March 15, 1960 L. H. LOGUE 2,928,543

FROTH FLOTATION SEPARATION

Filed Nov. 10, 1955 2 Sheets-Sheet 1

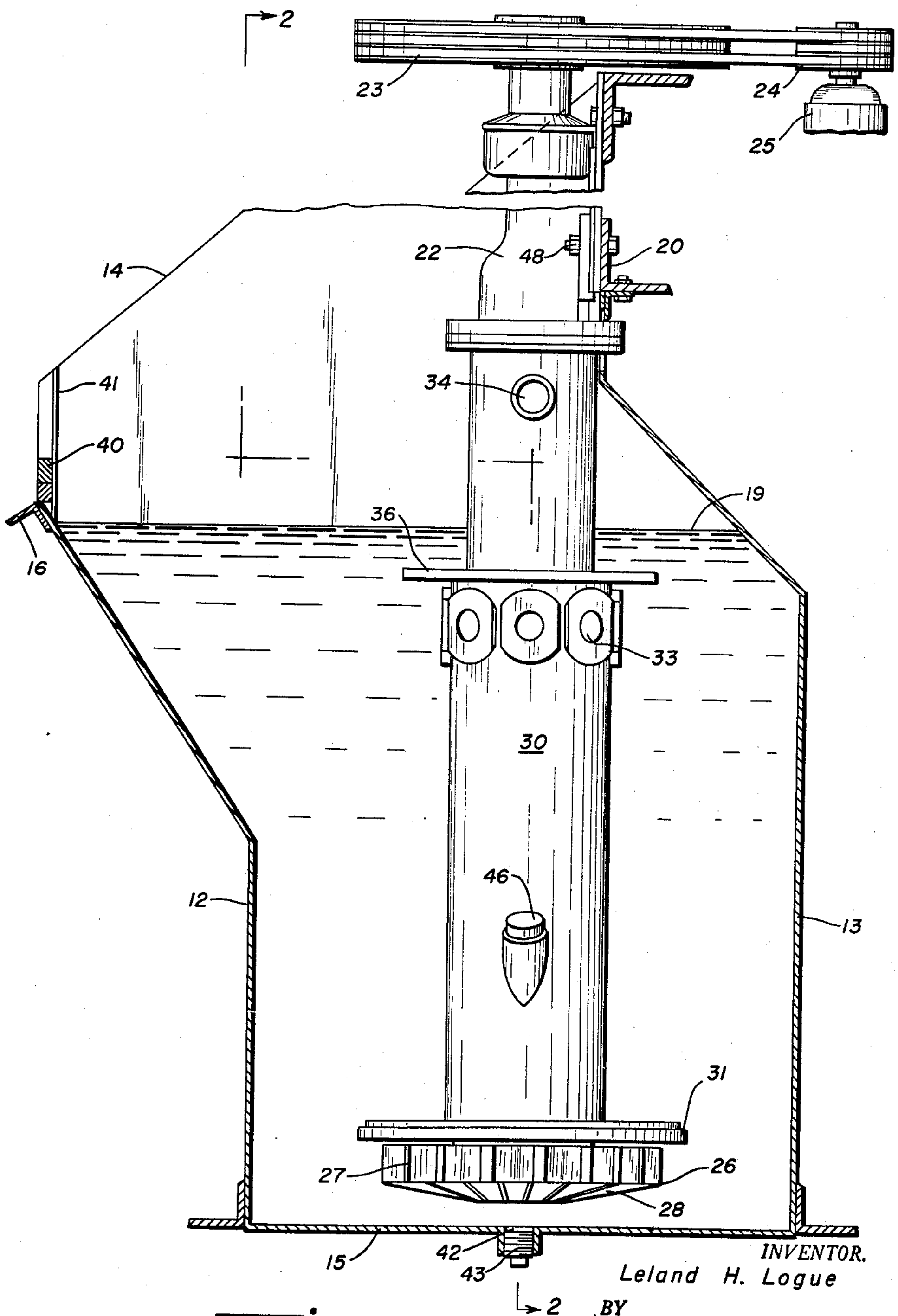

Fig. - 1

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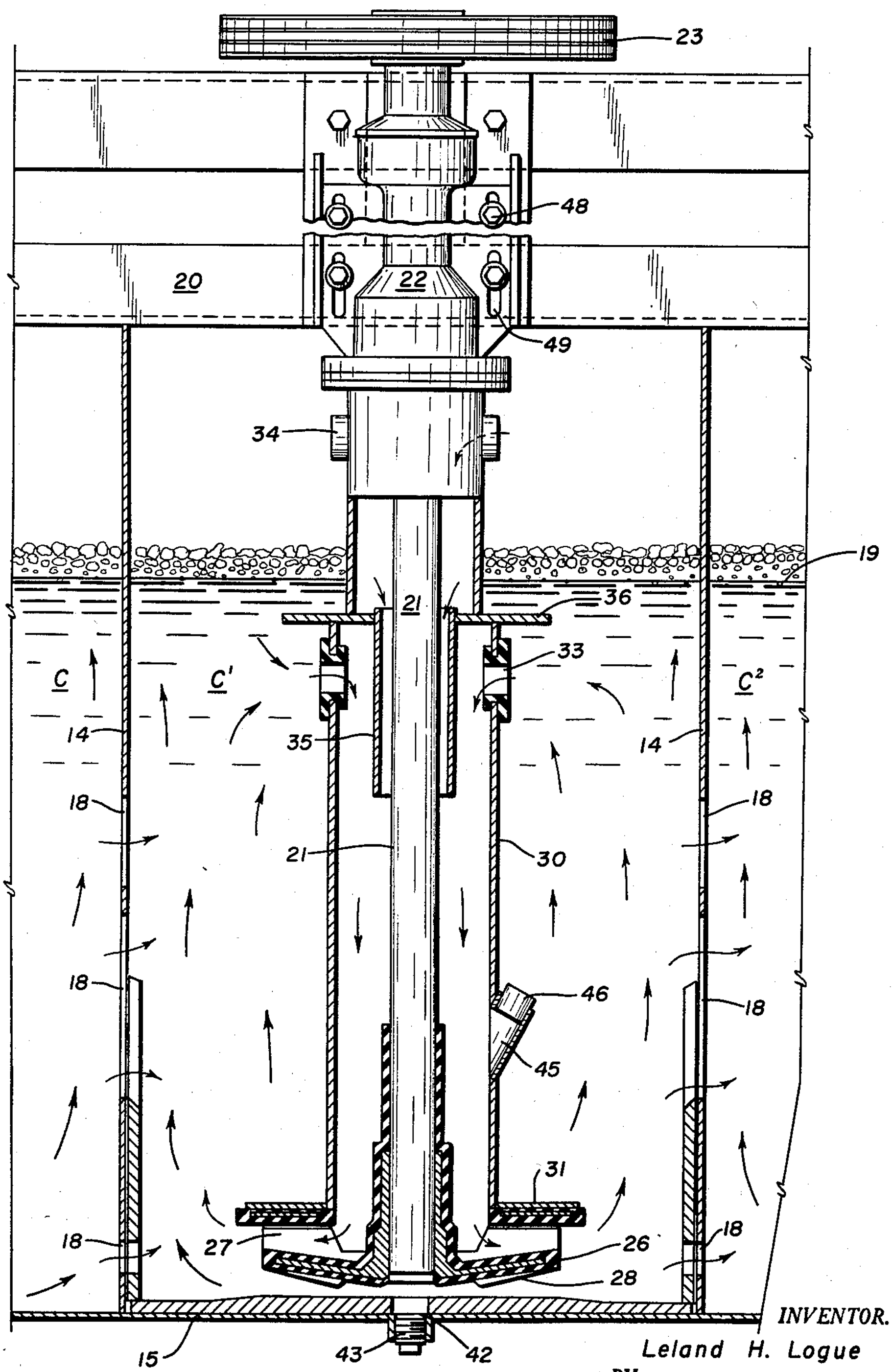

Fig.-2

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2,928,543

Patented Mar. 15, 1960

2,928,543

FROTH FLOTATION SEPARATION

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Application November 10, 1955, Serial No. 546,123

5 Claims. (Cl. 209—169)

This invention relates to the froth flotation art and more particularly relates to improved methods and means for performing froth flotation separations.

Mechanical type froth flotation apparatus has come into general acceptance by most flotation operators and many advantages over the pneumatic or air lift machines. There has been a tendency to go to larger sized equipment in ore milling and this has required the production of larger flotation cells. In almost all pulps, there will be a considerable portion of the solids in finer size ranges and another considerable portion in substantially coarser sizes.

There is a tendency toward size segregation or stratification in the modern machines with a substantial amount of the finer sizes remaining in the upper portion of the pulp body and another substantial amount of coarser sizes remaining in the lowermost portion of the pulp body. These conditions do not favor good flotation as the intermediate sizes tend to float more readily while the fine sizes near the top and the coarse sizes near the bottom cause a density build up that impedes the flotation efficiency. In addition, an appreciable amount of gangue in fine sizes frequently is entrained in the fine concentrate and thus reduces the grade of concentrate.

