United States Patent

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[54] **CENTRIFUGE**
14 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **210/369,** 210/377, 210/380
[51] **Int. Cl.** **B04b 3/00,** B04b 7/08, B04b 11/06
[50] **Field of Search** 210/78, 377, 369, 380

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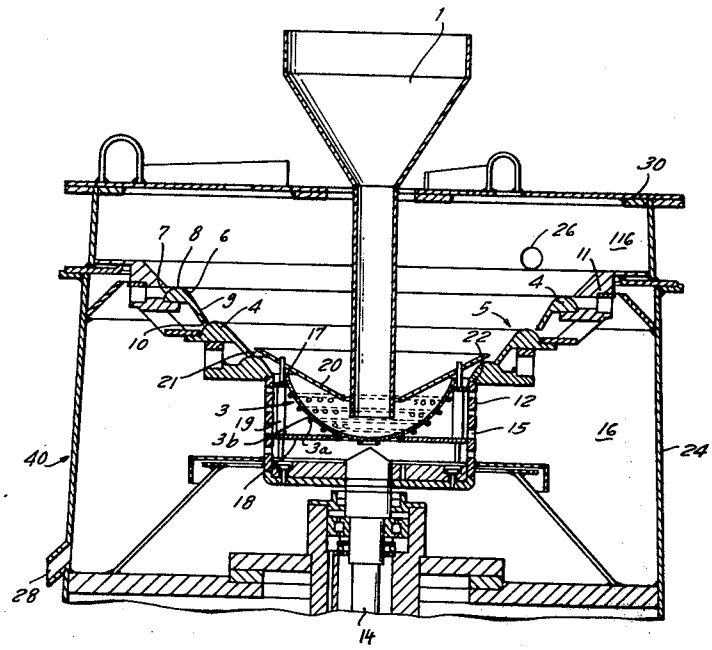
ABSTRACT: A centrifuge wherein a hollow apertured cylindrical carrier supports and rotates a primary and a secondary separating unit. The primary unit includes a perforated conical or semispherical bowl which is separably accommodated in the carrier and receives incoming material whereby some of the liquid fraction penetrates through the bowl and escapes through the carrier. The remainder travels upwardly beyond the open top of the bowl and travels along the upwardly and outwardly sloping inner annular surfaces of rings in the secondary unit. The solid fraction travels upwardly beyond the inner surfaces of successive rings. The liquid fraction adheres to such surfaces and flows along convex top surfaces and thereupon along downwardly and outwardly sloping outer surfaces of the rings.



