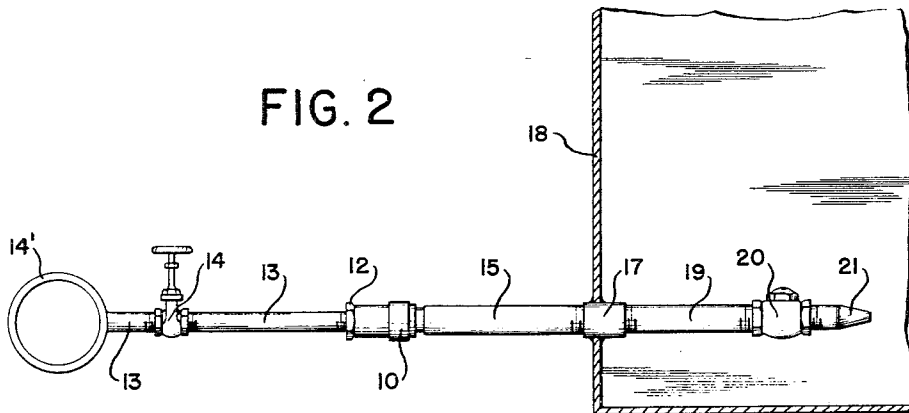
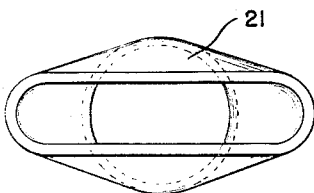


FIG. 3



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FIG. 4

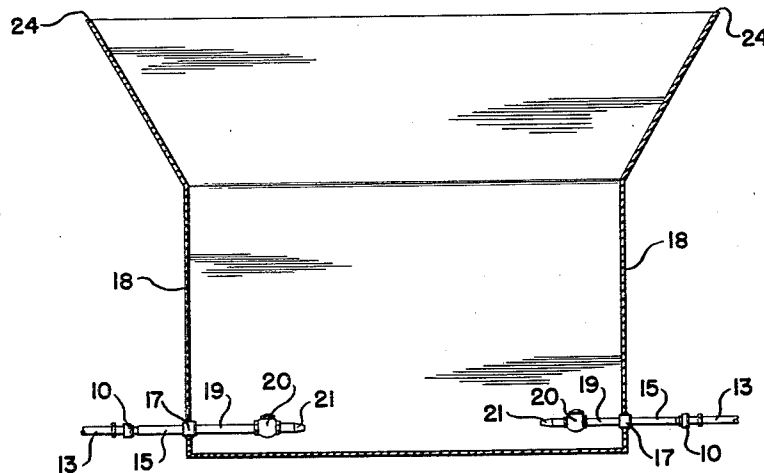
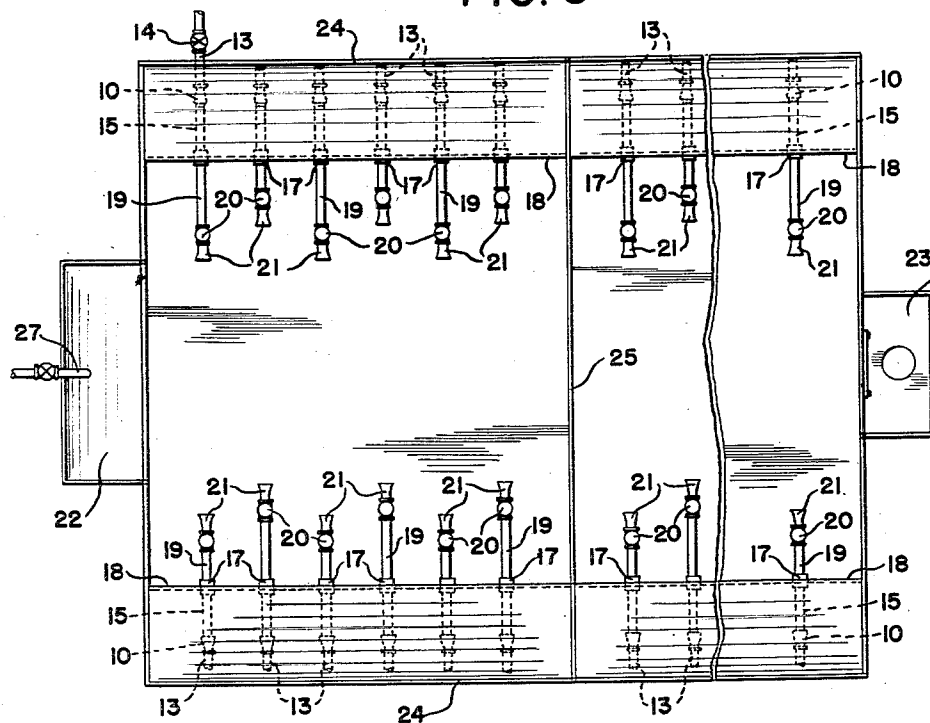