The coarse sizes in the lower portion of the pulp body are moving under the intense action of the agitation and exert a scouring action on the finer sizes which reduces the filming effect on such particles and thereby impedes flotation. However, the usual agitation fails to make provision for loosening and distribution of the coarse strata forming in the lower portion of the cell. Even in operations where a relatively high recovery is obtained at flotation there is a substantial amount of the valuable constituent passing from the treatment with the tailings which invites recovery if an economical method can be provided.

My invention is based on the discovery that by inducing a high degree of circulation along essentially vertical courses within a flotation cell, a size segregation of pulp particles can be greatly alleviated if not completely eliminated with substantial reduction of tailings losses. In inducing such circulation I prefer to utilize a free falling movement of pulp through a downward course of substantial vertical extent which develops a high velocity movement that is highly effective in entrainment of air or other aerating gas and reduces the power requirement of the impeller due to the high velocity input of pulp. I also utilize a high velocity discharge at the bottom of this vertical course which provides a high degree of intermingling of coarser and finer sizes accompanied by intense gas release and elevating movement of the commingled solids.

Accordingly it is an object of this invention to provide a simple, efficient and economical froth flotation process in mechanical type cells which process substantially eliminates size segregation of pulp constituents in the treatment and thereby improves grade and recovery.

Another object of this invention is to provide a simple,

durable and economical froth flotation cell which may have a greatly increased vertical dimension as compared with conventional cells, thereby permitting large volume treatment over a small floor space and with improved flotation efficiency.

A further object of this invention is to provide a simple, efficient and economical process which permits the circulation of a larger volume of pulp during a given flotation time and with improved grade and recovery.

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

One of the advantages of the present invention is that it may be incorporated in machines already installed and in use as well as in new embodiments specially designed for the practice of the invention. It may be utilized in unit cell operations although it will have its greatest utility in machines having a series of cells arranged in series. In all the various forms and embodiments essentially the same operation is performed in each cell although the highest efficiency will derive from the utilization of optimum dimensional relationship and operating controls.

The practice of the invention will be best understood by reference to the accompanying drawings in which a preferred embodiment of the apparatus of the present invention has been illustrated. In the drawings in both views of which like parts bear similar reference numerals:

Fig. 1 is an end elevation, partially broken to show arrangement of interior parts, of a flotation cell utilizing features of the present invention and represented as being empty; and

Fig. 2 is a developed section of a similar cell taken approximately on the line 2—2, Fig. 1 and with a fragmentary representation of the arrangement of adjoining cells in the series of a multiple cell machine and represented as in operating condition with flows indicated by arrows.

The machine shown in Fig. 2 comprises a three-cell arrangement in which cell C represents a first cell of the series, cell C^1 an intermediate cell, and cell C^2 a last cell of a "hog-trough" type mechanical machine in which a suitable control (not shown) of the tailings discharge from the last cell as by overflow weir or float valve control will control the rate of flow through the machine. Initial feed to the machine usually is through a feed box and submerged inlet (not shown). Since these features are old and well known in the art, detailed description and illustration appears unnecessary.

Each of the cells C, C^1, and C^2 will comprise a front wall **12**, a rear wall **13**, two side walls **14** and a bottom **15**. Preferably the front wall **12** inclines forwardly in its upper portion to provide an enlarged spitzkasten effect while rear wall **13** inclines inwardly as shown to crowd the froth bed toward overflow lip **16** at the top of wall **12**. This arrangement provides a large area near the surface of the pulp body which is out of the path of the circulating flow as will be subsequently described and assists in the collection and discharge of the froth concentrate.

Cell C^1 has one or a plurality of pulp inlets **18**, shown in Fig. 2 as three in number, and these inlets function as the tailings discharge of the preceding cell in the series which is the cell C of Fig. 2. The combination of feed inlet, froth overflow and tailings discharge determines a liquid level **19** in the cell when the machine is subject to continuous feed and discharge.

Superstructure **20** at the top of the cell walls provides the support for a shaft **21** journalled for rotation in a bearing assembly **22**. A sheave **23** at the upper end of shaft **21**, transmission **24** and a motor **25** or other prime mover are arranged to drive the shaft, and the rotor may be of the variable speed type to give selective control of the speed of rotation. An impeller 26 is mounted on the lower end of shaft 21 for conjoint rotation therewith and in preferred practice has a series of blades 27 on its upper surface and a plurality of sweeping vanes 28 on its under surface.