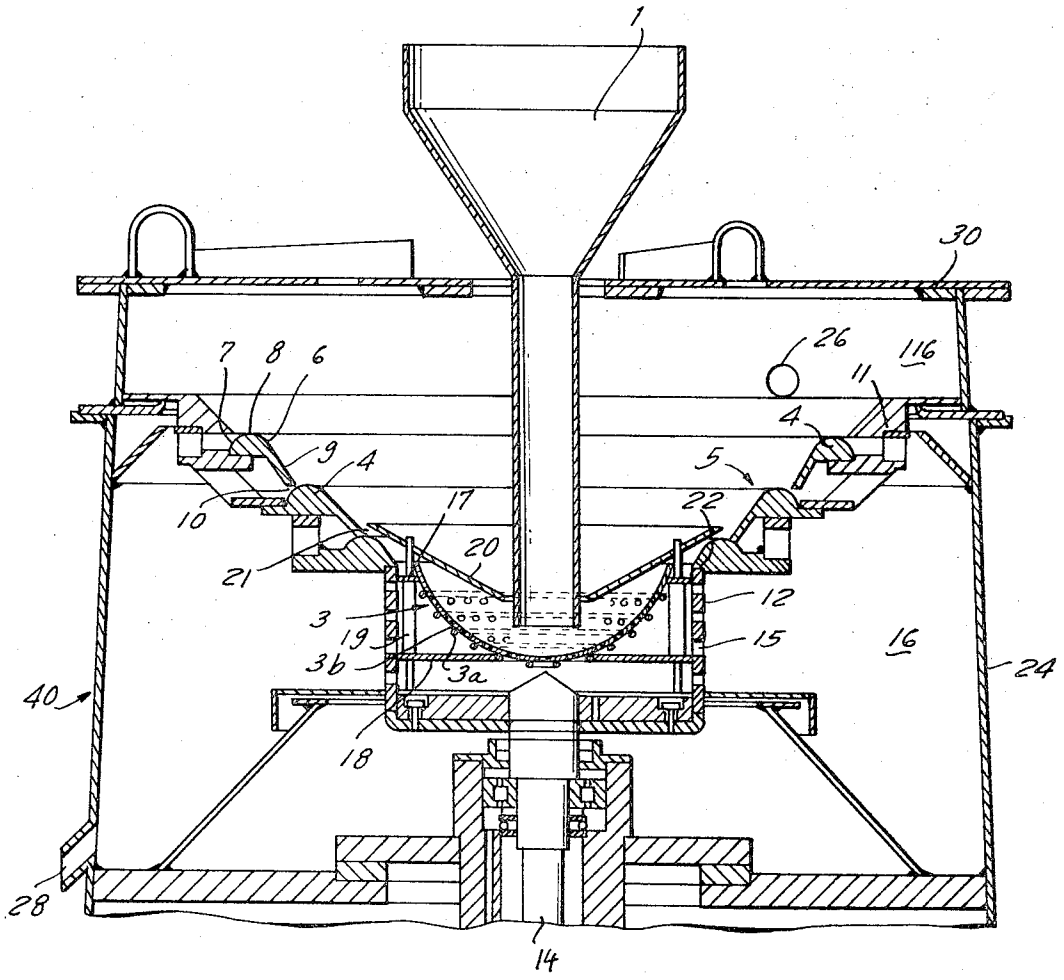


FIG. 1

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FIG. 2

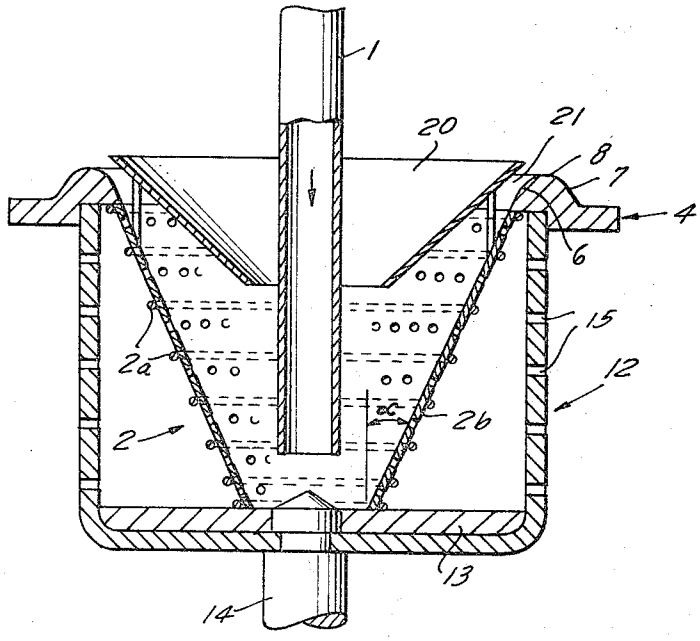
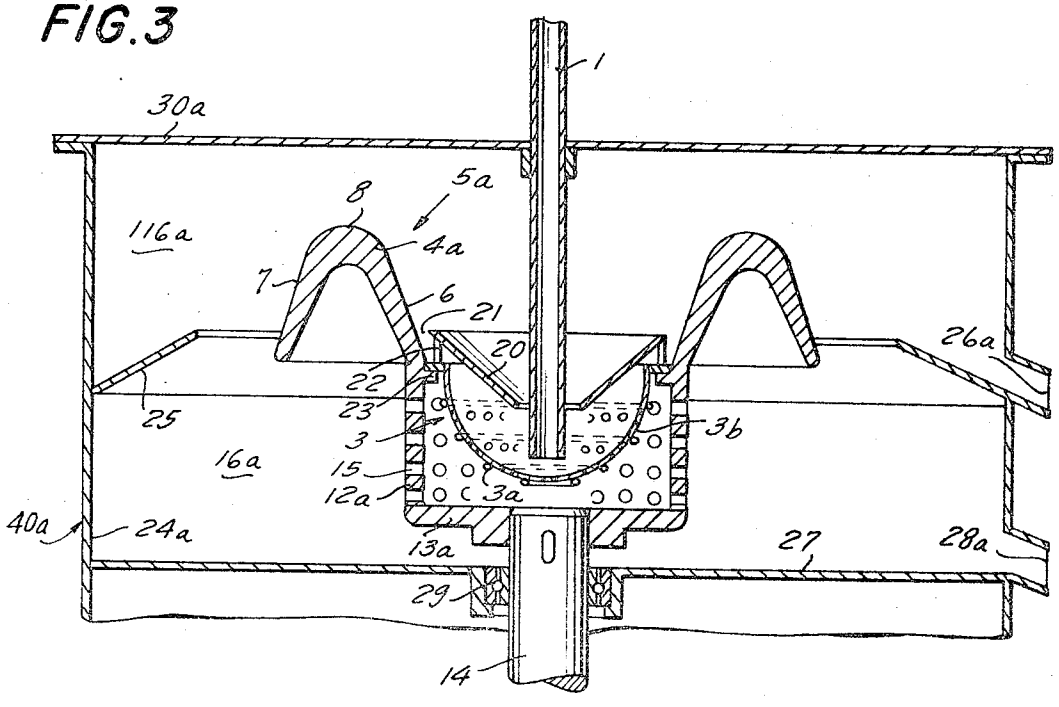


