

March 23, 1937.

M. KRAUT

2,074,403

FLOTATION APPARATUS

Filed Sept. 17, 1935

7 Sheets-Sheet 1

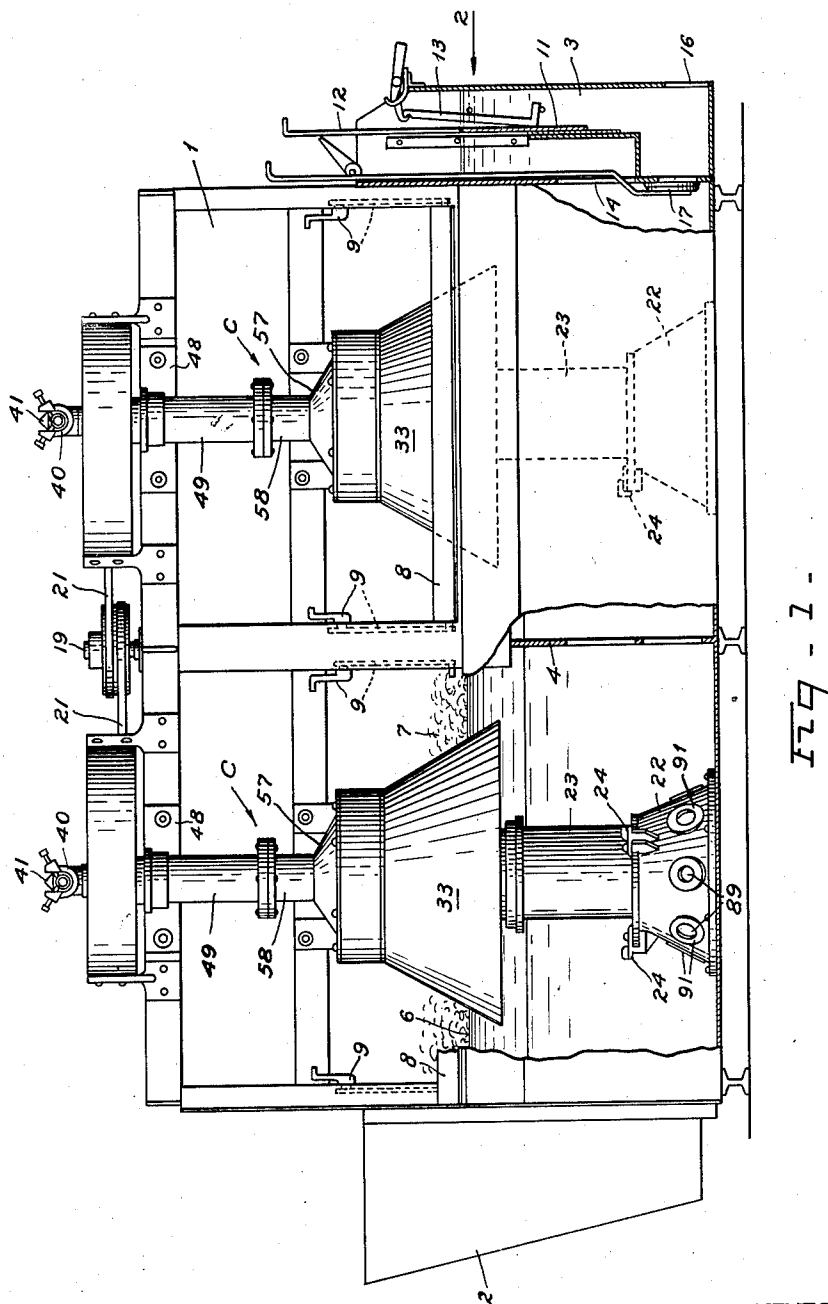


Fig. 1 -

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7 Sheets-Sheet 2

