United States Patent [19]

Shapiro

[11] **3,779,450**

[45] **Dec. 18, 1973**

[54] **BASKET CENTRIFUGE**

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[22] Filed: **Mar. 29, 1972**

[21] Appl. No.: **239,085**

[52] **U.S. Cl.** **233/21**, 233/34, 233/44, 233/46

[51] **Int. Cl.** **B04b 11/00**

[58] **Field of Search** 233/21, 22, 34, 38, 233/40, 44, 46, 27, 28

[56] **References Cited**

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[57] **ABSTRACT**

A centrifuge which rotates about a vertical axis, has a driving hub, a feed cone supported on and surrounding the hub, and a bowl with a separation chamber therein. The improvement includes structure which supports the bowl and feed cone on the hub, while simultaneously closing the bottom of the feed cone and forming a plurality of enclosed passageways which extend from the bottom interior of the cone into the separation chamber; the passageways are symmetrically arranged around the axis, and mounted so as to rotate with the bowl. During operation of the centrifuge, a feed mixture is introduced into the top of the rotating feed cone, the mixture descending to the bottom interior thereof; from the bottom interior of the feed cone, the mixture enters the enclosed passageways where it is tangentially accelerated while being fed into the separation chamber.

10 Claims, 6 Drawing Figures

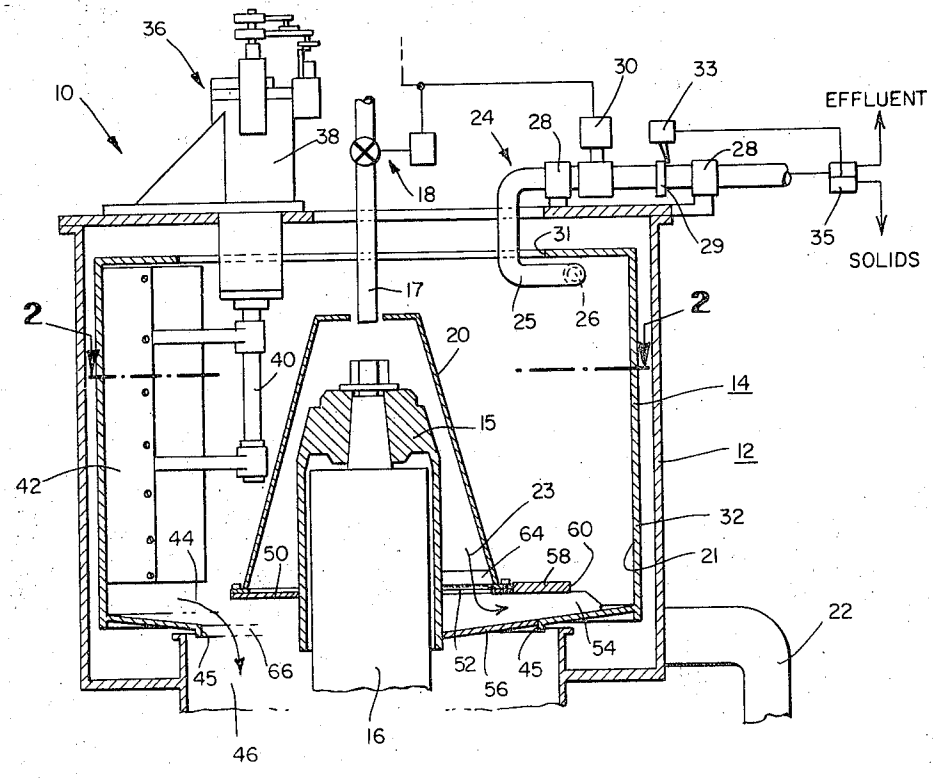

Fig. 1

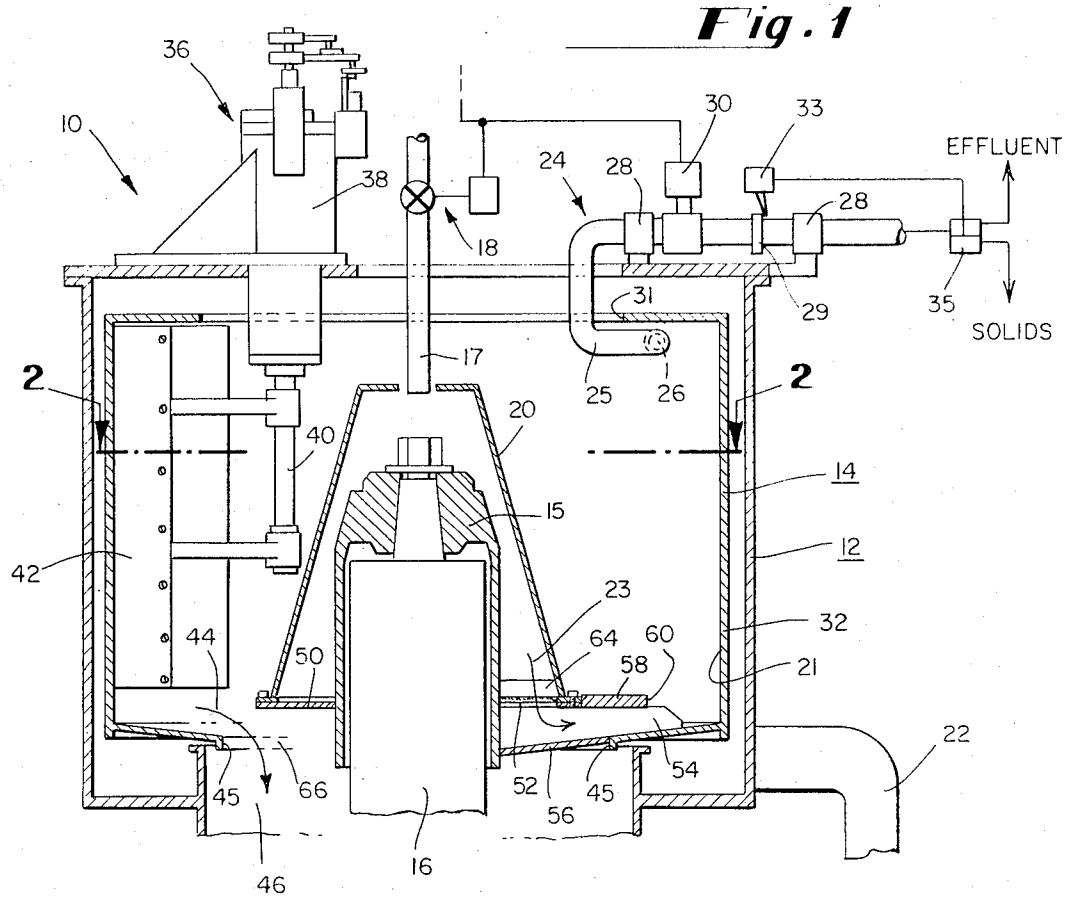
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Fig. 3

