Sept. 2, 1969 C. H. WARMAN 3,464,552

FROTH FLOTATION APPARATUS

Filed Dec. 18, 1967 2 Sheets-Sheet 1

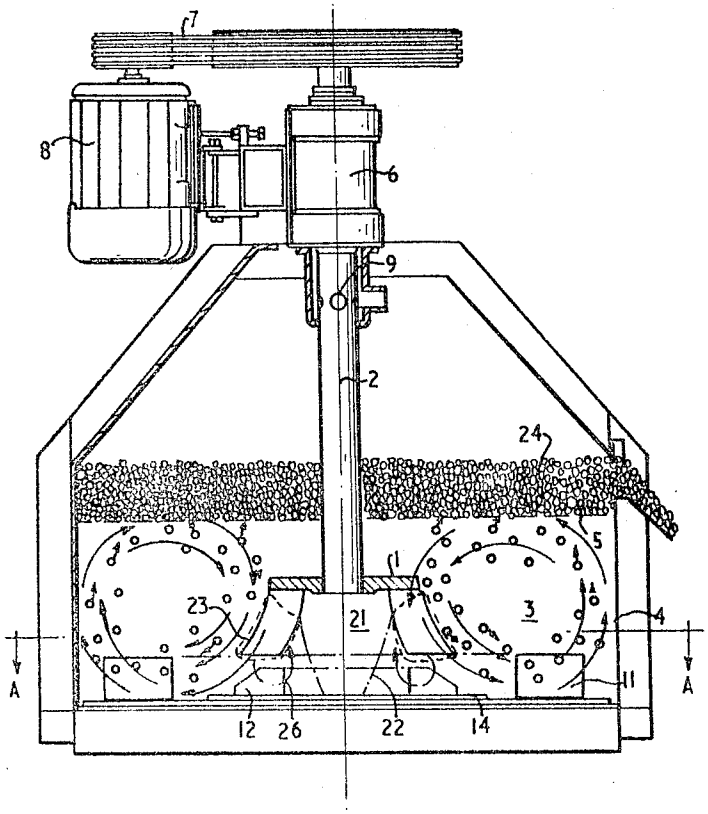


FIG.1

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Filed Dec. 18, 1967 2 Sheets-Sheet 2