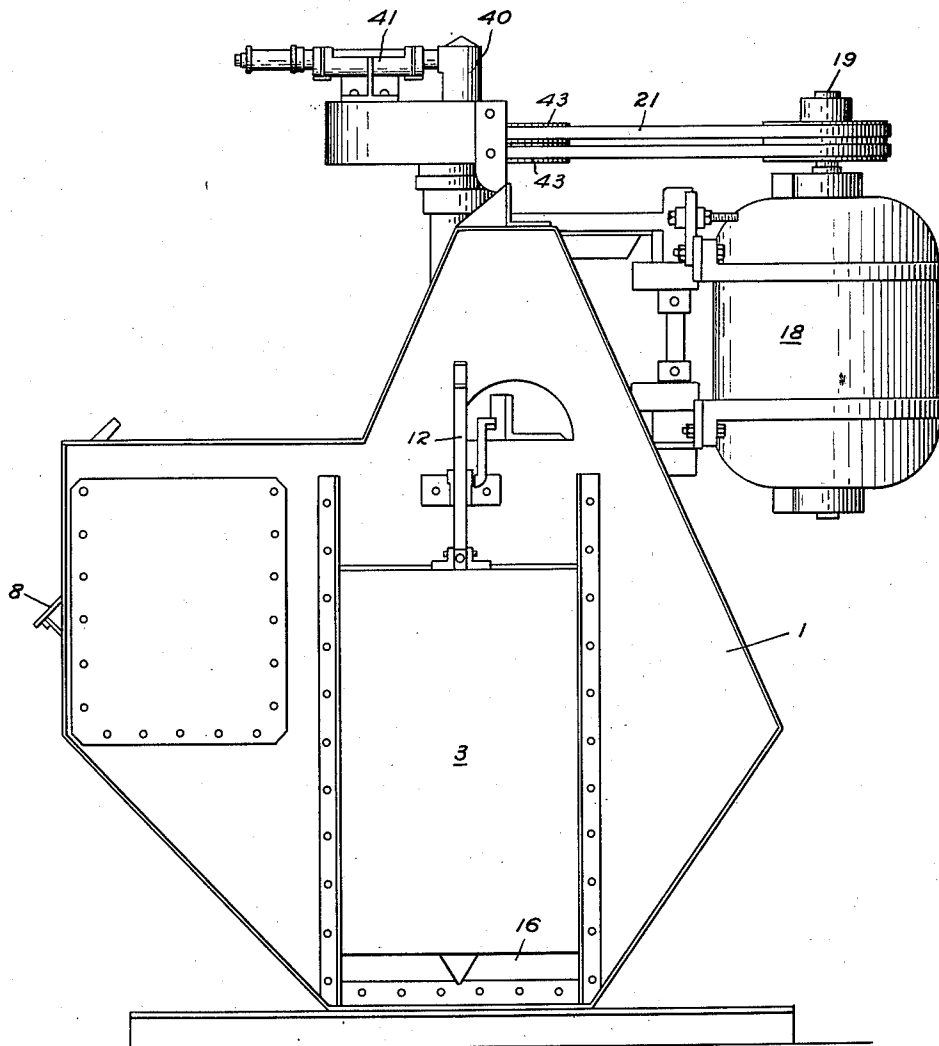


Fig. 2.

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7 Sheets-Sheet 3

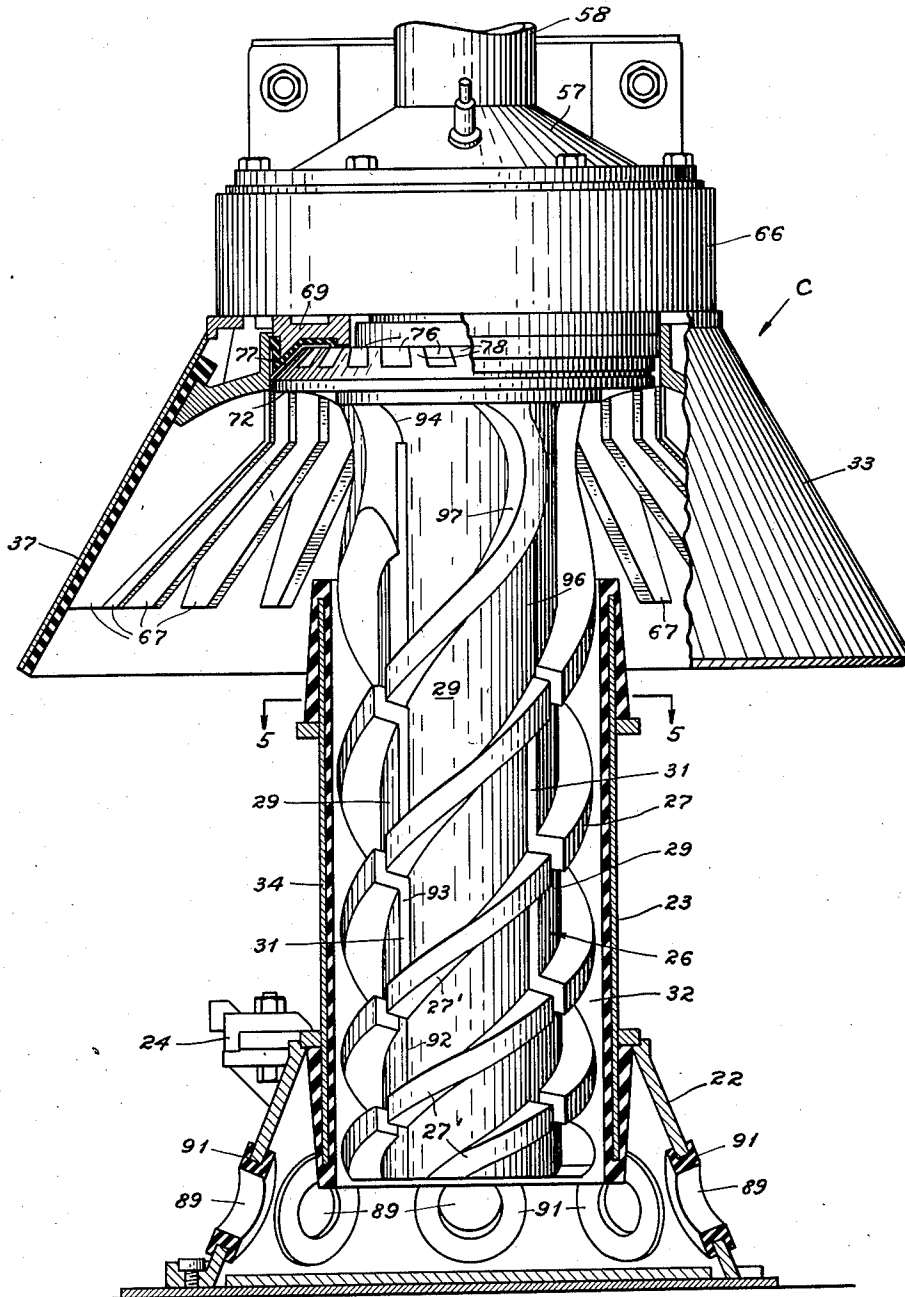


Fig. 3.