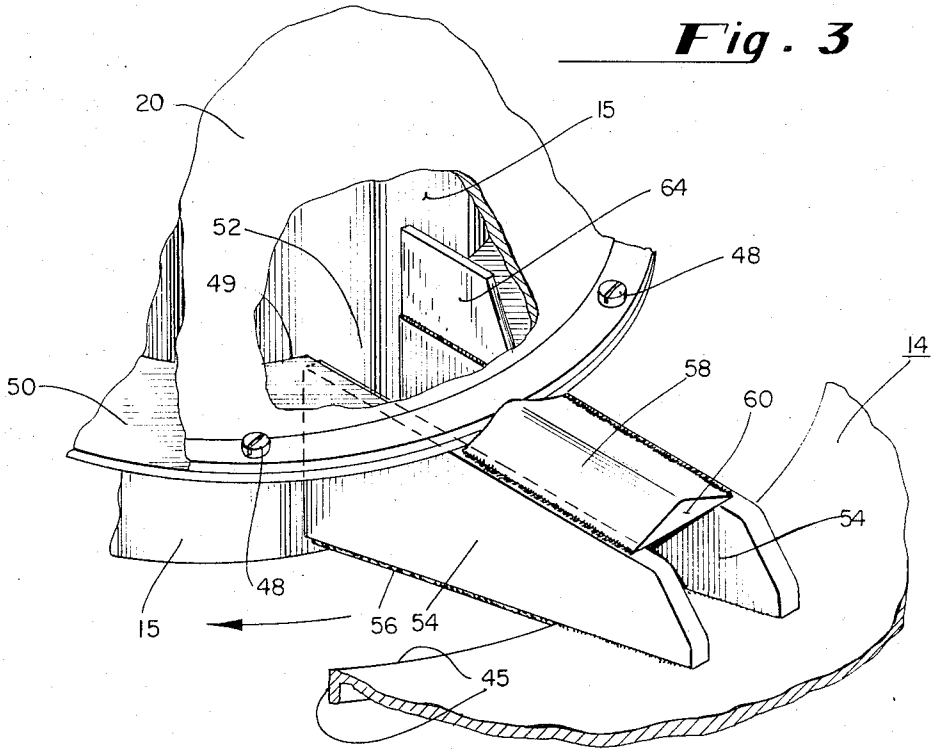
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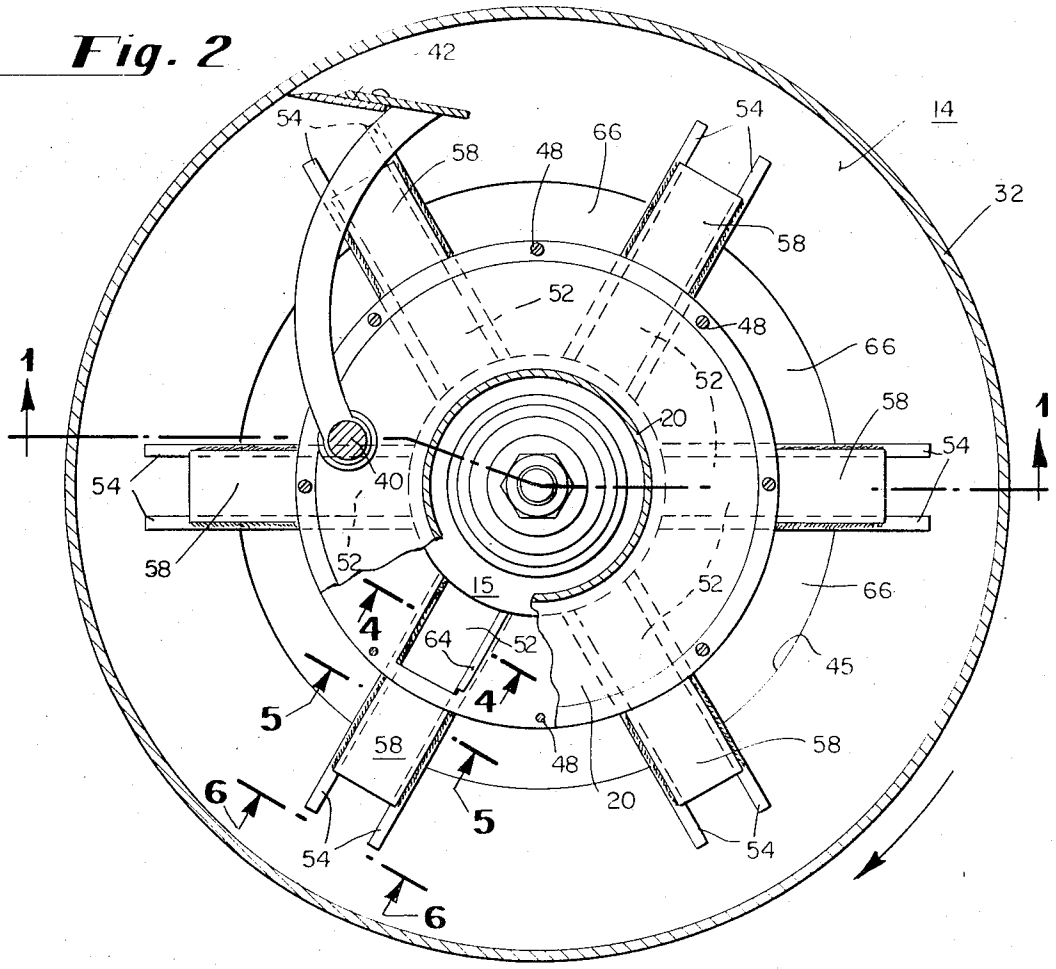
Fig. 2



