May 20, 1969 F. J. LODDENKEMPER ET AL 3,445,062

CENTRIFUGAL SEPARATOR APPARATUS

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FIG. 1.

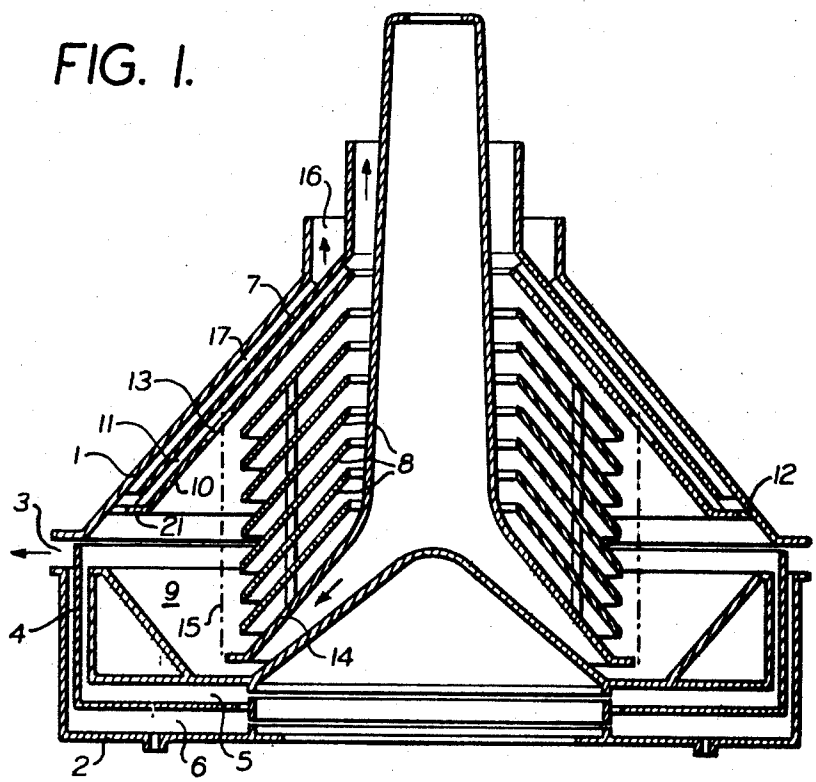
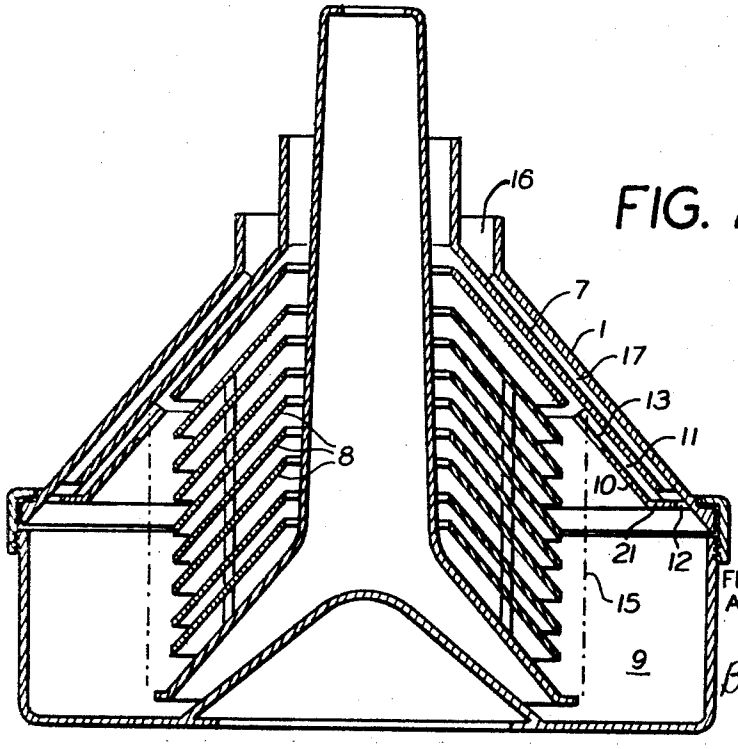


FIG. 2.



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CENTRIFUGAL SEPARATOR APPARATUS

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U.S. Cl. 233—29 10 Claims

ABSTRACT OF THE DISCLOSURE

A centrifugal separator having a centrifuge drum provided with internal barrier means defining a first annular passage extending outward from an inlet located beyond a separating zone to the drum wall, and a second annular passage communicating with the first and extending to a discharge outlet at the upper end of the drum, and an additional outlet located near the drum wall through which outlet part of the fluid flow through the first passage is diverted to discharge into the drum solids entrained in such flow before entering the second passage, and also to prevent entry into the second passage of solids accumulated in the drum.