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7 Sheets-Sheet 4

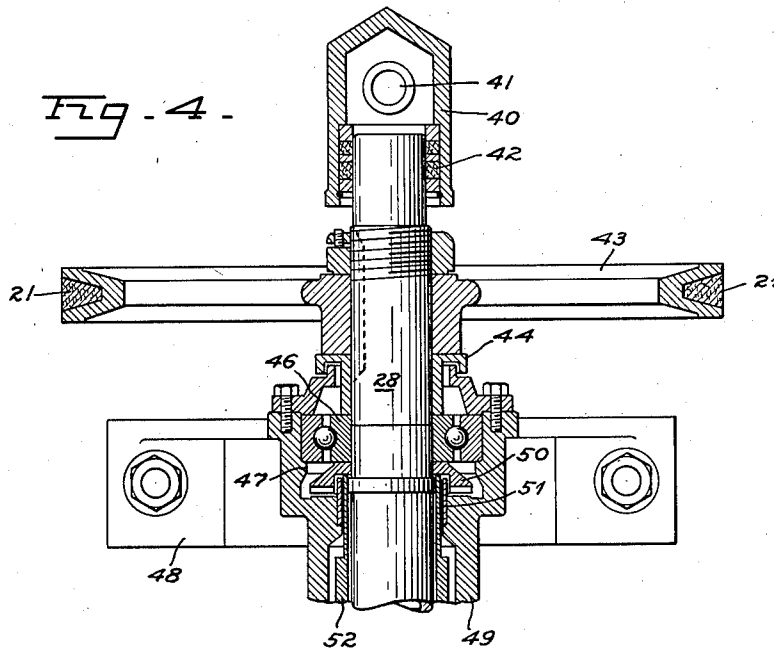
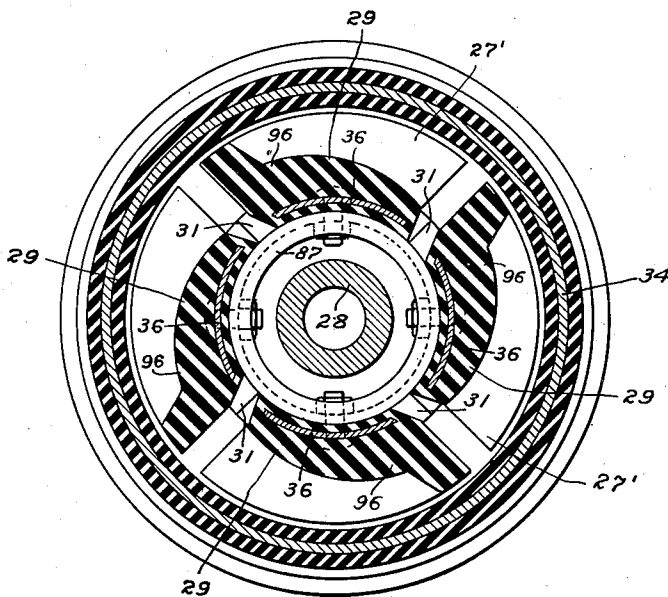


Fig. 5.

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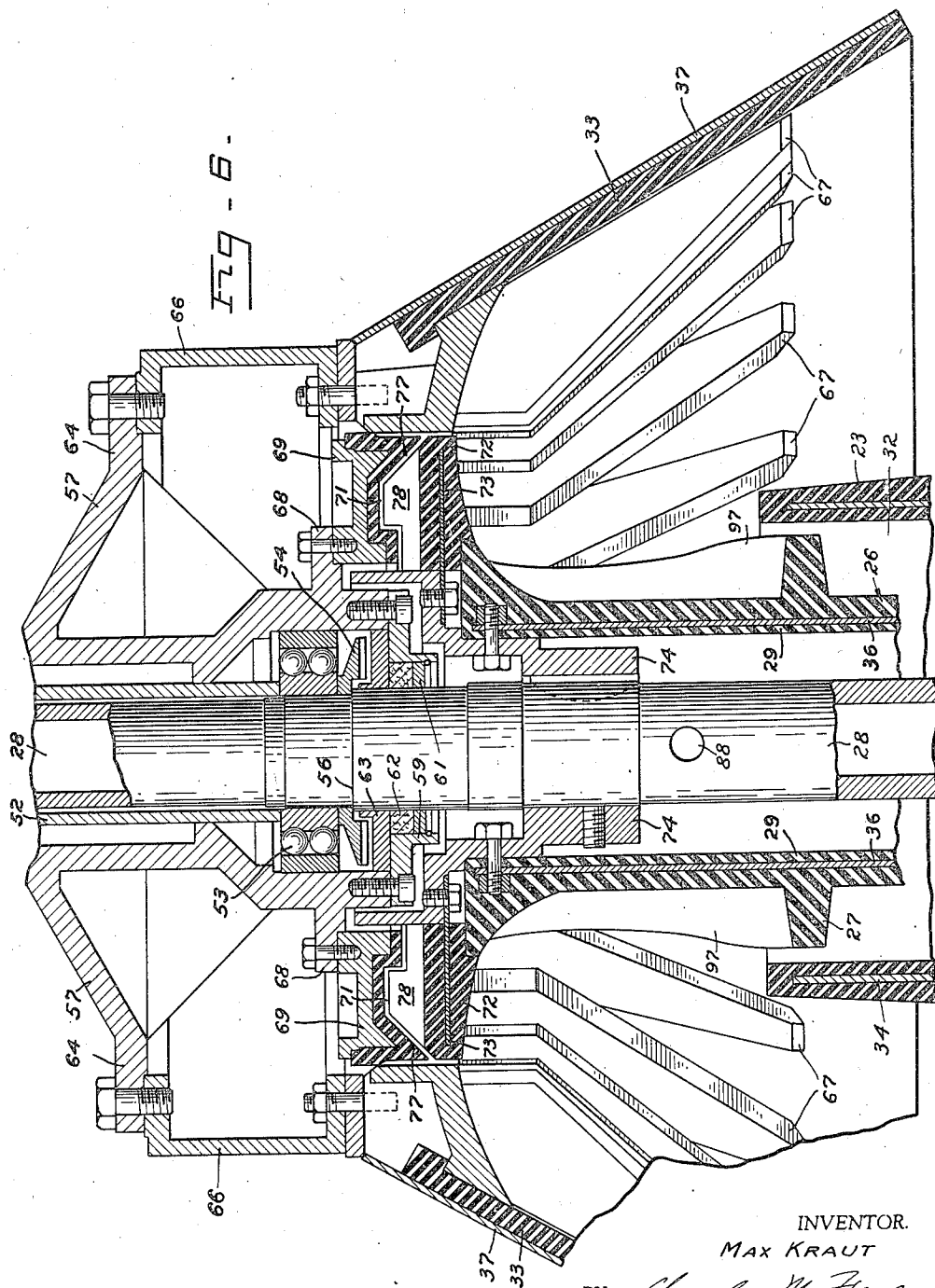
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7 Sheets-Sheet 5