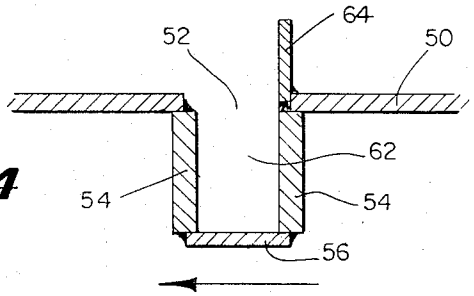


Fig. 4

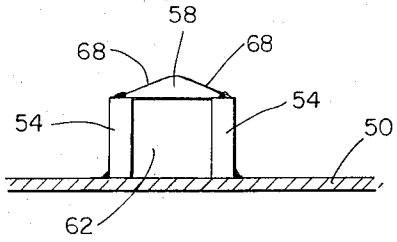


Fig. 6

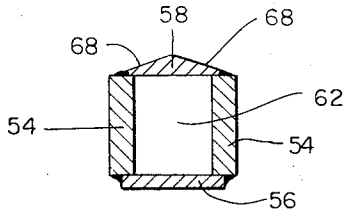


Fig. 5

BASKET CENTRIFUGE

BACKGROUND OF THE INVENTION

In using an imperforate basket centrifuge for difficult clarification or separation processes, it has been found that the technique of feeding the slurry or feed mixture into the separation chambers of the centrifuge bowl is of prime importance. The mixture must be accelerated by a feed system which brings the mixture up to at least the tangential velocity of the rotating pond in the bowl as gently as possible. At the same time, the system for accelerating the mixture should be such that it cannot be easily plugged with large extraneous material entrained in the mixture such as strings, rags, etc.

This combined requirement is especially difficult in basket centrifuges where part of the cycle requires discharging the accummulated solids through the bottom of the centrifuge at low speeds with the assistance of a knife or plow; the reason for this is because a large percentage of the bottom of the centrifuge must be open to allow discharge of the solids therethrough. Tube accelerator assemblies have been used, wherein the individual tubes for feeding the mixture into the separation chamber were attached to the sides of the ribs that support the bowl on the driving hub of the centrifuge. The problem with this arrangement has been that, when mounted to the sides of the ribs, the tubes had to be small enough so as not to significantly reduce the open area in the bottom of the centrifuge. Consequently, the tubes became plugged because of large particles in the mixture.

A feed cone supported on and surrounding the hub is also used to introduce the mixture into the separation chamber. The mixture is discharged radially outwardly from the bottom of the feed cone toward the separation chamber, and after entering the latter, is contacted by accelerator vanes located therein. Thus, a significant amount of turbulence is generated when the incoming mixture contacts the rotating pond, but prior to being tangentially accelerated by the accelerator vanes. Although the mixture enters near the bottom of the bowl, the accelerator vanes are sometimes disposed upwardly within the bowl, thus reducing the capacity of the bowl for separation. Also, with this feed cone arrangement, the mixture leaves the feed cone, and is discharged radially outwardly over the open areas in the bottom of the centrifuge; because of the air circulation generated by the rotating bowl and supporting ribs, some of the mixture is consequently atomized and decends into a solids compartment located beneath the bowl, thus reducing the dryness of the separated and discharged solids contained therein. Also, while passing from the feed cone into the separation chamber, the mixture is not being tangentially accelerated.