FIG. 5



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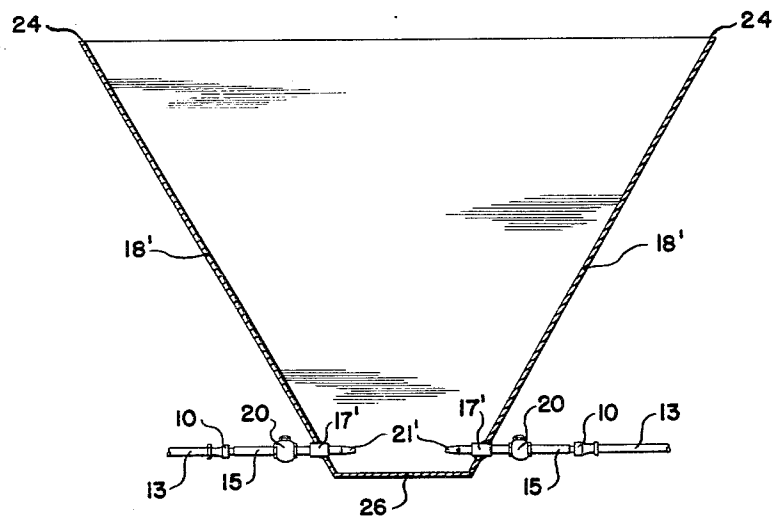
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CONCENTRATION OF COMMINUTED MATERIALS

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3 Sheets-Sheet 3

FIG. 6



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2,938,629

CONCENTRATION OF COMMINUTED MATERIALS

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3 Claims. (Cl. 209—170)

This invention relates to the concentration of comminuted materials by pneumatic flotation, and while particularly described with reference to the concentration of minerals, it may be advantageously applied to the flotation treatment of various other materials, such as graphite ores, coal, mineral slimes, sewage, trade wastes, chemicals such as starch-gluten mixtures, water soluble materials etc. More particularly, the invention involves an improved method of aerating a reagentized (or non-reagentized) pulp of mineral (or non-mineral) by introducing (into a body of the pulp) water containing entrained air in an extremely finely divided state and under such pressure as to exert a force against and throughout the pulp body sufficient to keep the pulp in motion at all times.

One object of the invention is to provide an apparatus which is simple in construction, low in cost of manufacture, highly efficient in operation and low in cost of maintenance, requiring no outside power consumption for its operation beyond the normal water volume under normal pressure required for the operation of the flotation process by other methods. The apparatus contains no moving parts and does not require a source of compressed air or blower air since it obtains the required air from the surrounding atmosphere at normal atmospheric pressure.

Apparatus (commonly called flotation machines or cells) in common use at the present time require considerable mechanical energy to maintain a flow of solids through the cell or system of cells. This is generally achieved by the use of rapidly moving agitators which tend to keep the solid particles in suspension thus permitting the flow of water to carry the solids through the cell. At the same time the air, required to perform the flotation action of the reagentized solid particles, is either introduced under pressure, or is drawn in through a hollow shaft of the agitator, or is drawn in by the agitator through a pipe terminating just under the impeller or agitator of the cell. In other cases where no agitator or impeller is used, air is forced into the apparatus along the center of the cell close to the bottom and under some pressure from a high speed blower to maintain the solids in suspension while again the water passing through the cell keeps the suspended solids moving therethrough. In still other types of apparatus air under pressure is introduced through a porous medium at the bottom of the cell and its expulsion through the porous medium keeps the mineral pulp suspended while water introduced above the porous medium moves the suspended solids through the cell.

In all these apparatus the air is introduced by means of mechanical action and expended electrical energy and under such violent agitative action as to produce undesirable turbulence in the cell unless movement of the pulp in the cell is quieted down by the use of weirs, baffles

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or grids of one kind or another. In the agitator type apparatus the agitation is generally so violent as to cause considerable disintegration of the solid particles, thus producing undesirable near-colloidal material generally referred to as slimes.