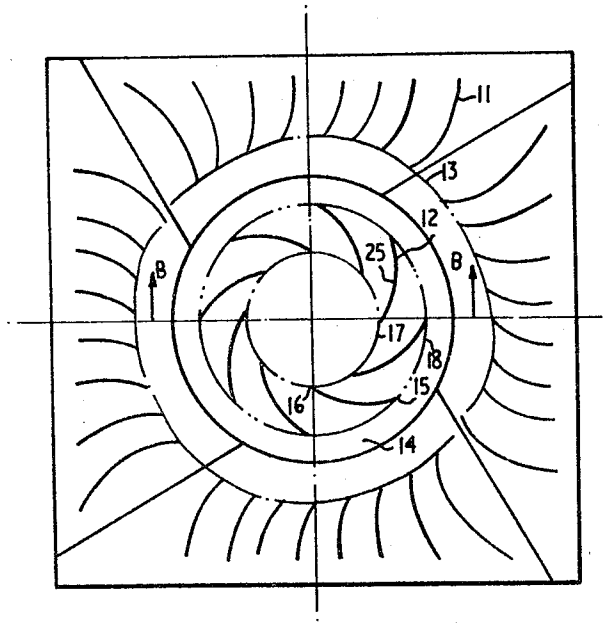


FIG. 2

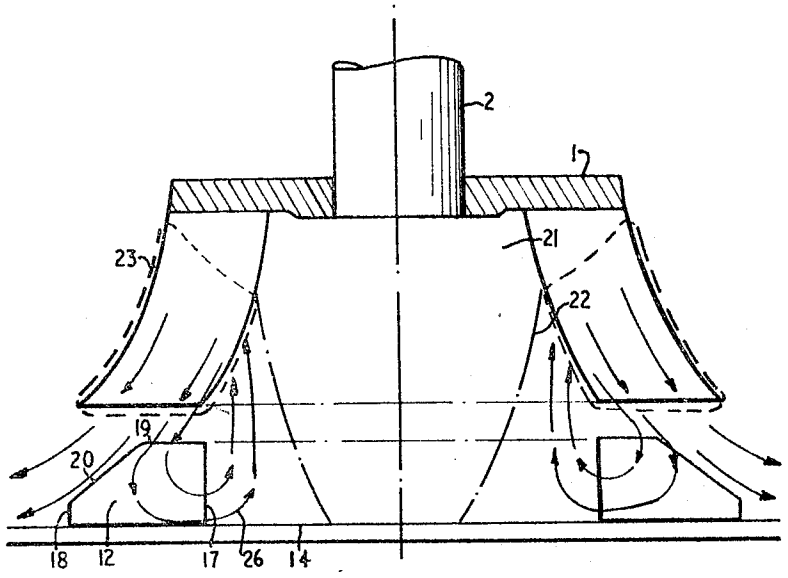


FIG. 3

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FROTH FLOTATION APPARATUS

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U.S. Cl. 209—170 8 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses guide surfaces on the bottom of the cell for generating a separate secondary flow pattern of gas and suspension passing through and below the mixing zone supplementary to the principal flow from the mixing zone to the surface froth layer in froth flotation cells of the type in which a driven rotor supported on a vertical axis discharges suspension downwardly from an axially symmetrical annular mixing zone surrounding a submerged gas zone.

Background of the invention

This invention relates to froth flotation apparatus of the type in which a driven rotor supported on a vertical axis in a vessel or cell containing pulp or solution downwardly discharges from an axially symmetric annular mixing zone surrounding a submerged gas zone a mixture of gas and pulp or solution, and has an object to provide improved characteristics of performance of flotation apparatus of this general type.

A feature of flotation apparatus of the type in which aeration of pulp or solution is effected by mechanical mixing at the surfaces of a rotatably driven submerged rotor is that quiescent conditions at the pulp or solution surface are difficult to achieve due to turbulence generated within the body of the pulp or solution in producing effective aeration and agitation. Quiescent conditions are required adjacent the surface of the pulp or solution to assist separation of bubbles from solution, and minimise entrainment of pulp or solution in the froth and re-entrainment of froth in the pulp or solution, such effects impairing concentration efficiency.

A further characteristic feature of flotation apparatus of the type as herein described is that the relatively high peripheral velocity of the rotor required to produce effective aeration and agitation results in a corresponding high rate of abrasive wear of the rotor surfaces by particles in suspension in the solution.

Heretofore the performance of flotation apparatus of the type as described herein was sensitive to variation of operating parameters due to inherent instability of the submerged gas zone. The instability was characterised by perturbations in the boundary surface of the submerged gas zone, and resulted in excessive turbulence at the froth level, and reduction in aeration rate.

Summary of the invention

This invention provides means for generating a separate secondary circulatory flow pattern of gas and pulp or solution mixture, passing through and below the mixing zone, supplementary to the principal flow of pulp or solution transporting gas bubbles from the mixing zone to the surface froth layer. It has been established that in combination with conventional flotation apparatus of the type as described herein, the provision of means for generating the said secondary circulatory flow pattern characteristic of this invention results in substantial improvements in performance.

One object of this invention is to reduce the degree of turbulence in the froth layer above the surface of the pulp or solution characteristic of this type of apparatus by the promotion of increased stability of the submerged gas zone.

Another object of the invention is to increase the rate of gas induction and mixing with the pulp or solution by comparison with conventional flotation apparatus.

A further object is to improve concentration efficiency by promotion of more effective mixing of the gas and pulp or solution.

Another important object of the invention is to increase the efficiency of the aeration and agitation processes with subsequent reduction in power consumption.

Still a further object is to reduce the rate of abrasive wear on the rotor aeration surfaces by comparison with conventional flotation apparatus. This is consistent with reduction of rotor speed as abrasive wear rate is a function of rotor speed.

Description of the drawings

The following description read in conjunction with the accompanying drawings outlines the features and practice of the invention. Like numbers refer to like parts throughout the drawings and in the description.

FIGURE 1 is a section through the vertical axis of a flotation cell of generally known type modified by the addition of means as disclosed by the invention.

FIGURE 2 is a sectional plan in line A—A of FIGURE 1.

FIGURE 3 is a fragmentary section of line B—B of FIGURE 2.

As shown in the drawings **1** is a rotor mounted on a hollow vertical shaft **2** for clockwise rotation (as viewed in plan) and submerged in a pulp or solution **3** contained in a vessel or cell **4** and having an upper free surface **5** through which the shaft **2** passes. The shaft **2** is supported for rotation toward its upper end by a bearing assembly **6** attached to the frame of the cell **4**, and at its uppermost end is driven by a belt and pulley drive **7** arranged to transmit power from a drive motor **8** to the rotor shaft assembly to rotate the rotor **1** at any given predetermined speed. The upper portion of the hollow rotor shaft **2** is provided with a plurality of holes **9** in the wall thereof through which gas may pass from the annular space around the shaft enclosed by the housing **10** attached to the underside of the bearing housing **6**, whereby gas is conducted to the underside of the rotor **1** via the hollow shaft. Air or other gas may be induced from the atmosphere through an opening in the housing **10** or supplied under pressure from a pipe header. A series of vertical baffle plates **11** are located on the floor of the cell **4** in an area beyond the lower peripheral diameter of the rotor when viewed in plan.