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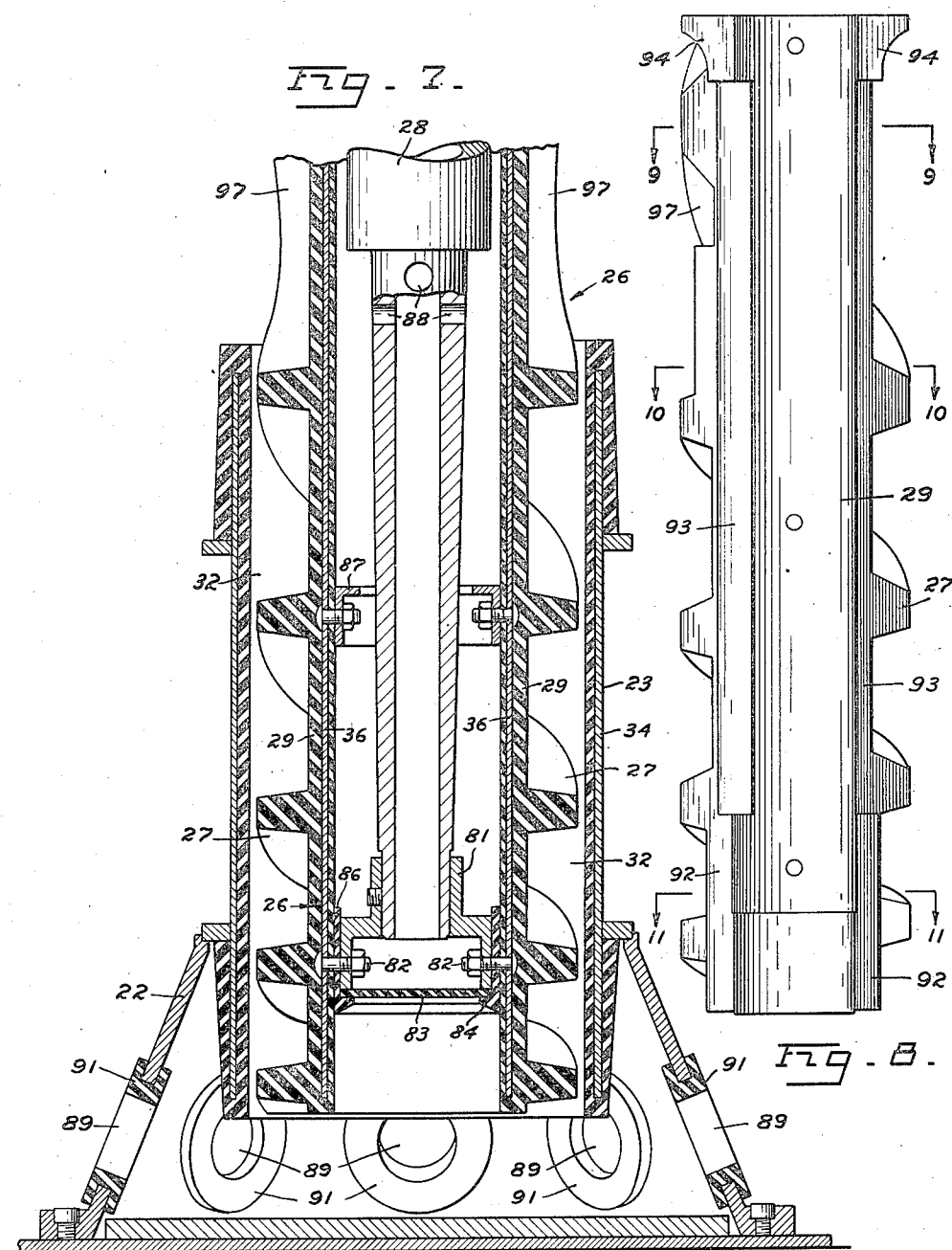
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7 Sheets-Sheet 7

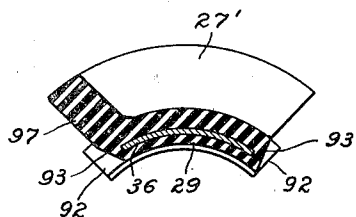


Fig. 9.

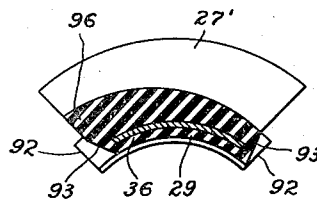


Fig. 10.

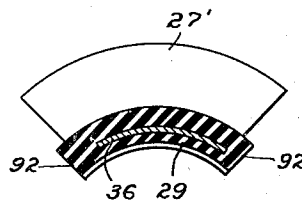


Fig. 11.