There are several reasons for avoiding the formation of slimes. For example, in the beneficiation of Florida phosphate ore the phosphatic values in the slimes run from 20% BPL (bone phosphate of lime) to 35% BPL and at the present time recovery of these values from slimes has not been economically achieved. Formation of these phosphatic slimes by excessive agitation reduces not only the recovery of phosphate values but is responsible for economic losses as well. As is well recognized in the industry, slimes seriously affect the amount of collector reagents required to produce good metallurgy. This is even more true in the case of cationic flotation where the collector reagent can be completely inactivated by the presence of slimes. Another point of great importance is the fact that since phosphatic slimes rarely settle beyond 15% solids, huge areas are required to settle out the plant waters containing them and these areas filled with the phosphatic slimes are at present waste land since they cannot be used for any purpose. Therefore, the elimination of any small percentage of phosphatic slimes in the flotation process advantageously increases the volume of material which does not require storage for a useless purpose. Similar problems are present in the case of almost every flotation operation.

In the conventional present-day methods of flotation the production of slime causes considerable interference in the proper execution of the flotation process. Slimes also result in an appreciable consumption of costly reagents, or the use of additional reagents to prevent their interference, or to keep the slimes under control. In the present invention the agitation action of the combined air and water is of such a gentle nature as to prevent excessive sliming of the solids (whether mineral or gangue) during the process of flotation. This is particularly true when a cationic reagent is used as the collector since cationic reagents are in most cases quite sensitive to slime and do not perform with efficiency where slimes are rapidly created during the retention of the comminuted solids in the cell.

All previous attempts to use only air and water as prime movers of solids through a flotation cell (without recourse to agitators or impellers activated by mechanical means) has necessitated the consumption of considerable power in order to introduce the required air at a pressure equal to or greater than the hydrostatic water pressure within the cell, or at least sufficiently great to exert a force which will keep the solids in suspension while the flow of water moves these solids through the cell.

Not too much attention has heretofore been directed to the actual size of the air bubbles introduced into the apparatus. In most cases these are relatively large, while in others their size depends on the pore opening of the porous material through which the air is forced. Where the impeller acts as the suction force to pull in the air, the air can be beaten to a relatively small bubble by the action of the impeller.

In none of these heretofore common methods of aeration does all the water present contain entrained air. It is also apparent that where air is forced into the apparatus under pressure the air bubbles are relatively large and consequently the total surface area of the entrained air bubbles in the apparatus is relatively small. This total surface area of the entrained air bubbles increases as the air bubble size decreases. It is recognized in the

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art that without air no flotation can take place, and the efficiency of the flotation process depends upon the air volume, increasing as the latter increases. Flotation research has shown that the process is made possible by the attachment of air bubbles to the solid particle to be floated. Therefore the smaller these bubbles are the more of them can attach themselves to the selectively reagentized particle to be floated resulting in a more efficient float with less air and less effort. In order to do this, an efficient means of producing diminutive air bubbles is required, and such air bubbles must be completely dispersed or entrained in the water or other liquid in which they function as carriers.

We have discovered that very finely divided air can be introduced into a flotation apparatus by proper utilization of the water or other liquid vehicle. The air so introduced is completely entrained in the liquid and no moving impellers or other mechanical means are required to produce the fully aerated liquid. Air is drawn into the apparatus from the surrounding atmosphere and requires no blower or compressor to introduce it. The great advantage of the invention is that the only movement within the apparatus is produced by the liquid which is normally introduced as the carrier or vehicle for the solid comminuted material. However, instead of introducing the liquid at only one point (e.g. at the feed end of the apparatus), it is added at several points along the apparatus and at each point of introduction carries with it finely disseminated air. A sharp reduction in operating cost is thereby effected since no power is required either for a blower to produce air or for the motors necessary to turn the conventional impellers. Only the amount of liquid ordinarily required to carry out the flotation process is utilized to provide all the necessary force to introduce the finely divided air as well as to move the pulp through the apparatus and carry the mineralized air bubbles to the surface in a froth and out of the apparatus into the froth discharge launders.

In order to maintain proper level of the water (or other liquid) in the apparatus, aerated or non-aerated make-up water (or liquid) may be bled-in without affecting the efficiency of the process.