The present invention relates to a centrifugal separator apparatus featuring a centrifuge drum arranged for rotation about a central axis to separate a liquid mixture received within the drum into a plurality of component liquid phases arranged radially within the drum according to their specific gravities. To assure the separation of a selected component having a high degree of purity and substantially free from any solids as may be present within the liquid mixture, the invention provides a barrier means disposed within the drum to defer in a first annular passage extending from an inlet located a predetermined radial distance from the rotation axis to the peripheral wall of the drum, and a second annular passage communicating with the first and extending along the drum wall to a discharge outlet at the upper end of the drum. The same barrier means provides an additional outlet which is located adjacent to the drum wall through which a portion of the flow through the first passage is diverted prior to entering the second passage so as to discharge into the drum such solids as may be entrained in the component flow through the first passage and to prevent entry into the second passage of any solids collected within the drum.

According to a preferred embodiment of the invention, the barrier means includes two plate shell members disposed within the upper portion of the drum and each having a frusto-conical portion. The frusto-conical portion of the first shell member is disposed in radially spaced-apart relation to the drum wall, and the frusto-conical portion of the second shell member is disposed in radially spaced-apart relation to both the drum wall and the first shell member intermediate between the two, so that the first annular passage is defined by the second shell member-to-first shell member spacing, and the second annular passage is defined by the second shell member-to-drum wall spacing.

In the separation of two-phase liquid mixtures by means of a centrifuge, a zone of separation always develops in the drum between the two liquid phases. The distance between the zone of separation and the axis of rotation depends both on the specific gravities of the components and on the distances between their discharges and the drum axis. The two liquid columns which extend from the zone of separation to their discharge, which

is further inward, maintain an equilibrium under the action of the centrifugal force. In practice, however, one always starts out from the desired situation of the zone of separation and, on the basis of the specific weights of the two liquid components, computes the radial distances between their discharges and the axis of rotation and adjusts them accordingly.

In the case of centrifugal separators having a plate insert, the liquid being separated is generally fed through uptakes into the spaces between the plates. The distance at which the two discharges are located from the axis of rotation is then selected so that the zone of separation is located in these uptakes. The liquid rising into the plate stack is thus subjected then and there to a rough division into a higher specific gravity component filling the outer part of the drum and a lighter specific gravity component filling the inner part of the drum. In passing through the interstices between the plates, both phases yield more or less completely the portions of the other component that they have entrained.

A basic point in the selection of the position of the zone of separation is that the greater portion of the plate area must be available to the component which has to meet the higher requirements as regards purity. If, for example, in the separation of a mixture of oil and water, the oil is to emerge as free of water as possible, the uptakes and hence the zone of separation must be located in the outer portion of the plate stack. However, in the case of the separation of whole milk, if the residual fat content of the skim milk is to be low, a plate stack having internally placed uptakes is used.

If particularly high purity requirements must be met by the lighter component, the zone of separation may even be placed outside of the plate stack. The entire plate area is then available to the lighter liquid for the separation of heavier components.

In the case of certain prior art separators, in order to prevent the specifically lighter liquid from getting through to the discharge for the specifically heavier liquid, the dividing plate must be immersed sufficiently deeply into the ring of heavier liquid. The further outward the zone of separation is shifted, the more the dividing plate must be extended outward.

This is very disadvantageous in the case of liquid mixtures containing solids. The ring of solids forming in the sludge chamber of the drum cannot be permitted to grow inward to such an extent as to obstruct the discharge passage for the heavier liquid. So the further the dividing plate extends outward, the smaller the usable space in the sludge chamber becomes. Drums that have to be cleaned by hand must then be shut down at relatively short time intervals, whereas in the case of self-cleaning drums the solids that are discharged are not sufficiently free of liquid.

The invention is directed to the problem of designing separator drums having a plate stack so that the drum sludge chamber can be utilized all the way to the zone of separation located outside of the plate stack for the deposition of solids, while avoiding the danger of clogging the discharging passages carrying the heavier liquid.

The separator apparatus according to the invention is characterized by a dividing plate which is actually a frusto-conical shell, disposed at a distance from the upper portion of the drum wall or drum cover and extending into the sludge chamber, the portion of which extending beyond the outer margin of the plate stack is screened off from the sludge chamber by another frusto-conical shell insert which is provided on its upper side with accelerating vanes and with one or more orifices on its radially external end, in the vicinity of the outer margin of the plate stack.