The invention provides for the location of a series of guide surfaces **12** below the rotor **1** and within the line **13** defining the radial location of the leading edges of the baffle plates **11**. In the preferred embodiment of the invention as depicted in the drawings the guide surfaces are in the form of a plurality of vertical guide vanes **12** symmetrically disposed about the vertical axis of the rotor and located within an annular area when viewed in plan. The guide vanes **12** are attached by means of a mounting plate **14** to the floor of the cell **4**. When viewed in plan the guide vanes **12** of the preferred embodiment are curved, and positioned with the outer edges **15** displaced relative to the inner edges **16** in an angular direction opposite to the direction of rotation of the rotor **1**. Although the guide vanes **12** are depicted as being vertical in the preferred embodiment, it is possible that for some operating conditions advantages may result

from inclination of the vanes from the vertical to more closely match the angle of approach of the entering fluid mixture.

No fixed relationship has been established for the vertical distance between the underside of the rotor **1** and the top edges of the guide vanes **12**, however, in practice satisfactory results have been achieved with a spacing of approximately one twentieth the lower peripheral diameter of the rotor. The vertical height of the guide vanes **12** is limited by the distance of the underside of the rotor **1** above the cell floor, and in practice a guide vane height of about one sixth the lower peripheral diameter of the rotor has been found desirable. Likewise the diameters of circles defining the radial location of the inner edges **17** and outer edges **18** of the guide vanes **12** when viewed in plan may be subject to considerable variation, however values of 0.65 and 1.1 times the lower peripheral diameter of the rotor respectively have been found in practice to yield satisfactory results.

In axial section the edges of the guide vanes **12** lie on a surface of revolution generated about the vertical axis of the rotor **1**. The surface of revolution comprises inner **17** and outer **18** cylindrical sections corresponding to the inner **16** and outer **15** edges respectively of the guide vanes, intersected by a horizontal plane **19** defining the top edge of the guide vanes, and a downwardly diverging frustoconical surface **20**. The angle of the enveloping frustoconical surface **20** to the horizontal is not critical to performance, however an angle of approximately 40° has been found to yield satisfactory results.

The operation and advantages disclosed by the practice of the invention will be evident from a description of the flow pattern of pulp or solution **3** and entrained gas within the cell **4**.

In conventional flotation cells of the general type as hereinbefore described gas is mixed with pulp or solution by the turbulent shearing action of the rotor **1** driven through the said pulp or solution. With the rotor **1** turning clockwise in plan at a rotational speed equivalent to a linear speed of approximately 30 to 40 feet per second at the maximum diameter of the rotor, an axial zone **21** within and beneath the rotor, with boundaries approximately as indicated by the chain dotted line **22** is generated and maintained substantially free of liquid by the outward and downward impelling action of the inclined surfaces of the rotor. Surrounding the axial gas zone **21**, and extending into the region of intense turbulence adjacent the surface of revolution generated by the outer limits of the rotor **1** lies a mixing zone, the extent of which is approximately indicated by the dashed line **23**, in which pulp or solution entering downwardly from the upper regions of the cell is mixed with gas from the contiguous axial zone **21**, and the resulting mixture impelled downwardly and outwardly from the mixing zone **23** to impinge on the bottom of the cell **4** beyond the lower peripheral diameter of the rotor **1**. The mixture flowing outwardly on the bottom of the cell from the area of impingement thereon passes between the baffles **11**, and is distributed in substantially a uniform manner at right angles towards and against the sidewalls of the cell, thereafter rising towards the upper free surface **5** of the liquid, turning at and adjacent said surface and flowing substantially parallel thereto with separation of bubbles from the mixture to form the froth layer **24** above, the residual mixture thereafter turning and flowing downwardly to the mixing zone **23**.

The characteristic feature of this invention relates to modification of the known flow pattern of pulp or solution and gas within the cell as previously described. A substantial proportion of the mixture of gas and pulp or solution discharging downwardly from the rotor **1** passes parallel to and outside the frustoconical surface **20** of the guide vanes **12**, impinging on the floor of the cell **4**, and proceeding therefrom in the manner as described previously. The remaining portion of the downwardly discharging flow passes through the horizontal annular plane **19** defining the upper extremity of the guide vanes **12**, and impinges obliquely on the leading surfaces **25** of the said vanes. By virtue of the orientation of the leading surfaces **25** a radially inward component of momentum is imparted to the fluid mixture causing the stream to separate from the principal outward flowing stream to form a stable secondary flow pattern **26** supplementary to the main flow as previously described for conventional flotation cells.