In the present invention no limitation is placed on the physical shape, or dimensions of the apparatus in which the liquid aerator operates. On the contrary, the novel liquid aerator of the invention performs equally well in a shallow tank type cell or in a narrow deep cell where the internal pressure to be overcome by the aerated liquid is two or three times the pressure of a shallow cell. The air is so well dispersed and entrained in the liquid that it does not segregate. This is perhaps dependent on the fact that all the liquid within the cell is fully aerated and movement of the pulp within the cell is so rapid and efficient, always moving the froth product from the cell before segregation can occur.

Movement of the pulp longitudinally through the flotation apparatus or a system thereof is effected by the aerated liquid (and perhaps a small amount of unaerated liquid) alone. No great pressure stream is required since the buoyancy of the aerated liquid greatly decreases the tendency of solid particles to settle out of the pulp, and the pulp is thus kept in fluid motion at all times until discharged from the cell either over a froth lip or through a tailings discharge valve.

As already pointed out, the size, shape and general dimensions of the flotation cell do not affect the efficiency of operation of the cell equipped with the novel liquid aerators of the invention. These have shown themselves to be equally well adapted to a shallow tank type cell in which a rapid discharge of froth takes place, or in a deep tank type cell in which the aerated mineral particles collect as a froth more slowly. The type of cell best suited is of course dependent on the nature of the mineral or other material being processed. With some materials it may be advantageous to operate the cell or cells with

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mechanical agitation in addition to liquid aerators. It may also be advantageous in some operations to operate one or more cells of a multiple cell bank with liquid aerators and one or more cells with agitators, as, for example, where metallic type ores are treated which have a high specific gravity and are difficult to keep in suspension. Again it may be found advantageous to operate a bank of cells using liquid aerators in the first group of cells without agitators in the removal of easily slimed materials and follow this with the second group of cells in which both aerators and agitators are employed for the residual float.

In the general construction of the flotation apparatus, the location of the liquid aerators is not critical. The aerators may be positioned above the cell with long discharge pipes leading into the lower strata of pulp in the cell. They may extend through the sides of the cell to discharge directly into the pulp area, or they may be located on the bottom of the cell to discharge upwardly into the cell. Neither is the angle of insertion of the aerators critical, and they may be placed perpendicular to the cell walls or at such an angle thereto as to provide the greatest thrust into the pulp within the cell. Irrespective of the actual location of the liquid aerators, they are arranged to introduce aerated liquid into a longitudinally flowing body of mineral pulp at a distance from the bottom of the flotation cell substantially less than half the cell's depth and over substantially the entire transverse area of the pulp body at the depth of aerated liquid introduction.

The liquid aerators constitute the essentially novel feature of the invention and are characterized by their unique and efficient aerating action. The aerators are adapted to completely aerate each particle of liquid flowing through them, and the liquid and air in intimate union enter the cell as a jet stream which may be dissipated by a diffusion plate, or other suitable means of spreading the resulting jet through the cell. In a preferred form of the aerator, liquid (e.g. water) passing through a constriction tube (somewhat like a venturi tube) produces a suction of such magnitude as to draw in sufficient air to completely aerate all the liquid used in creating such suction and also sufficient air to perform the aeration of the comminuted particles to be floated. The volume of air injected into the liquid stream is dependent on the angle of the liquid entering the constriction zone. It is within this zone that the actual, thorough mixing of air and liquid takes place, and the air is so completely dispersed in the liquid that it is substantially all retained in either the froth overflowing the lip of the apparatus or the tailings discharged therefrom.

The liquid aerators may be made of a variety of materials depending on the use to which they are applied or the choice of the manufacturer. Where used in an operation in which corrosive action exists, they may be made of plastic, hard rubber, Karbate, graphite or stainless steel. Brass, copper, black iron or other machinable metals or non-metals may be used in their manufacture, where used in non-corrosive operations. The aerators may be machined from one metal and then plated with another, or the parts thereof may be made from different metals if required or desired.

In processes where a liquid other than water is used, the aerators perform equally well. Some processes particularly those in the potash, and other soluble mineral salt field, use a saturated solution (brine) of the water-soluble mineral salt which is to be concentrated, as the vehicle of the process. This saturated brine, when used in place of water, aerates and entrains finely dispersed air as completely as does water. Processes carried out in non-aqueous liquids can utilize the invention to a distinct advantage since the same liquid can be used over and over again to draw in additional air in the consummation of the flotation operation.

One of the important advantages of the invention is

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the fact that any liquid aerator unit may be individually removed from a flotation cell while the cell is operating, without materially affecting the operation in any way. The removal of individual aerators may become necessary at times to permit cleaning or replacement.