Consequently, what is needed, is a structure which permits a substantial portion of the bottom of the centrifuge to remain open, but also provides relatively large passageways for tangentially accelerating the feed mixture while introducing the same into the separation chamber.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to a basket centrifuge which rotates about a vertical axis and has a hub, a feed cone supported on and surrounding the hub, and a bowl with a separation chamber therein. An annular plate is connected to the bottom periphery of the feed cone, the annular plate extending radially inwardly to the hub to which it is welded. This annular plate has a plurality of openings formed therein which are symmetrically arranged around the axis of rotation, and disposed radially inwardly from the feed cone. A plurality of pairs of radially extending ribs supports the bowl on the hub, each rib extending into the separation chamber and being welded to the bottom interior surface of the bowl, to the underside of the annular plate, and to the hub, one rib of each pair being located on each side of each opening. To complete a plurality of enclosed passageways extending from the bottom interior of the feed cone into the separation chamber, each pair of ribs is closed on top thereof by a cover plate welded thereto which extends from the bottom periphery of the cone into the separation chamber, the upper surface of each plate being inclined; the bottom of each pair of ribs is closed by a bottom plate welded thereto which extends from the hub into the separation chamber. Disposed adjacent each opening within the bottom interior of the feed cone, is a generally radially extending accelerator plate.

Thus, during operation of the centrifuge, a feed mixture is introduced into the top interior of the rotating feed cone. The mixture then descends to the bottom interior of the feed cone where it contacts the accelerator plates immediately prior to entering the enclosed passageways, thus increasing the tangential velocity of the mixture. After entering the rotating enclosed passageways, the mixture is further tangentially accelerated while it is simultaneously fed into the separation chamber. Consistent with maintaining an adequate open area in the bottom of the centrifuge, as many enclosed passageways as possible are desirable. These passageways, however, should be symmetrically disposed around the axis of rotation so as to distribute the mixture equally around the interior of the centrifuge bowl. The upper surface of each of the enclosed passageways is inclined as stated above; this allows the heavy phase material (e.g. solids) separated from the mixture, to slide off these surfaces during that portion of the cycle when solids are being discharged through the bottom of the centrifuge.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional elevational view of a basket centrifuge incorporating the present invention.

FIG. 2 is a transverse cross-sectional view taken through line 2—2 of FIG. 1, and showing a plurality of enclosed passageways symmetrically disposed around the axis of rotation, the passageways extending from the bottom interior of the feed cone into the separation chamber.

FIG. 3 is a perspective view showing one of the enclosed passageways extending from the bottom interior of the feed cone into the separation chamber within the bowl.

FIG. 4 is a cross-sectional view taken through line 4—4 of FIG. 2.

FIG. 5 is a cross-sectional view taken through lines 5—5 of FIG. 2.

FIG. 6 is a cross-sectional view taken through lines 6—6 of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a basket centrifuge 10 is shown which includes a stationarily mounted housing 12. A

centrifuge bowl 14 is fixedly connected (by means which will be hereinafter described) to a driving hub 15, the latter in turn being fixedly connected to a drive shaft 16 which is adapted to rotate about a vertical axis of rotation. To rotate drive shaft 16, the lower end thereof has a pulley (not shown) connected thereto, the pulley being connected by a belt to a driving motor.

During operation of the centrifuge, a feed mixture is introduced into bowl 14 through a feed tube 17, this tube being stationarily mounted. Tube 17 is provided with a solenoid operated valve 18 for controlling the passage of the mixture into the centrifuge. The mixture exits tube 17 and enters the top interior of the rotating cone 20. The mixture then descends to the bottom interior of the cone where it is discharged radially outwardly through a plurality of enclosed passageways (to be hereinafter described) toward the peripheral surface 21 of the bowl. The radially outwardly discharge of the mixture from the cone 20 is indicated generally by the arrow 23.