A hollow column 30 is supported in a depending position from the lower end of bearing assembly 22 in encompassing relation to shaft 21. The column 30 extends throughout substantially the vertical extent of cell C^1 and carries a laterally extending cover member 31 at its lower end which overhangs impeller 26 with its under surface providing only a slight clearance with the tops of blades 27 on the impeller.

A plurality of pulp intake openings 33 are located in the upper portion of column 30 near but below liquid level 19 and air intake openings 34 are located in the column above the liquid level. If the aeration is to utilize atmospheric air the openings 34 will be left unplugged, but if an aerating gas under pressure is used, all but one of said openings will be plugged and the remaining one connected as by threaded nipple with a header or other source of gas supply (not shown). For best results the liquid head over openings 33 should correspond to the showing in Fig. 1, and if a given operation produces a greater froth depth or lowering of liquid level 19, one or more slots 40 should be inserted in guide member 41 to provide a weir overflow above lip 16 and thereby bring the liquid level into proper relationship with openings 33.

An annular baffle 35 divides the upper hollow portion of column 30 into an inner air passage and an outer pulp passage. This baffle may be of any suitable length but should extend below the pulp intake openings 33 so that the entering pulp streams are diverted without converging and thus fall by gravity in an unimpeded descent to the impeller. In order to avoid any vortex formation at the surface which might remove a substantial quantity of the froth concentrate, I provide an annular shield 36 above openings 33. Other shapes of shield may be provided but the annular form is simple to construct and is easily connected.

As shown in Figs. 1 and 2, the cell bottom 15 may be provided with a central aperture 42 normally closed by a plug 43 and this opening will be used for draining the machine as required, or if desired, a suitable gas line may be connected for the supply of additional aerating gas, or reagent. The machine illustrated has the bearing member 22 detachably mounted on superstructure 20 so that the impeller 26 and column 30 may be installed and removed as a unit. In addition, an access opening 45 closed by a plug 46 permits separate mounting and removal of the impeller. Also as shown, the spacing between the impeller may be varied by adjustment of bolts 48 in slots 49.

The practice of the invention in a machine such as illustrated in Fig. 2 will be described. A conditioned pulp is fed continuously to a first cell, such as cell C, flows through the openings 18 to fill the next cell C^1 which may be any number of intermediate cells, and again passes through openings 18 to fill a last cell C^2 which has a continuous, regulated discharge such as an adjustable weir (not shown). The flow permitted by the openings 18 provides a substantially uniform liquid level 19 in all cells. The pulp will contain one portion of solids in a coarser size range and another portion of finer sizes, the actual size distribution varying with each ore treated.

Each of said cells will have a circulation of the type depicted in Fig. 2 in which the impeller 26 will be rotated at a peripheral speed on the order of 1600 feet per minute and all feed thereto enters through the plurality of openings 33 in column 30 from near but below the liquid level 19. This entering pulp is directed by the annular baffle 35 into gravitational fall initially separated from the flow of aerating gas downwardly through said baffle.

Due to the substantial distance between the openings 33 and the impeller 26 and the unrestricted fall of the pulp onto the impeller, such pulp attains a relatively high velocity movement before reaching the impeller which induces a high degree of gas entrainment in the cascading action. The impeller is rotated at a speed which will discharge the pulp-gas intermixture at a rate at least equal to the rate of its delivery to the impeller, and in preferred practice, at an even higher rate. As a consequence pulp enters column 30 in a volume permitted by the area of openings 33 collectively under the hydrostatic head of the liquid extending to level 19. The shield 36 prevents a vortex formation which might recirculate froth concentrate and the circulatory action effectively retards size stratification of pulp particles.

Whenever feed entering a given cell tends to cause such stratification by delivering too large a proportion of coarse sizes into the lower part of the pulp body, the impeller discharge effects a displacement action in which a substantially higher percentage of finer sizes replaces the coarser sizes elevated by the upward sweep of pulp through the cell. In the usual flotation cell, this elevating movement is offset by resulting downward currents as the upper portion of the cell has no capacity to relieve itself from the input of pulp. However in the present arrangement, the input and discharge capacity of the upper portion of the cell is substantially balanced and solids are free to descend only within the enclosure of the column.

As a result, a high degree of mixing of fine and coarse sizes accompanied by intense gas release in fine bubble formation occurs in the ascending pulp column. In a typical test installation in a cell of approximately 375 gallons capacity and arranged substantially as shown in Fig. 2, it was determined that the pulp was recirculating at a rate of between 450 and 500 gallons per minute. Average flotation time in such installations is on the order of two minutes so the entire pulp volume recirculates between two and three times within the flotation time period provided for such cell.