The invention may advantageously be embodied and practiced in a flotation cell having upright side walls and a solid bottom, say about 4 x 4 ft. square with the side walls about 4 ft. in height, equipped with a feed intake at one end and at the other end with a tailings discharge or else joined to a similar cell, or bank of cells, the last one of which is equipped with a tailings discharge valve, gate, or the like. Through such a cell (or bank of cells) the body of mineral pulp undergoing pneumatic flotation flows longitudinally from the feed inlet to the final tailings discharge. At the top, the side walls of each cell are provided with froth discharge lips or weirs which are so constructed as to control the height of the liquid level in the cell. Near the bottom of the side walls, say about 3 inches from the bottom, there are welded through the wall of the cell a plurality of pipe sleeves. In a cell having perpendicular side walls, these sleeves are fitted on the inside of the cell alternately with 4 inch and 8 inch long nipples, which in turn are equipped with a butterfly or similar type of check valve into which another short discharge nozzle is fitted which preferably is of such form that the aerated liquid is discharged therefrom as a flat jet spreading over a substantial transverse area of the cell at the depth of aerated liquid introduction. Into the outside opening of each pipe sleeve in the cell wall is fitted the liquid aerator which is in turn connected through a valve to the main liquid header pipe.

In cells of the type in which the bottom is only from 12 to 18 inches wide and the side walls flare outwardly to around 48 inches wide at the top, a similar plurality of pipe sleeves are welded into the cell walls. However, in this type of cell it is preferred to position the check valve outside the cell walls leaving within the cell only the discharge nozzle.

The aerator may be of any air-injector type suited for the purpose. A well-known type is that used in the laboratory as a filter pump or aspirator, which operates by the entrainment of air in an injected stream of water. This type is not well adapted for commercial size flotation cells since the air intake is relatively small and a very large number of units are required to give satisfactory performance. However, this type of air-injector has worked satisfactorily in experimental size or laboratory flotation cells where the air and liquid requirements are comparatively low.

We have discovered that a similar effect can be achieved (in which the air volume is relatively large) by passing a jet of rapidly moving liquid into an elongated tube provided with an air intake approximately at the outlet of the jet of liquid. Although in its preferred form this tube has a constricted area toward its outlet end, good performance has been obtained with a tube having a bore of uniform diameter. However, in the latter case slightly less air is drawn in by the same volume of liquid passing the air intake.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a plan, partly in section, of a fluid aerator embodying the principles of the invention,

Fig. 2 is a sectional elevation of a lower corner of a flotation apparatus with a fluid aerator unit extending through a side wall,

Fig. 3 is a detail view of the flared end of the aerator unit's discharge nozzle.

Figs. 4 and 5 are a transverse sectional elevation and top plan, respectively, of a flotation apparatus embodying the invention, and

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Fig. 6 is a transverse sectional elevation of a slightly modified form of apparatus.

The liquid aerator comprises a liquid spray nozzle 10 having a tapered or jet discharge end 11; and an internally threaded coupling 12 at its other end. A pipe 13, in which is operatively included a valve 14, connects the coupling 12 of the nozzle 10 to a source of water or other liquid 14' under a pressure normally ranging from about 15 to about 60 pounds per square inch.

One end of an elongated tube 15 is screw-threaded onto the discharge end 11 of the nozzle 10. The tube 15 has one or more air inlet vents or openings 16 positioned slightly back of the discharge end of the nozzle. Preferably, the elongated bore of the tube 15 is constricted toward its discharge end to provide increased efficiency of air intake. The other end of the tube 15 is screw-threaded (preferably by standard pipe threads) into a pipe sleeve 17 secured by welding or the like in the upright side wall 18 of a flotation apparatus. Inside the apparatus, a nipple 19, to which is attached a butterfly check valve 20, connects the pipe sleeve 17 to a discharge nozzle 21. The outlet of the nozzle 21 is of fish-tail configuration, i.e. elongated or spread horizontally, as best shown in Fig. 3, in order to spread the aerated liquid over a substantial transverse area of the pulp body in the flotation apparatus. Aeration takes place within the elongated tube 15 and the aerated liquid emerges from the discharge nozzle 21 under considerable thrust.

The jet stream of liquid discharging from the nozzle 10 draws in atmospheric air through the vent or vents 16, and the draw-in air is intimately mixed with and thoroughly disseminated throughout the liquid stream in the bore or chamber of the tube 15. The thus-aerated liquid passes into the nipple 19 through the check valve 20 and discharges fan-wise from the nozzle 21 into the body of mineral pulp in the flotation apparatus.