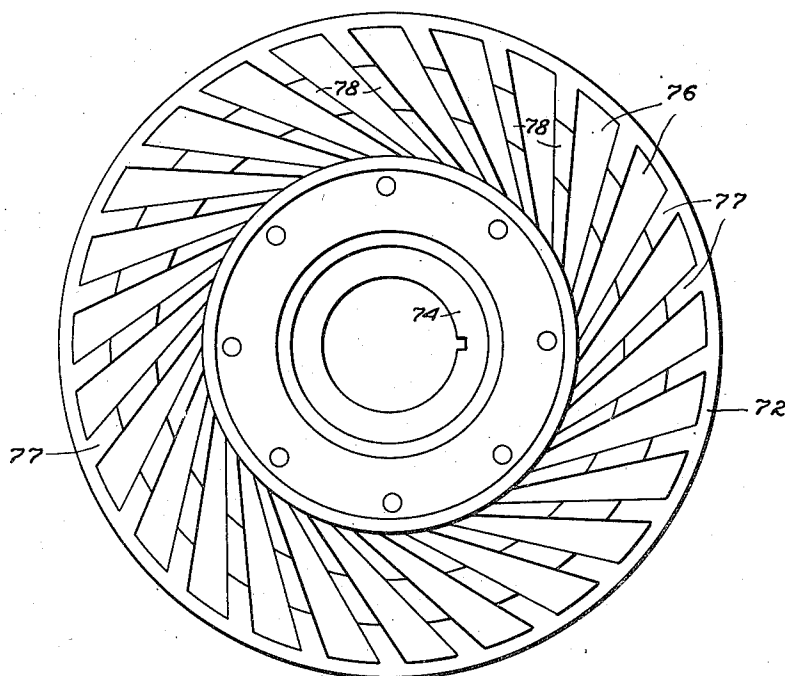


Fig. 12.

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UNITED STATES PATENT OFFICE

2,074,403

FLOTATION APPARATUS

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Application September 17, 1935, Serial No. 40,897
In Canada October 1, 1934

7 Claims. (Cl. 261--93)

My invention relates to an apparatus and method for the recovery of values from ore pulp, and more particularly to a flotation apparatus of improved construction.

In my prior Patent No. 1,802,919, granted April 28, 1931 and in my prior co-pending application, Serial No. 651,175, filed January 11, 1933, Patent 2,044,250, dated June 16, 1936 are disclosed apparatus which include a stationary shell or stator, and a rotor rotatable within the stator and forming an annular passageway therebetween through which ore pulp is caused to flow at a high velocity by means of helical screw flights on the rotor. Air is induced into such passageway; and parts of the apparatus are so constructed as to cause expansion of the pulp. Such expansion produces the effect of a partial vacuum to thereby enhance absorption of the induced air; the particles of air serving as the means for attachment to the mineral particles to be floated from the pulp.

The prior application, in addition, discloses means for squeezing the pulp during some portion of the flow, to effect a differential increase in velocity of the pulp, with respect to the mean velocity flow, to attenuate or divide the air in extremely small particles. In the machine of the present application, improved features of construction are employed to provide for expansion and squeezing of the pulp.

Objects of invention

My invention has as its objects, among others, the provision of an improved apparatus, of the character related, which is

- (1) Of simple and economical construction;
- (2) Of durable construction;
- (3) Provided with improved means to preclude piling up of sand in the pulp as the material enters into the passageway formed by the rotor and the stator of the apparatus; and which is
- (4) Provided with improved means for enhancing formation of froth on top of the pulp level in the apparatus.

Other objects of the invention will become apparent from a perusal of the following description thereof.

General description

In general, the apparatus includes a tank in which pulp (a fluid mixture of water and the mineral to be treated) is fed. To the pulp may be added any of the suitable flotation reagents known to the art, for enhancing selective separation or flotation of the desired mineral substances in the pulp. The tank may have therein a single flotation cell for effecting induction of air into the pulp to provide means for attachment to the mineral particles to be floated. However, to increase the capacity of the machine, as is well

known in the art, the tank is of sufficient size to contain a plurality of flotation cells arranged in tandem. Such arrangement is disclosed herein.

The cell unit to which my invention is primarily directed comprises a cylindrical shell or stator member, and a cylindrically shaped rotor member forming an annular passageway with the stator, through which passageway the pulp flows. The rotor is rotated at a comparatively high speed, and is formed with screw flights of increasing pitch or lead all the way from the point of entrance for the pulp into the passageway, to the point of discharge thereof from the passageway. Also, the rotor is hollow inside and its wall is apertured to permit air to be induced into the passageway. Because of the increasing pitch of the screw flights and the mechanical movement of the pulp which is effected by the screw flights as the rotor is rotated at a high velocity, expansion of the pulp occurs to produce the effect of a partial vacuum, to thereby enhance aerating, or absorption of the induced air in the pulp.

Adjacent the point of discharge of the aerated pulp from the annular passageway formed by the stator and the rotor, a portion of the screw flights is formed with an increased root diameter to diminish or restrict the cross-sectional size of the passageway. Hence, a relative restriction to the flow of pulp obtains at the point of discharge thereof, to exert a squeezing action on the pulp. Such squeezing action is translated into terms of increased velocity of the pulp with respect to the mean velocity flow, to effect fine division or attenuation of the induced air.

Both the stator and the rotor are formed primarily of rubber. Such material has been found to have a remarkably long life, even when the machine is handling coarse feed.

To prevent piling up of sand at the point of entrance of the pulp into the annular passageway formed between the rotor and the stator, shroud means is provided. Such shroud means is formed with ports or apertures of comparatively small size. The ports cause the pulp to flow at an increased velocity therethrough, to minimize deposit of sand, and thereby preclude clogging of the apparatus. A conically shaped deflector is provided to direct the aerated pulp into the froth on top of the pulp level in the apparatus.