After the mixture enters the rotating bowl 14, it is separated into an outer annular layer of heavy phase material (e.g., solids), which accummulates against the surface 21, and into the concentric inner annular layer of light phase material (e.g., liquid).

Connected to the lower end of housing 12 is an effluent (light phase material) conduit 22 which leads to an effluent tank (not shown), from which the collected effluent is later withdrawn.

To remove the separated materials from within the bowl 14 during the cycle of operation of the centrifuge, a conventional skimmer 24 is provided. This skimmer includes a skimmer tube 25 which presents an open mouth 26 facing against the direction of rotation of bowl 14. The skimmer tube 25 is mounted on housing 12 in a plurality of bosses 28 in which the skimmer tube 25 is longitudinally movable. As the skimmer tube 25 is moved radially outwardly through the inner annular layer, i.e., deeper into bowl 14, the combination of the velocity of the liquid passing into the mouth 26 of the skimmer tube, and the centrifugal pressure head of the liquid in which the skimmer tube is submerged, causes the liquid to be " pumped" into and through the skimmer tube.

The means for moving skimmer tube 25, is indicated schematically at 30, and comprises a piston-cylinder assembly which alternately drives the skimmer tube radially outwardly and radially inwardly. Drive means 30 is carefully arranged so that at its inward limit of travel, skimmer tube 25 is disposed with its mouth 26 located radially inwardly from liquid overflow lip 31, and consequently, out of the liquid. At its outward limit of travel, skimmer tube 25 is located so that its mouth 26 is approximately one-sixteenth to one-quarter inch from surface 21.

As skimmer tube 25 is moved radially outwardly toward outer peripheral wall 32 of the bowl, it will eventually move into the outer annular layer of accummulated solids. In order to segregate the clarified effluent from the accummulated solids during the skimming operation, a lug or protuberance 29 is mounted on the skimmer tube 25 between bosses 28. A limit switch 33 is actuated by protuberance 29 in either direction of travel of the skimmer tube 25. Limit switch 33 is connected to a solenoid operated diversional valve 35, the arrangement being such that when limit switch 33 is tripped in either direction the diversional valve will be shifted. For example, when skimmer tube 25 is moved radially outwardly toward the surface 21. The diversional valve 35 is shifted to its "solids" position so as to discharge solids as the mouth 26 of the skimmer tube reaches the line of separation ("*e*-line") between the inner annular layer and the outer annular layer. When the skimmer tube moves radially inwardly, the diversional valve is shifted back to the "effluent" position. With this arrangement, the light phase material is directed to one discharge line, and the heavy phase material is directed to another discharge line. From diversional valve 35, the effluent discharge line can be connected to the same effluent tank to which the conduit 22 is connected, and the solids discharge line will be connected to a separate collecting point.

During operation of centrifuge 10, the above mentioned layers of material will accummulate within separation chamber of bowl 14, the separation chamber being defined as that annular area within the bowl located radially outwardly from liquid overflow lip 31. The inner annular layer of liquid will accumulate until reaching liquid overflow lip 31 at which time, it will flow over the lip and into the housing 12 from which it is discharged via effluent conduit 22.

Also mounted to housing 12 of the centrifuge, is a knife or plow assembly 36, this assembly including a motor 38 utilized for rotating a shaft 40 upon which is mounted a knife blade or plow 42. It may be desirable in certain instances to utilize this assembly instead of skimmer 24 for removing accumulated solids from within the bowl 14. If it is desired to use plow assembly 36 to remove accumulated solids, skimmer 24 may first be used to remove the effluent, after which the plow 42 is moved outwardly to remove accumulated solids. Solids thus removed, are discharged, as indicated generally by the arrow 44, over an annular solids discharge lip 45 and through a plurality of openings formed in the bottom of the centrifuge including opening 46, and are collected in a bin or other receptacle located beneath the centrifuge. It is noted that the solids discharge lip 45 is located radially inwardly from the liquid overflow lip 31.