FIG. 3



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CENTRIFUGE

BACKGROUND OF THE INVENTION

The present invention relates to centrifuges in general, particularly to continuous centrifuges for segregation of solid and liquid fractions in suspensions. Still more particularly, the invention relates to improvements in multistage centrifuges wherein a suspension or the like is subjected to a plurality of successive separating actions.

SUMMARY OF THE INVENTION

It is an object of my invention to provide a centrifuge, particularly a centrifuge for separation of solid and liquid fractions in suspensions, and to construct and assemble the centrifuge in such a way that the part or parts which are most likely to become clogged and which are most likely to require frequent inspection, cleaning and/or replacement are readily accessible for removal and reinsertion into the housing of the centrifuge.

Another object of the invention is to provide a continuous multistage centrifuge wherein the first or primary stage is readily removable from and reinsertable into the housing while the remaining stage or stages can remain in fully assembled condition.

A further object of the invention is to provide novel and improved means for supporting the stages of a multistage continuous centrifuge for suspensions or the like.

An additional object of the invention is to provide a centrifuge which can be used for treatment of various types of mixtures of solid and liquid fractions.

The improved centrifuge is particularly suited for separation of solid and liquid fractions of suspensions and comprises a rotary driving member which is provided with a preferably cylindrical hollow apertured carrier, a primary separating unit including a perforated conical or semispherical bowl having an open top and being separably supported by and rotatable with the carrier (the bowl preferably extends into and may be fully accommodated in the interior of the hollow carrier), means for feeding incoming material into the bowl, preferably into the bottom zone of the bowl, whereby some of the liquid fraction passes through the perforations and the remainder of the material travels toward and beyond the open top of the bowl, and a secondary separating unit including at least one annular member which is preferably removably supported by and is rotatable with the carrier. The annular member comprises a first or inner annular surface arranged to intercept the remainder of material which leaves the bowl, a second (outer) annular surface located downstream of and diverging (downwardly and outwardly) in a direction away from the first annular surface, and a convex annular intermediate or top surface disposed between the first and second annular surfaces. The arrangement is such that, when the two units rotate, the solid fraction of the remainder of material which leaves the bowl travels upwardly along and beyond the first annular surface whereas the liquid fraction of the remainder adheres to and travels along the first, intermediate and second annular surfaces to accumulate in a collecting chamber.

The carrier preferably rotates about a vertical axis and the cross-sectional area of the entire bowl, or of the major portion of the bowl, preferably increases toward the open top of the bowl.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved centrifuge itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary axial sectional view of a centrifuge which embodies one form of my invention;