Figs. 4 and 5 diagrammatically illustrate a complete flotation cell embodying the invention. The liquid aerator units of the construction shown in Figs. 1, 2 and 3, extend inwardly through each side wall 18 of the cell, with alternate discharge nozzles 21 extending further into the cell than the other adjacent nozzles. Thus with a cell width of about 4 feet the alternate nipples 19 may advantageously be about 4 and 8 inches long, respectively. The cell has a feed intake launder 22 at its forward end and a tailings discharge launder 23 at its opposite end. The upper portions of the side walls 18 flare outwardly and terminate at their upper edges in froth overflow lips 24 discharging into suitable froth launders (not shown). Each cell unit may be a separate structure, with the discharge from one cell constituting the feed of the next cell in a bank or series of cells. Or, as shown in Fig. 5, several cells may be formed in an elongated structure or tank by one or more vertical partitions 25. The partitions 25 are provided with suitable openings to permit the discharge of pulp from each succeeding cell to the following cell in the bank.

In the form of cell shown in Fig. 6, the side walls 18' slope downwardly and inwardly to a relatively narrow bottom 26. Only the sleeve 17' (welded in the wall 18') and the discharge nozzle 21' (screw-threaded into the sleeve) are positioned within the cell, the check valve 20 being screw-threaded onto the elongated tube 15 and positioned outside the cell between the sleeve 17' and the tube 15.

In some operations it may be desirable to diminish the amount of aerated liquid introduced into the flotation apparatus. This may be accomplished by appropriately adjusting the valves 14 of the fluid aerator units to permit introduction of the desired volume of aerated liquid, and then adding unaerated liquid into the feed launder 22 through a valved supply pipe 27. The liquid supply pipe 27 also permits adjusting the liquid levels in a series of cells to the proper heights for optimum operation.

The following examples illustrate various advantages of the invention.

Example I

The tests of this example compare the attrition losses of an aerated liquid flotation cell of the invention with those of a conventional cell of the agitator type.

An aqueous slurry from the second cell of a six cell bank in a cationic flotation process employing an amine as the collector agent was collected and screened to remove all plus 150 mesh particles. The resultant slurry was then mixed to assure complete and uniform distribution of solids in the water, and 1000 ml. were poured into a graduated cylinder. The same procedure was followed with each type of cell. The cylinder contents were allowed to settle for 15 minutes at which time the volume of settled solids was determined and expressed in percent on the original volume of slurry (1000 ml.)

TEST NO. 1

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	76.94	2.54	73.40	6.40	18.38
Agitator Cell.....	76.41	3.40	73.40	6.40	21.68

TEST NO. 2

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	76.78	2.27	73.53	7.40	17.22
Agitator Cell.....	75.82	3.06	73.53	7.40	19.99

In both these tests the aerated liquid cell consisted of a battery of six cells the first two of which were equipped with liquid aerating units of the invention while the remainder were cells of the agitator type. The agitator cell on the other hand was a six cell bank completely equipped with mechanical agitators but with no liquid aerators. The slurry specimens were taken at the juncture of the second and third cells but in the second cell in order to give a good comparison of the actions of the aerated liquid cell and the agitator cell. These tests show that attrition losses are practically negligible in the aerated liquid cell in comparison with such losses in the agitator cell.

TEST NO. 3

Tests 3 and 4 illustrate the difference in attrition losses between the aforesaid two types of cells when an anionic flotation operation is carried out on phosphate ore. The slurry sample was taken at the end of the cell in the tailings discharge launder.

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	74.71	2.60	71.41	7.44	14.62
Agitator Cell.....	75.32	3.64	71.41	7.44	19.56

TEST NO. 4

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	74.71	2.60	71.41	7.44	14.62
Agitator Cell.....	75.32	3.64	71.41	7.44	19.56

Example II

The tests of this example illustrate the decrease in insoluble obtained using a 6-cell combination of two aerated

liquid cells and four agitator cells and comparing these results with a 6-cell agitator bank in a cationic flotation operation (cleaner circuit) carried out on phosphate ore.