Elements of fluid in the secondary flow pattern **26** flowing downwards towards the floor of the cell **4** are reacted upon by fluid adjacent and in contact therewith, and are caused to flow with increasing radial component of velocity at the expense of vertical velocity component, ultimately flowing parallel with the cell floor. Therefrom the fluid elements turn upwardly, and return to the annular mixing zone **23** with increasing radially outward component of velocity. As described the fluid elements of the secondary flow pattern **26** trace out effectively closed paths, when viewed in axial section, although discharging from and returning to the mixing zone at spaced angular positions when viewed in plan by virtue of the unidirectional tangential component of velocity of the fluid elements throughout the flow path.

As a consequence of the axial symmetry of the annular mixing zone **23** and guide vanes **12**, the secondary flow pattern **26** is of substantially toroidal form with fluid elements tracing out approximately spiral paths about a virtual circular axis thereof. The said virtual axis of the toroidal flow pattern is symmetrically disposed about the vertical axis of rotation of the rotor **1**, and located in a substantially horizontal plane below the rotor.

The distribution of fluid mixture, issuing from the mixing zone **23**, between the main flow pattern and the secondary flow pattern **26**, to produce best performance, is a function of a number of operating variables, and may be varied by adjustment of the radial location of the guide vanes **12** about the vertical axis for optimum performance conditions.

An important effect produced by the invention is that the boundary **22** of the submerged gas zone **21** is contracted radially inwards by comparison with conventional flotation cells of this general type, causing the surfaces of the rotor **1** to project further beyond the gas zone boundary into the pulp or solution thereby yielding more stable operating conditions. In conventional flotation cells operating with a reduced penetration of the gas zone boundary by the rotor surfaces, unstable perturbations in the boundary surface are experienced causing fluctuations and overall reduction in aeration rate, and subsequently in concentration efficiency. With flotation cells in accordance with this invention reduced perturbations are experienced in the boundary **22** of the submerged gas zone **21**, and the deeper penetration of the rotor surfaces therein results in a substantially reduced effect on aeration and concentration efficiency consistent with stable operating conditions.

Furthermore the deeper projection of the rotor surfaces into the pulp or solution **3** surrounding the gas zone **21** increases the effective volume of the mixing zone **23** and aerating surface area of the rotor **1** by utilising the inner surfaces of the rotor for gas entrainment thereby increasing the rate of aeration by comparison with conventional cells.

The improved stability of the gas zone **21** results in more uniform conditions of mixing of gas with pulp or solution in the mixing zone **23**, and together with the increased average bubble path length resulting from the circulatory secondary flow pattern **26**, yields favourable conditions to increasing the probability for attachment of mineral particles to gas bubbles with subsequent increased concentration efficiency.

The embodiments described in this specification are intended as preferred and typical construction only, and

are not considered as defining the scope of the invention, said scope being defined only by the appended claims.

What I claim is:

1. A flotation concentration apparatus comprising a vessel or cell for holding a suspension, feed means feeding a suspension into said vessel or cell, discharge means for discharging a non-floated product from said vessel or cell, froth discharge means for discharging a froth product from the vessel or cell, a rotor in said vessel at a level to be submerged in said suspension and having bars directing a mixture of gas and said suspension in a generally downward direction, gas admitting means feeding gas into the interior of said rotor, a hollow axial shaft on which said rotor is mounted, rotating means coupled to said hollow axial shaft and rotating said rotor about a substantially vertical axis, and wherein the improvement comprises means for imparting to a portion of said downwardly discharging mixture of gas and suspension a radially inward component of momentum symmetrical about said substantially vertical axis, said means comprising a plurality of mutually spaced guide vanes submerged in the suspension and located below the said rotor and symmetrically therewith.

2. A flotation concentration apparatus as claimed in claim 1 wherein the guide vanes are attached to the bottom of the vessel or cell.

3. A flotation concentration apparatus as claimed in claim 2 wherein the guide vanes are symmetrically disposed about the vertical axis of the vessel or cell, are located within an annular area when viewed in plan, and are attached to a removable mounting plate.

4. A flotation concentration apparatus as claimed in claim 1 wherein the guide vanes are symmetrically disposed about the vertical axis of the vessel or cell, are located within an annular area when viewed in plan, and are attached to a removable mounting plate.

5. A flotation concentration apparatus as claimed in claim 4 wherein when viewed in plan the edge of a guide vane furthest from the vertical axis is displaced relative to the edge nearest said vertical axis in an angular direction opposite to the direction of rotation of the rotor.

6. A flotation concentration apparatus as claimed in claim 5 wherein the guide vanes are curved when viewed in plan.

7. A flotation concentration apparatus as claimed in claim 5 wherein the guide vanes are vertical.

8. A flotation concentration apparatus as claimed in claim 7 wherein the guide vanes are curved when viewed in plan.

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U.S. Cl. X.R.

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