FIG. 2 is a fragmentary axial sectional view of a second centrifuge; and

FIG. 3 is a fragmentary axial view of a third centrifuge which constitutes a simplified version of the centrifuge shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there is shown a centrifuge which comprises a housing or casing **40** having a cylindrical shell **24** and a removable cover or top wall **30**. The latter is provided with a central opening for a feeding device **1** which supplies incoming material (e.g., a suspension of solid particles in a liquid carrier) into a perforated semispherical bowl **3***b* which forms part of a primary separating unit **3** in the centrifuge and is removably accommodated in a hollow cylindrical apertured carrier **12**. The bowl **3***b* has an open top and is reinforced by ring-shaped stiffening members or hoops **3***a*. These stiffening members are preferably located in planes which are normal to the axis of a driving member **14**, here shown as a shaft which is rigid with the bottom wall **13** of the carrier **12**. The discharge end of the feeding device **1** preferably supplies incoming material into the bottom zone of the bowl **3***b*, i.e., the outlet of the device **1** is preferably coaxial with the shaft **14**. Some of the liquid fraction in the incoming material passes through the perforations of the revolving bowl **3***b* and through the apertures **15** of the carrier **12** to accumulate in a liquid collecting chamber **16** surrounded by the shell **24** of the housing **40**. The remainder of the material travels upwardly toward and beyond the open top of the bowl **3***b* and is treated in a secondary separating unit **5** which comprises a series of annular members **4**. The lowermost or innermost annular member **4** is separably secured to the carrier **12** and is positioned in such a way that it intercepts the remainder of material which ascends above and beyond the open top of the bowl **3***b*. Each such annular member has an upwardly diverging first annular surface **6** which receives material from the bowl **3***b* or from the preceding ring **4**, a second annular surface **7** which diverges (downwardly and outwardly) in a direction away from the corresponding annular surface **6**, and an annular convex intermediate surface **8** which provides a gradual transition between the respective first and second surfaces **6** and **7**. The annular members **4** rotate with the carrier **12**, and the arrangement is such that the remainder of material leaving the open top of the bowl **3***b* moves against the first annular surface **6** of the lowermost annular member **4** whereby the solid fraction travels upwardly in response to rotation of the unit **5** and is propelled to reach the surface **6** of the next following annular member **4**. Some of the liquid fraction adheres to the surface **6**, thereupon to the surface **8** and finally travels along the surface **7** of the lowermost annular member **4** to be discharged into the collecting chamber **16**. Annular ramps **9** are interposed between successive annular members **4** to facilitate ascent of solid fraction and some liquid fraction from a lower annular surface **6** to the next following annular surface **6**. The lower edge of each ramp **9** defines with the adjoining convex annular surface **8** a narrow annular gap **10** for the liquid fraction which flows along such surface **8** and onto the corresponding surface **7**.

The solid fraction which travels upwardly beyond the annular surface **6** of the uppermost annular member **4** is separated from the remainder of the liquid fraction as it travels along successive surfaces **6** and finally moves onto the platform of an annular evacuating member **11** to be discharged from a collecting chamber **116** through one or more outlets **26** in the wall **24**.

The means for separably coupling the bowl **3***b* to the carrier **12** comprises annular supporting members **17**, **18** which are affixed to the bowl, and pins, bolts or analogous fasteners **19** which extend through the supporting members **17**, **18** and are secured to the carrier. If desired, one of the supporting members **17**, **18** can be secured to the carrier **12**. The lower ends of the fasteners **19** extend into tapped bores provided in the bot-

tom wall 13 of the carrier 12. The lowermost annular member 4 of the secondary separating unit 5 rests on and is secured to the upper edge portion 22 of the carrier 12. The annular members 4 of the unit 5 are secured to each other in such a way that they permit the liquid fraction to move beyond the surfaces 7 and into the collecting chamber 16. The latter has an outlet 28. The fasteners 19 preferably extend upwardly beyond the supporting member 17 and support a hollow frustoconical baffle 20 which overlies the bowl 3*b* and serves to direct the remainder of incoming material toward the surface 6 of the lowermost annular member 4. The downwardly and inwardly converging conical lower side of the baffle 20 defines with the lowermost annular member 4 a narrow annular clearance 21.

When the bowl 3*b* requires replacement, inspection and/or cleaning, it is simply lifted out of the carrier 12 together with the fasteners 19, baffle 20 and supporting members 17, 18 subsequent to separation of fasteners from the bottom wall 13.