TEST NO. 1

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	76.94	2.54	73.40	6.40	18.38
Agitator Cell.....	76.41	3.40	73.40	6.40	21.68

TEST NO. 2

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	76.78	2.27	73.53	7.40	17.22
Agitator Cell.....	75.82	3.06	73.53	7.40	19.99

TEST NO. 3

Type Cell	Conc.		Feed		Tails, Percent BPL
	Percent BPL	Percent Insol.	Percent BPL	Percent Insol.	
Aerated Liquid Cell.....	74.71	2.60	71.41	7.44	14.62
Agitator Cell.....	75.32	3.64	71.41	7.44	19.56

In each of these tests the aerated liquid cell of the invention produced under identical conditions a much lower insoluble in the concentrate and a much lower tailing content of BPL. The feed in these tests was a rougher concentrate product from a primary fatty acid-caustic-fuel oil flotation step which was deoiled with sulphuric acid and agitation rinses prior to introduction as feed into the cleaner circuit. Conditions of the operation in the two banks of cells were as nearly identical as possible with the exception of the changes brought about by the variation of air supply and agitation, which are the subject of the invention.

Example III

The following tests compare the effectiveness of the aerated liquid cell and the agitator cell in a single cell equipped with both liquid aerators and agitators. In two of the tests only the liquid aerators were functioning and no agitators were running, while in the other test only the agitators were running in a conventional flotation operation but no liquid aerators were operating. The large impeller runner in the cell interfered somewhat with the circulation of the pulp and the operation of the aerated liquid cell, since this runner is not normally present in an operating aerated liquid cell. Even under these adverse conditions the aerated liquid cell performed as well as the agitator cell with whose operation the liquid aerators do not interfere. These tests were run on raw phosphate ore feed coming into the flotation section, and employed a fatty acid-caustic-fuel oil mixture as the flotation reagent with removal of a phosphate froth while discharging a silica tailing.

Test No.	Conc.		Tails, Percent BPL	Cell Operating With--
	Percent BPL	Percent Insol.		
1.....	75.08	6.30	12.13	Liquid Aerators only.
2.....	75.86	6.50	11.30	Agitators only.
3.....	74.75	7.50	7.08	Liquid Aerators only.

Example IV

The tests of this example were run with a primary (rougher) step feed similar to that of Example III. In these tests, two-cell banks were used, one being completely equipped with liquid aerators and no agitators and the other being completely equipped with agitators and no liquid aerators.

TEST NO. 1

Type Cell	Conc.		Tails, Percent BPL
	Percent BPL	Percent Insol	
Aerated Liquid Cell.....	75.27	6.08	9.15
Agitator Cell.....	74.29	7.26	10.83

TEST NO. 2

Type Cell	Conc.		Tails, Percent BPL
	Percent BPL	Percent Insol	
Aerated Liquid Cell.....	73.24	7.87	6.05
Agitator Cell.....	72.70	8.66	5.92

In this rougher step float, as in a cleaner step float (Example II), the aerated liquid cell produces a concentrate of lower insoluble content than the agitator cell.

Example V

In this example, rougher step floats of a raw phosphate ore feed were carried out in a combination cell and in an aerated liquid cell. The combination cell comprised a six-cell bank of which the first two cells were equipped with liquid aerators while the last four were equipped with conventional agitators. The aerated liquid cell was a six-cell bank completely equipped with liquid aerators and having no agitators.

Type Cell	Conc.		Tails, Percent BPL
	Percent BPL	Percent Insol	
Aerated Liquid Cell.....	73.24	7.87	6.05
Combination Cell.....	72.24	8.84	3.93

Example VI

In this example anionic flotation of the same phosphate ore feed was carried out in an aerated liquid cell and in an agitation cell. The aerated liquid cell gave lower insoluble and higher grade of concentrate under substantially identical conditions of operation.

Type Cell	Conc.		Tails, Percent BPL
	Percent BPL	Percent Insol	
Aerated Liquid Cell.....	74.36	5.50	18.92
Agitator Cell.....	71.41	7.26	14.75

The invention may be efficiently carried out in a single cell or in any multiple cell system with equally good results. Any number of liquid aerators may be installed in one cell. It is possible in a small cell to effect flotation separation with but one aerator, while in a larger cell the required number may be many times that.

In cationic flotation where no pre-conditioning is required, it may be desirable to utilize one or more of the aeration units as reagent dispersion units in which case the reagent is allowed to feed into the air vent in place of a part or all of the air volume, thus giving instantaneous dispersion when the mixture enters the cell.

It may also be desirable to aerate with a gas other than atmospheric air, in which case the gas supply is connected to the air vent and the apparatus operated as with atmospheric air.