Description of drawings

Reference will now be made to the drawings for a more detailed description of invention. In the drawings:

Fig. 1 is a front elevation of the apparatus, showing a plurality of cells in a single tank. Parts of the structure are omitted from the view to disclose more clearly the construction.

Fig. 2 is an end view looking in the direction of arrow 2 in Fig. 1.

Fig. 3 is a part vertical section and part elevation, of the cell apparatus of my invention.

Portions of the structure are omitted from the view to disclose more clearly the construction.

Fig. 4 is a fragmentary vertical sectional view, illustrating the upper portion of the cell apparatus mounting means.

Fig. 5 is a horizontal section taken in a plane indicated by line 5—5 in Fig. 3.

Fig. 6 is an enlarged fragmentary vertical sectional view, taken adjacent the pulp discharge end of the cell apparatus.

Fig. 7 is a vertical sectional view, through the rotor and the stator of the cell apparatus.

Fig. 8 is a vertical elevational view, looking at the inside of one of the plurality of like staves which form the rotor of the cell apparatus.

Figs. 9, 10, and 11, are sectional views taken, respectively, in planes indicated by the lines 9—9, 10—10, and 11—11 in Fig. 8.

Fig. 12 is a plan view of a froth expulsion ring employed in the apparatus and which is also illustrated in Figs. 3 and 6.

Detailed description

With reference to Figs. 1 and 2, the apparatus including a plurality of flotation cells, comprises tank 1 of suitable material, preferably of welded metal plate construction having at one end thereof intake box 2 for the pulp, and at the opposite end pulp discharge box 3. An apertured partition wall 4 is provided between the various cell units C. As can be seen more clearly from Fig. 2, the bottom of tank 1 is formed to taper inwardly so as to provide a funnel-shaped structure for directing the pulp being treated, toward the inlets of the cell units.

Each cell unit, in a manner which will be subsequently described, aerates the pulp and discharges such aerated pulp adjacent the pulp level 6 in the tank. Aeration of pulp creates froth 7 over the pulp level; the froth comprising air particles to which the floated mineral particles are attached. All cells C have a common pulp level, but each cell has its own froth control lip 8 adjustable as to height by means of suitable adjusting mechanism 9. The discharged froth, as can be seen most clearly from Fig. 2, flows over lip 8 into a suitable sluice box not shown.

For adjusting the pulp level of the apparatus, an adjustable weir gate 11 is provided in discharge box 3; suitable adjusting mechanism 12 and latching mechanism 13 being employed, respectively, to adjust gate 11 and hold it in the adjusted position. Pulp flows over gate 11 after passing through aperture 14 in the discharge end wall of the tank, and then flows out of the discharge box through aperture 16. An adjustable sand discharge gate 17 is provided below discharge aperture 14; and a portion of the pulp flows past gate 17 when it is adjusted to discharge sand. It is thus seen that the major portion of the pulp is caused to discharge from the apparatus in a tortuous path to enhance separation of sand therefrom.

In operation of the apparatus having a plurality of cells, the pulp enters near the bottom of the first cell, and is advanced by displacement from cell to cell until it reaches the discharge end of the apparatus. The apparatus may, of course, comprise only a single cell, but it is customary to employ a battery of cells to increase the capacity.

Each cell includes a part to be rotated, as will

be subsequently described. For driving such parts, an electric motor 18 is mounted on the apparatus; its drive shaft 19 being connected by belts 21 to the rotatable parts of the individual cells.

Referring particularly to Figs. 1, 3, 4, 6, 7 and 8, it will be observed that the cell unit comprises stationary tapered shroud 22 secured to the bottom of tank 1, and to which is secured cylindrically-shaped rubber covered stator or shell 23, by means of clamps 24. Rotatable within the stator is hollow rubber covered rotor 26, having thereon screw flights 27. Such rotor is secured for rotation with rotatable hollow shaft 28, and is formed of a plurality of individual rubber covered staves 29 (Figs. 3 and 8). The staves are spaced apart to provide slots 31 for admission of air into annular passageway 32 formed between the stator and the rotor. A stationary conically-shaped rubber covered deflector 33 having its discharge lip extending below pulp level 6 (Fig. 1), is positioned over the top of the stator. It will be noted that in each of the stator, the rotor staves and the deflector has, respectively, metal reinforcing plates 34, 36 and 37 to which the rubber of these parts is vulcanized.

Mounting means for the rotor parts, the rotatable hollow shaft and the stationary deflector are provided. Such mounting means, and also mechanism associated with the mounting means will now be described. Hollow shaft 28 extends, at its upper end, into stationary housing member 40 (Figs. 2 and 4), having secured thereto adjustable air inlet control valve 41; suitable packing 42 being provided between stationary member 40 and rotatable shaft 28. Pulley 43, fixedly secured to shaft 28, is driven from belt 21 in the manner previously related.

The hub of pulley 43 rests on thrust collar 44 keyed to shaft 28. Collar 44 in turn bears against the inner race of bearing 46; the outer race of such bearing seating on flange 47 of upper bracket 48 which is secured to the frame of the apparatus and has tubular depending portion 49 (Fig. 4). The inner race of bearing 46 rests on grease slinger 50 of usual construction; within which is positioned grease guard ring 51. Grease slinger 50 rests upon spacing sleeve 52 which is clamped for rotation with shaft 28, between grease slinger 50 and the inner race of bearing 53 (Fig. 6). Such bearing is supported by shoulder 56 formed on the shaft.