FIG. 2 illustrates a portion of a second centrifuge wherein the primary separating unit 3 is replaced by a different primary separating unit 2 which includes an upwardly diverging frustoconical bowl 2*b* reinforced by ring-shaped stiffening members or hoops 2*a*. The angle alpha of divergence of the bowl 2*b* is constant all the way from the bottom wall 13 to the lowermost annular member 4. The manner in which the bowl 2*b* is separably installed in and rotates with the carrier 12 is the same as or similar to that described in connection with FIG. 1. If desired, the bowl 2*b* can be held in the carrier 12 by snap action.

FIG. 3 shows a portion of a third centrifuge with a simpler secondary separating unit 5*a* which comprises a single annular member 4*a*. The housing 40*a* comprises a removable cover or top wall 30*a* and a cylindrical shell 24*a* which accommodates two annular partitions 25, 27. The partition 27 constitutes the bottom panel of the collecting chamber 16*a* for the liquid fraction and the partition 25 constitutes the bottom panel of a second collecting chamber 116*a* for the solid fraction. The partition 25 slopes downwardly and outwardly so that the solid fraction is evacuated by gravity by way of an outlet 26*a*. A second outlet 28*a* is provided in the shell 24 directly above the partition 27 for evacuation of the liquid fraction. The feeding device 1 extends through a seal in the top wall 30 and discharges incoming material (preferably a suspension) into the bottom zone of a semispherical bowl 3*b* which is identical with the bowl of FIG. 1.

The numeral 23 denotes an annular flange of the carrier 12*a* for the marginal portion of the bowl 3*b* and the numeral 22 denotes one of several fasteners which secure the marginal portion of the bowl to the baffle 20. An antifriction bearing 29 surrounds the drive shaft 14 and is installed in the lower partition 27. The shaft 14 drives the bottom wall 13*a* of the carrier 12*a*.

The operation of the centrifuge shown in FIG. 3 is analogous to that of the centrifuge which is illustrated in FIG. 1. The solid fraction travels with the remainder of the liquid fraction through the clearance 21 between the baffle 20 and the surface 6 of the single annular member 4*a*. That part of the liquid fraction which did not penetrate through the perforations of the bowl 3*b* and the apertures 15 of the carrier 12*a* travels along the upwardly diverging surface 6 and adheres to such surface to thereupon travel along the intermediate surface 8, along the downwardly and outwardly diverging surface 7 and into the collecting chamber 16*a*. The solid fraction is propelled beyond the upper edge of the surface 6 and accumulates in the chamber 116*a* to be evacuated by way of the outlet 26*a*. The outlet 28*a* serves to evacuate that part of the liquid fraction which enters the chamber 16*a* by way of the apertures 15 as well as the remainder of the liquid fraction which enters the chamber 16*a* by moving downwardly beyond the surface 7.

That portion of the bowl 3 which is immediately adjacent to its open top is preferably a cylinder which is coaxial with the shaft 14.

The purpose of the primary separating unit 2 or 3 is to segregate from incoming material at least some liquid matter and to thereby enhance the operation of the secondary unit 5 or 5*a*. This is particularly desirable and advantageous when the solid fraction consists of coarse or medium-sized particles of synthetic plastic material.

An important advantage of my centrifuge is that the primary separating unit, or at least the bowl of the primary separating unit, can be rapidly and readily separated and removed from or reinstalled in the carrier 12 or 12*a*. This is desirable when the centrifuge is to be used for treatment of different types of suspensions and the contents of one suspension should not mix with the contents of the other suspension or suspensions. Furthermore, cleaning of the bowl can be carried out more readily if the latter is removed from the housing 40 or 40*a*. Still further, the centrifuge can be furnished with two or more bowls so that one bowl is being cleaned while the centrifuge is in use with another bowl.

Since the primary and secondary separating units are separably secured to the carrier 12 or 12*a*, this carrier takes up the weight of these units, i.e., the primary separating unit need not carry the secondary unit so that the primary unit can employ a lightweight bowl which is just strong enough to take up stresses which arise under the action of material fed by the device 1. In many presently known centrifuges, the primary separating unit must be strong enough to carry one or more secondary units.