The flotation operation just described has the effect of increasing plant capacity as a higher volume of pulp can be treated efficiently in a shorter time than in conventional operations. A greatly improved grade and recovery is attained. Impeller speeds are reduced with consequent power savings and reduced wear. This was demonstrated in a comparative test in a commercial milling operation. Three standard cells were subjected to comparative tests for ten day periods with size analysis of concentrate produced in each cell. The ten day average established that cell No. 1 had 33 percent in the plus 100 size range, cell No. 2, 31 percent plus 100 and cell No. 3, 33 percent plus 100.

The middle No. 2 cell was then modified to correspond with the arrangement shown in Fig. 2, cells 1 and 3 were not changed, and another ten day test run on the same ore was undertaken. The average analysis was as follows: cell No. 1, 27 percent plus 100, cell No. 2, 45 percent plus 100, and cell No. 3, 34 percent plus 100. The foregoing test results are cited as typical of the degree of concentration of the coarser sizes which can be attained in the practice of the present invention.

The machine illustrated in the drawings is a Denver Equipment Company "hog-trough" type modified to embody features of the present invention. While such a machine is well suited to the practice of my invention, it will be understood that other standard mechanical-type cells may be similarly modified for the practice of the invention. However, the invention lends itself to embodiment in specially designed cells of much greater depth than conventional cells. The extension of depth apparently does not lessen metallurgical efficiency and in some instances may improve it, and the resulting increase in cell capacity permits substantial increase in plant capacity without enlargement of plant area and no increase in operator requirements.

Changes and modifications may be availed of within the spirit and scope of the invention as defined in the hereunto appended claims.

I claim:

1. In the froth flotation art in which a conditioned pulp is subjected to a succession of flotation treatments at progressive stages of a course of flow with a predetermined flotation time at each stage, the improvement which comprises maintaining a body of pulp of substantial vertical extent subject to continuous feed and discharge at each stage, inducing a circulatory flow within said body so as to direct an elevating component of movement to substantially all the solids in the lower portion of said body and an unimpeded gravitational fall to a substantial portion of the solids in the upper portion of said body and below the surface thereof, supplying an aerating gas for entrainment in the pulp in said gravitational fall, and controlling the volume and velocity of pulp in said gravitational fall so as to recirculate a major part of the pulp volume during said flotation time.

2. In the froth flotation art in which a conditioned pulp is subjected to a succession of flotation treatments at progressive stages of a course of flow with a predetermined flotation time at each stage, the improvement which comprises maintaining a body of pulp of substantial vertical extent subject to continuous feed and discharge at each stage, inducing a circulatory flow within said body so as to direct an elevating component of movement to substantially all the solids in the lower portion of said body and an unimpeded gravitational fall to a substantial portion of the solids in the upper portion of said body and below the surface thereof, supplying an aerating gas for entrainment in the pulp in said gravitational fall, controlling the volume and velocity of pulp in said gravitational fall so as to recirculate a major part of the pulp volume during said flotation time, and removing a concentrate by overflow at a distance from said circulatory flow.

3. A process as defined in claim 1 in which the circulatory flow is directed to cause a continuous intermingling of finer and coarser sizes in the pulp.

4. In the froth flotation art in which a conditioned pulp is subjected to a succession of flotation treatments at progressive stages of a course of flow with a predetermined flotation time at each stage, the improvement which comprises maintaining a body of pulp of substantial vertical extent subject to continuous feed and discharge at each stage, inducing a circulatory flow within said body so as to direct an elevating component of movement to substantially all the solids in the lower portion of said body and an unimpeded gravitational fall to a substantial portion of the solids in the upper portion of said body and below the surface thereof, supplying an aerating gas for entrainment in the pulp in said gravitational fall, and controlling the volume and velocity of pulp in said gravitational fall so as to recirculate a quantity of pulp in excess of the pulp volume of said stage during said flotation time.

5. In the froth flotation art in which a conditioned pulp is subjected to a succession of flotation treatments at progressive stages of a course of flow with a predetermined flotation time at each stage, the improvement which comprises maintaining a body of pulp of substantial vertical extent subject to continuous feed and discharge at each stage, inducing a circulatory flow within said body so as to direct an elevating component of movement to substantially all the solids in the lower portion of said body and an unimpeded gravitational fall to a substantial portion of the solids in the upper portion of said body and below the surface thereof, supplying an aerating gas for entrainment in the pulp in said gravitational fall, and controlling the volume and velocity of pulp in said gravitational fall so as to recirculate the pulp volume of said stage a plurality of times during said flotation time.

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