With reference to Figs. 3 and 6, it will be observed that spacing sleeve 52 extends through lower bracket 57 fixedly mounted on the frame of the machine. Such lower bracket provides the support for conical deflector 33 and related parts. As can be seen from Fig. 1, bracket 57 has an upwardly extending tubular portion 58 secured to the depending portion 49 of upper bracket 48 to provide for strength of construction. To the lower end of bracket 57 (Fig. 6), is removably secured annular plate 59 having therein split ring 61 for retaining suitable packing 62. A grease guard ring 63 is also supported on plate 59.

Upper flange 64 of bracket 57 has removably secured thereto channel-shaped ring 66; and to the lower end of ring 66 is removably secured the stationary conically-shaped deflector 33. The inner side of such deflector has a plurality of peripherally-spaced fins or baffles 67 mounted thereon. Lower flange 68 of bracket 57 provides a support for stationary plate 69 having its under surface covered with rubber and formed with an

annular channel 71 adapted to co-operate with rotatable rubber covered froth expulsion ring 72 having reenforcing plate 73 secured to stave supporting member 74 in turn fixedly attached to shaft 28. The upper ends of rotor staves 29 are secured to member 74. Hence, the rotor formed of such staves is secured for rotation with hollow shaft 28.

From Fig. 12, it will be observed that froth expulsion ring 72 is formed with a plurality of tangentially arranged slots 76. Such slots in conjunction with the co-operating bevelled outer edges 77 of rubber covered member 69 and ring 72, and upstanding portions 78 rotatable in annular channel 71, serve effectively to prevent froth from creeping past ring 72. Hence, means is provided to prevent froth from piling up or collecting too high under deflector 33.

To the lower end of hollow shaft 28 (Fig. 7) is secured a collar member 81, to which the lower ends of the rotor staves are secured by means of studs 82. For the purpose of protecting studs 82 against abrasion by material flowing into the cell, a rubber cover 83 is provided. Such cover is clamped between the lower edge of collar member 81 and a flange 84 formed at the lower end of a rubber ring 86 held between member 81 and the inner side of the rotor. Intermediate their ends, the rotor staves are fastened to reenforcing ring 87 through which shaft 28 passes.

As can be seen from Fig. 7, apertures 88 are formed in shaft 28 to provide for flow of induced air from the shaft through the slots 31 (Fig. 3) of the rotor and into the annular passageway 32 formed between the stator and the rotor. Shroud 22 is formed with ports or apertures 89 to provide for flow of pulp into the cell. Such apertures 89 are formed by rubber rings 91 removably held on the shroud. The rings being of rubber withstand effectively the abrasive action caused by the flowing pulp. Furthermore, since the rubber rings are removably mounted, they can be readily replaced to provide for apertures of selected size to control the velocity flow of pulp into the cell.

Figs. 3, 5, 8, 9, 10 and 11 illustrate the construction of the rotor, and the rotor staves 29. It will be noted that adjacent their lower edge portions at 92, the construction of the staves is such as to provide for edge to edge contact of the staves upon assembly thereof. Above such edge portions 92, the stave edges are cut away at 93 to provide the apertures or slots 31 in the assembled rotor. At the top, the staves have edge portions 94 adapted for edge to edge contact. Rubber screw flight portions 27' of the individual staves, are of such character, as to provide screw flights of increasing pitch or lead all the way from the inlet of annular passageway 32 to the outlet thereof at the top, as can be observed from Fig. 3. Since the staves form a substantially cylindrically-shaped rotor, the external diameters of the screw flights is substantially the same throughout. Consequently, and because of the increasing lead or pitch of the screw flights, the volume defined by the grooves or spaces between the helical screw flights or ribs, progressively increases from the inlet to the outlet of the passageway 32.

Adjacent the outlet for pulp from passageway 32, it will be observed, as can be seen most clearly from Figs. 5 and 10, that the rotor staves have portions 96 of increased root diameter, compared to the constant root diameter of the staves below such portions. Consequently, adjacent the outlet or discharge end of the pulp from passage-

way 32, the passageway is of decreased cross-sectional size to offer a restriction to the flow of pulp to thereby effect a differential increase in velocity thereof. At such outlet of pulp from passageway 32, the screw flights terminate in flange portions 97 extending substantially longitudinally with respect to the axis of the rotor to effect tangential throw-off of the pulp and thereby facilitate, by the action of centrifugal force, discharge of the pulp against baffles 67 on the conically-shaped deflector 33.

In operation, the pulp to be aerated enters the inlet of annular passageway 32 after having passed through the ports or apertures 89 of shroud 22. Because of ported shroud 22, the pulp has a comparatively high velocity flow, caused by rotation of the rotor, prior to entering the inlet of passageway 32. As a result, sand, slag and other heavy foreign substances are prevented from piling up at the inlet of passageway 32 to thereby preclude clogging of such passageway, which might otherwise occur. Since ports 89 are adjustable as to size by virtue of the removable rubber rings 91, it is apparent that the velocity flow through the ports can be controlled by preselection.

The high speed of rotation of the rotor, which may be as high as 1000 R. P. M. or even higher, depending upon the character of material being treated, causes the helical screw flights 27 thereon to elevate the pulp mechanically at high velocity; the pulp being discharged over the outlet opening adjacent the upper edge of the stator 23. During such elevation of the pulp at a high velocity, the air passing from within the rotor through its apertures formed by slots 31, is subjected to outward forces created by centrifugal action; and the high velocity flow of the pulp creates an aspirator effect. These two actions together cause induction of air into the pulp, through the rotor slots to thereby effect aeration of the pulp.