Attention is now directed to an essential portion of the invention. Referring to FIGS. 2 through 6, a means will be described for supporting the bowl 14 and feed cone 20 on the hub 15, while simultaneously defining a plurality of enclosed passageways extending from the bottom interior of the feed cone into the separation chamber, these passageways being utilized to feed the mixture into the separation chamber while simultaneously tangentially accelerating the mixture.

The bottom of the feed cone has a flange for fixedly connecting the feed cone by means of bolts 48 to the outer periphery of an annular plate 50, this annular plate extending radially inwardly to the hub 15; the inner periphery of the annular plate 50 is preferably welded to the hub 15.

Annular plate 50 has a plurality of openings 52 formed therein, these openings being symmetrically disposed around the axis of rotation so that the angular distances between adjacent openings are equal. Each opening 52 forms the beginning of each of the enclosed passageways described herein.

On each side of each opening 52, a radially extending rib is welded to the underside of annular plate 50. As can be seen in FIGS. 2 and 3, these ribs extend radially outwardly into the separation chamber, the bottom

edges of the ribs contacting the interior surface of the bottom of bowl 14 from the solids discharge lip 45 radially outwardly to the outer ends of said ribs. Ribs 54 are welded to this interior surface of the bottom of the bowl, and also to the hub 15, thus supporting the bowl on the hub. Thus, a pair of ribs 54 cooperates with each opening 52 to partially define an enclosed passageway extending from the bottom interior of feed cone 20 into the separation chamber.

To complete the enclosed passageways for feeding the mixture from the bottom interior of feed cone 20 into the separation chamber, a bottom plate 56 extends across the bottom (see FIG. 4 for example) of each pair of ribs, and is welded to the ribs. Each bottom plate extends radially outwardly from hub 15 to the annular solids discharge lip 45 (see FIG. 1), and is preferably welded to both. A cover plate 58 extends across the top of each pair of ribs and is welded to the ribs, each cover plate extending radially outwardly from the outermost periphery of the feed cone-annular plate assembly into the separation chamber. It is noted that the outer end 60 of each cover plate extends at least to, but preferably outwardly beyond the radius of the liquid overflow lip 31. The outer ends of ribs 54 preferably extend slightly beyond the outer end 60 of each cover plate 58, as is clearly shown in FIG. 3. Thus, a plurality of enclosed passageways 62 are defined, each passageway 62 extending from the bottom interior of the feed cone into the separation chamber (i.e., each enclosed passageway 62 extends outwardly at least to the radius of liquid overflow lip 31).

As shown in FIG. 2, six enclosed passageways are symmetrically disposed around the axis of rotation. As stated above, however, the number of such passageways may vary.

Thus, during operation of centrifuge 10, the incoming mixture exits the bottom interior of feed cone 20, entering enclosed passageways 62 as it is passing through openings 52. Just before entering the passageways 62 and consequently openings 52, the mixture is tangentially accelerated by contact with accelerator plates 64 (see FIGS.3 and 4). As shown, a generally radialiy extending accelerator plate 64 is mounted adjacent each opening 52, the plate preferably being welded in place. As the mixture enters passageways 62, it is further tangentially accelerated by contact with ribs 54 while being simultaneously fed radially outwardly into the separation chamber. As stated above, ribs 54 preferably extend radially beyond the radius of the liquid overflow lip 31. If the ribs 54 terminated at the radius of the liquid overflow lip 31, tangential acceleration of the incoming mixture would then be dependent upon the viscosity of the mixture. Because the tangential velocity of the mixture within the passageways 62 is close or equal to that of the rotating pond in bowl 14, substantially less turbulence is generated when the mixture enters the rotating pond.