Where a soluble ore is to be floated, a saturated solution of the ore in water is pumped through the liquid nozzle 10 and also to the make-up liquid supply pipe 27. Similarly, where flotation is carried out in a non-aqueous liquid (i.e. other than water or a soluble ore solution) the non-aqueous liquid is pumped to the liquid nozzle 10 and, where required, to the supply pipe 27.

The invention may be practiced with advantage in any type of flotation operation, whether the floated fraction is the desired value or the floated fraction is the waste or gangue material. The floated fraction, whether value or waste, depends on the type of material undergoing treatment, and (where required) on the reagents used to promote the float. In the interest of simplicity, mineral in the appended claims includes any comminuted material as hereinbefore explained, the mineral froth may consist essentially of either the desired value or the waste as hereinabove explained, and the residual demineralized pulp is the original mineral pulp from which a substantial amount of either the desired value or the waste (as the case may be) has been removed in the mineral froth.

In practicing the invention, the density of the mineral pulp feed to the cell (e.g. to the feed intake launder 22 of Fig. 5) is higher than it would normally be in conventional agitator or pneumatic types of cell. The amount of liquid (as aerated liquid) which is introduced into the mineral pulp through the liquid aerators generally ranges between 20 and 70% of the total liquid of the pulp; the usual amount being about 50%. If it were practical to use a dry feed to the cell, all of the liquid required for pulp-making could be introduced as aerated liquid. The tailings or residual demineralized pulp discharged from the cell (e.g. through the tailings discharge launder 23 of Fig. 5) is accordingly substantially more dilute than the mineral pulp feed to the cell.

We claim:

1. A pneumatic flotation apparatus comprising the combination with a tank adapted to contain a longitudinally flowing body of mineral pulp and having mineral feeding means and pulp discharge means at its opposite longitudinal ends respectively, of a multiplicity of liquid aerators positioned outside the tank each of which includes a liquid jet nozzle and associated means for drawing atmospheric air into the aerator by suction created by the liquid jet discharged from the nozzle and an associated tubular chamber in which the drawn-in air is adapted to be thoroughly disseminated throughout the liquid discharged from the nozzle, means positioned in proximity to the bottom of the tank for introducing aerated liquid into the tank in a substantially horizontal plane and over substantially the entire horizontal area of the tank proximate that plane, said means comprising a series of conduits extending into the tank from at least one side wall thereof and having discharge openings at their inner ends, the discharge openings of said series of conduits being located alternately at different distances from said side wall, and tubular means for operatively connecting said tubular chamber to said means within the tank for introducing aerated liquid.

2. A pneumatic flotation apparatus comprising the combination with a tank adapted to contain a longitudinally flowing body of mineral pulp and having mineral feeding means and pulp discharge means at its opposite longitudinal ends respectively, of a multiplicity of liquid aerators positioned outside the tank each of which includes a liquid jet discharge nozzle and a pipe having a constricted bore communicating with the discharge end of the nozzle, said pipe having at least one air inlet opening proximate the discharge end of said nozzle, a multiplicity of aerated liquid discharge nozzles positioned within said tank proximate the bottom thereof at points at least an inch inside

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the wall of the tank and adapted to introduce aerated liquid into a body of pulp flowing through the tank in a substantially horizontal plane and over substantially the entire horizontal area of the tank proximate that plane, tubular means extending through the wall of the tank for operatively connecting each of said aerated liquid discharge nozzles to one of said liquid aerators, and a check valve in each of said tubular connecting means for preventing the back flow of pulp from the tank to the associated liquid aerator.

3. A pneumatic flotation apparatus comprising the combination with a tank adapted to contain a longitudinally flowing body of mineral pulp and having mineral feeding means and pulp discharge means at its opposite longitudinal ends respectively, of a multiplicity of liquid aerators positioned outside the tank each of which includes a liquid jet nozzle and associated means for drawing atmospheric air into the aerator by suction created by the liquid jet discharged from the nozzle and an associated tubular chamber in which the drawn-in air is adapted to be thoroughly disseminated throughout the liquid discharged from the nozzle, means positioned in proximity to the

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bottom of the tank for introducing aerated liquid into the tank in a substantially horizontal plane and over substantially the entire horizontal area of the tank proximate that plane, tubular connecting means operatively connecting said tubular chamber to said means within the tank for introducing aerated liquid, and a check valve in each of said tubular connecting means for preventing back flow of pulp from the tank to the associated liquid aerator.

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