Still another advantage of the improved centrifuge is that the carrier 12 or 12*a* can accommodate and transmit motion to different types of bowls. Thus, the type of bowl can be selected as a function of the composition of incoming material, not only as regards the shape of the bowl but also as regards the number and size of perforations. The shape (angle of divergence) of a conical bowl is preferably selected in such a way that it enables the solid fraction to rise which enters the bowl (in and beyond the open top with minimal resistance. Hollow semicylindrical bowls are preferred in many instances because the inclination of the rising solid fraction with reference to the axis of rotation changes continuously and gradually. If the uppermost part of a hollow semispherical bowl resembles a cylinder, it accumulates a layer of coarser particles of solid fraction, i.e., the internal surface of such layer is uneven and accelerates the material which slides thereover so that such material rotates at the speed of the bowl when it enters the secondary separating unit. Another advantage of a semicylindrical or similar bowl is that the kinetic energy of material which enters the bowl (in parallelism with the axis of rotation) is utilized for segregation of the liquid fraction.

The stiffening rings 2*a* or 3*a* render it possible to employ a very lightweight bowl because they reinforce the bowl in the region where the perforated wall of the bowl must withstand considerable centrifugal forces and the pressure of incoming material.

The main purpose of the baffle 20 is to insure separation of at least some liquid fraction in the primary unit 2 or 3, and also that the remainder of material is properly directed against the surface 6 of the first or lowermost annular member 4 or against the surface 6 of a single annular member 4*a*. Thus, the narrow clearance 21 guides the material which leaves the bowl 2*b* or 3*b* against the adjoining surface 6.

It will be noted that the area of the surface (6) along which the solid fraction travels in an annular member 4 or 4*a* increases in the direction of travel of the solid fraction. The same holds true for the surfaces (6, 8, 7) along which the liquid fraction travels toward the chamber 16 or 16*a*.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that to others can, be applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art.

I claim:

1. A centrifuge, particularly for separation of solid and liquid fractions of suspensions, comprising rotary carrier means; a primary separating unit including a perforated bowl having an open top and being removably supported by and rotatable with said carrier means; means for feeding incoming material into said bowl whereby some of the liquid fraction passes through and the remainder of such material travels toward and beyond the open top of said bowl; and a secondary separating unit including at least one annular member supported by and rotatable with said carrier means, said annular member having an upwardly diverging first annular surface arranged to intercept said remainder of the material, a second annular surface located downstream of and diverging in a direction away from said first surface, and a convex annular intermediate surface disposed between said first and second surfaces, the solid fraction of said remainder being arranged to travel upwardly along and beyond said first surface and the liquid fraction of said remainder being arranged to adhere to and to travel along and beyond said first, intermediate and second surfaces.

2. A centrifuge as defined in claim 1, wherein said carrier means is arranged to rotate about a substantially vertical axis and wherein the cross-sectional area of said bowl increases toward said open top thereof.

3. A centrifuge as defined in claim 1, wherein said carrier means is hollow and wherein at least the major part of said bowl is accommodated in said carrier means.

4. A centrifuge as defined in claim 1, wherein said carrier means is provided with at least one aperture for escape of liquid fraction which enters said carrier means through said bowl.

5. A centrifuge as defined in claim 1, wherein said bowl is of conical shape and diverges upwardly toward said open top as such an angle that the solid fraction can readily slide therealong in response to rotation of the bowl.

6. A centrifuge as defined in claim 1, wherein said bowl is of substantially semispherical shape.

7. A centrifuge as defined in claim 1, wherein said bowl is rotatable about a substantially vertical axis and said primary separating unit further comprises stiffening means for said bowl.

8. A centrifuge as defined in claim 7, wherein said stiffening means comprises rings located in planes making right angles with said axis.

9. A centrifuge as defined in claim 1, wherein a portion of said bowl in the proximity of said open top is a cylinder which is coaxial with said carrier means.

10. A centrifuge as defined in claim 1, further comprising annular baffle means defining with said open top an annular clearance for the remainder of said material.

11. A centrifuge as defined in claim 10, further comprising fastener means securing said baffle means to said bowl.

12. A centrifuge as defined in claim 10, wherein said baffle means has an upwardly and outwardly diverging outer side.

13. A centrifuge as defined in claim 1, wherein said secondary unit comprises a plurality of annular members located one above the other and annular ramps having upwardly and outwardly diverging guide surfaces each arranged to direct the solid fraction from the first surface of a lower annular member against the first surface of the adjoining upper annular member.

14. A centrifuge as defined in claim 13, wherein each of said ramps has a lower edge defining with the intermediate surface of the adjoining lower annular member an annular gap for the liquid fraction.