Periodically during the cycle of operation of the centrifuge, the rotational velocity of the bowl 14 is decreased, the inner annular layer of effluent is then removed by skimmer 24, and the plow 42 is then moved outwardly to remove solids which have accumulated against the peripheral surface 21, the removed solids dropping through the openings 66. To permit solids to slide off, the upper surface of each cover plate 58 is inclined or upwardly tapered as indicated by the numeral 68. As best seen in FIGS. 1 and 2, adjacent pairs of passageways 62 are spaced apart to define between them the individual openings 66 through which the separated solids or other heavy phase material are discharged from the bowl in downward axial direction therethrough.

I claim:

1. A basket centrifuge comprising a centrifuge bowl adapted to rotate about a vertical axis and having a separation chamber therein, said bowl having an annular liquid overflow lip formed about said axis at the upper end of said bowl, an annular solids discharge lip formed about said axis at the lower end of said bowl, said solids discharge lip being located radially inwardly from said bowl a greater distance than said liquid overflow lip, a hub, first means comprising a feed cone formed about said axis and surrounding said hub for feeding a mixture of at least two materials into said separation chamber wherein the first material thereof has a higher specific gravity than the second material thereof, whereby said first material builds up against the peripheral wall of said bowl during rotation thereof to form an outer annular layer, while said second material forms a concentric inner annular layer, and second means for fixedly supporting said bowl on said hub while simultaneously forming both a bottom on said feed cone and a plurality of enclosed passageways extending from the bottom interior of said feed cone into said separation chamber, said passageways being adapted to deliver said mixture from said bottom interior into said separation chamber, at least two of said passageways being spaced apart to define between them an opening for the discharging of separated first material from said bowl therethrough.

2. A basket centrifuge according to claim 1, said second means also fixedly connecting said feed cone to said hub.

3. A basket centrifuge according to claim 2 wherein said second means includes an annular plate, said plate being fixedly connected at its outer periphery to the bottom of said feed cone and extending radially inwardly to said hub, said plate having a plurality of openings formed therein which are disposed radially inwardly from the bottom of said feed cone, and are symmetrically disposed around said axis so that the angular distances between adjacent openings are equal, a plurality of pairs of radially extending ribs welded to the underside of said plate and to said hub, one rib of each pair being disposed adjacent each side of each of said openings, said ribs extending into said separation chamber and being welded to the interior surface of the lower end of said bowl, the bottom edges of said ribs contacting the interior surface of the bottom of said bowl from said solids discharge lip radially outwardly to the outer ends of said ribs, a bottom plate mounted across the bottom of each pair of ribs and extending radially outwardly from said hub to said solids discharge lip, and a cover plate mounted across the top of each pair of ribs and extending radially outwardly from the outermost periphery of said feed cone/annular plate assembly into said separation chamber.

4. A basket centrifuge according to claim 3, including a generally radially extending accelerator plate disposed adjacent each of said openings within the interior of said feed cone.

5. A basket centrifuge according to claim 4, wherein the inner periphery of said annular plate is welded to said hub.

6. A basket centrifuge according to claim 5, wherein the upper surfaces of said cover plates are inclined so that said first material may slide off said cover plates.

7. A basket centrifuge according to claim 2, and further including means for accelerating the tangential velocity of said mixture prior to entering said openings.

8. A basket centrifuge according to claim 7, wherein the upper surfaces of said passageways between said feed cone and said separation chamber are tapered upwardly.

9. A basket centrifuge according to claim 6, wherein the outer ends of said cover plates extend radially outwardly beyond said liquid overflow lip, and the outer ends of said ribs extend radially outwardly beyond the outer ends of said cover plate.

10. A basket centrifuge according to claim 9, and further including skimmer means for removing said inner annular layer of said second material, and a plow extending substantially the entire height of said bowl, said plow being mounted for outward movement toward the outer peripheral wall of said bowl for removing said outer annular layer of said first material within said separation chamber, the lower end of said plow being disposed adjacent the locus of rotation of the upper surfaces of said cover plates.

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