Because of the progressive increase in volume caused by the increase in pitch or lead of the screw flights all the way from the inlet to the outlet of the annular pulp aeration passageway 32, the pulp is expanded as it is mechanically elevated, to thereby produce an effect equivalent to that of a partial vacuum. As a result, absorption of the induced air is enhanced to provide for efficacious aeration. In this connection, it will be noted that the substantially cylindrical stator 23, the substantially cylindrically-shaped rotor 28, and the screw flights of gradiently increasing pitch, provide an economical construction for creating expansion of the pulp, as such parts lend themselves to ready production.

As was previously related, the increased root diameter of the rotor adjacent the outlet of passageway 32, restricts the cross-sectional size of the passageway at this point. Hence, at the location of discharge of the pulp from passageway 32, there is provided a restriction to the flow of pulp resulting in a squeezing action on the pulp. Such squeezing action effects, with respect to the mean velocity flow of the pulp, a differential increase in velocity. This results in fine division or attenuation of the air induced into the pulp, to provide a large number of fine air particles for attachment to the mineral particles to be floated. Such squeezing action does not cause the pulp to flow inwardly through the rotor slots 31, because the outward forces created by centrifugal action of the rotor as the pulp is mechanically elevated at a high velocity by positive rotation of the screw

flights on the rotor, are greater than the forces created by the squeezing action. It is thus seen that the improved machine of the present application has means for squeezing the pulp, as well as means for expanding it, as is generically disclosed in my copending application to which reference has been made.

The pulp is tangentially discharged by means of the axially extending portions 97 of the screw flights, and it, consequently, strikes against the radial baffles 67 on conical deflector 33. Such baffles break up whirling, so that the froth may rise gently above the pulp level without breaking up of the air particles or bubbles to which the mineral particles are attached. In this connection, the conical or outwardly tapered shape of the hood or deflector 33, the lower edge of which extends below the pulp level 6, as can be seen in Fig. 1, serves to direct the material more or less tangentially into the froth, minimizing breakage of the air bubbles or particles, which might occur with a cylindrically-shaped deflector.

I claim:

1. A flotation apparatus comprising a cylindrical stator, a cylindrically-shaped rotor rotatable within said stator and forming an annular passageway therebetween, said passageway having an inlet and an outlet for the flow of pulp, screw flights on said rotor of increasing pitch from adjacent said inlet to adjacent said outlet, a ported shroud adjacent said inlet, and a conically-shaped deflector adjacent said outlet.

2. In a flotation apparatus, a rotor formed of a plurality of staves spaced apart to provide slots therebetween, and helical screw flights formed on the staves, said screw flights having a continuous increasing pitch.

3. A flotation apparatus comprising a cylindrically shaped stator, a cylindrically shaped rotor defining an annular passageway therebetween, said passageway having an inlet and an outlet for the flow of pulp, means for introducing air into said rotor, said rotor being apertured to allow admission of air into said passageway, and means to effect expansion of said pulp to enhance aeration thereof including screw flights on said rotor extending all the way from adjacent said inlet to adjacent said outlet and of increasing pitch from adjacent said inlet to adjacent said outlet.

4. A flotation apparatus comprising a cylindrically shaped stator, a cylindrically shaped rotor defining an annular passageway therebetween, said passageway having an inlet and an outlet for the flow of pulp, means for introducing air into said rotor, said rotor being apertured to allow admission of air into said passageway, and means to effect expansion of said pulp to enhance aeration thereof including screw flights on said rotor extending all the way from adjacent said inlet to adjacent said outlet and of increasing pitch from

adjacent said inlet to adjacent said outlet, the external diameter of said screw flights being substantially the same throughout, and the wall of said rotor adjacent said outlet being of increased root diameter to provide a restriction to the flow of pulp adjacent said outlet.

5. A flotation apparatus comprising a chamber adapted to contain pulp, a cylindrically shaped stator in said chamber, a cylindrically shaped rotor in said chamber and defining an annular passageway with said stator, said passageway providing at one end thereof an inlet for pulp contained in said chamber and at the opposite end thereof an outlet for said pulp, means including a hollow shaft extending into said rotor for introducing air, said rotor being apertured to allow admission of air into said passageway, and means to effect expansion of said pulp to enhance aeration thereof including screw flights on said rotor extending all the way from adjacent said inlet to adjacent said outlet and of increasing pitch from adjacent said inlet to adjacent said outlet.

6. A flotation apparatus comprising a chamber adapted to contain pulp, a cylindrically shaped stator in said chamber, a cylindrically shaped rotor in said chamber and defining an annular passageway with said stator, said passageway providing at one end thereof an inlet for pulp contained in said chamber and at the opposite end thereof an outlet for said pulp, means including a hollow shaft extending into said rotor for introducing air, said rotor being apertured to allow admission of air into said passageway, means to effect expansion of said pulp to enhance aeration thereof including screw flights on said rotor extending all the way from adjacent said inlet to adjacent said outlet and of increasing the pitch from adjacent said inlet to adjacent said outlet, and a conically shaped pulp deflector over said outlet.

7. A flotation apparatus comprising a chamber adapted to contain pulp, a cylindrically shaped stator in said chamber, a cylindrically shaped rotor in said chamber and defining an annular passageway with said stator, said passageway providing at one end thereof an inlet for pulp contained in said chamber and at the opposite end thereof an outlet for said pulp, means including a hollow shaft extending into said rotor for introducing air, said rotor being apertured to allow admission of air into said passageway, means to effect expansion of said pulp to enhance aeration thereof including screw flights on said rotor extending all the way from adjacent said inlet to adjacent said outlet and of increasing pitch from adjacent said inlet to adjacent said outlet, and means adjacent said inlet including a ported shroud for precluding piling up of sand contained in said pulp.

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