Whereas the contents of the sludge chamber generally have a certain amount of slip in relation to the speed of the

drum, the heavier fluid entering between the plate stack and the dividing plate is brought up to the peripheral speed of the drum by the accelerating vanes. In this manner, a higher pressure develops in this passage and hence a pressure gradient towards the sludge chamber. This pressure gradient causes the flow in the orifices on the radially external end of the conical insert to be directed toward the sludge chamber. The heavier liquid can therefore enter into its outlet passage only in the vicinity of the zone of separation, so that the sludge chamber can be utilized all the way to these inlet orifices. Since a portion of this liquid passes back into the sludge chamber at the outer end of the insert, a constant circulation takes place which keeps these orifices free and brings back into the sludge chamber any solids which get into the outlet passage with the liquid. Clogging of the outlet passage is thus made impossible.

It is desirable for the conical insert to be affixed to the uppermost plate of the plate stack or to form a one-piece unit therewith.

Dutch Patent 75,976 discloses a centrifugal separating drum in which the dividing plate, which extends outwardly beyond the outer margin of the plates, is likewise screened off by a conical insert. The purpose of this insert, however, is to keep the situation of the zone of separation constant in the drum. For this purpose it has to be sealed at the radially external end by means of a special gasket, because otherwise no zone of separation can form in the passage between the insert and the dividing plate. Neither is it provided on its upper side with accelerating vanes, which might have the purpose of creating certain pressure ratios. The problem at which this invention is aimed cannot be solved by this prior art design, whereas on the other hand, with the design according to the invention, the situation of the zone of separation cannot be kept constant.

It is therefore, an object of the invention to provide a centrifugal separator apparatus whereby a selected specific gravity component separated from a liquid mixture can be delivered from a centrifuge drum with a high degree of purity and relatively free from solids.

Another object of the invention is to provide a centrifugal separator apparatus as aforesaid wherein solids can be removed from the selected component at a point along its flow path before discharge from the drum.

A further object of the invention is to provide a centrifugal separator apparatus as aforesaid having means to prevent solids collected in the sludge chamber of the drum from entering into the outflowing separated component.

Still another and further object of the invention is to provide a centrifugal separator apparatus as aforesaid in which the separated component to be delivered from the drum can be taken from a location within its separation zone relatively close to the drum rotation axis so as to allow a greater volume within the drum for collection of solids without interference with the outflow of the separated component.

Other and further objects and advantages of the invention will become apparent from the following detail description and accompanying drawing in which:

FIG. 1 is a schematic elevation view, partly in section, of a centrifugal separator apparatus according to a preferred embodiment of the invention.

FIG. 2 is a schematic elevation view, partly in section, of a centrifugal separator apparatus according to another embodiment of the invention.

In FIGS. 1 and 2, the cover or upper portion of a centrifuge drum is designated by **1**, and the lower portion of the drum by **2**. The FIG. 1 embodiment of the invention is exemplified in conjunction with a self-cleaning type drum having its cover **1** end lower portion **2** held together in a conventional manner by means of an assembly ring (not shown), and provided with one or more orifices **3** for the ejection of solids collected within the sludge chamber **9** of the drum. These orifices **3** can be opened and closed as desired during the rotation of the drum about its central axis X by means of an axially displaceable piston slide valve **4** which is shifted by admitting pressurized hydraulic fluid into one of the chambers **5** and **6** and releasing hydraulic fluid from the other, as the case may be.

Spaced radially inward from the frusto-conical drum cover **1** there is disposed a dividing plate **7**, which is actually a frusto-conical shell of revolution having a lower edge that extends radially beyond the outer margin of the plate stack **8** into the sludge chamber **9**. The portion of the dividing plate **7** that projects beyond the plate stack **8** is shielded from the sludge chamber **9** by a frusto-conical insert shell **10**, which in the FIG. 1 embodiment can be considered as being united with the top plate in stack **8**.

On the upper side of the insert shell **10**, ribs or vanes **11** are provided, and orifices **12** are provided on the radial flange **21** extending from the lower end of the frusto-conical portion of shell **10** to the drum cover **1** wall surface. One or more orifices **13** are provided on the frusto-conical portion of shell **10** at radial locations in the vicinity of the outer margin of the plate stack **8**.

In the typical operation of the centrifugal separator apparatus of the invention, a solid-containing liquid mixture is fed into the centrifuge drum through a distributor foot **14**. The zone of separation between the two liquid phase components is located outside of the plate stack **8** at **15**. The heavier liquid phase separated from the mixture enters through the orifices **13** into the annular passage between the insert shell **10** and the dividing plate **7**, and is brought by vanes **11** up to the peripheral speed of the drum. This produces a pressure gradient toward the sludge chamber **9**, so that a portion of the liquid passes back through orifices **12** into the sludge chamber **9**, while the remainder of the liquid flows through the annular passage defined by the dividing plate **7**-to-drum wall spacing and is discharged at the upper end of the drum through an annular outlet **16**. Because liquid is constantly flowing through orifices **12** into the sludge chamber **9**, these orifices **12** are kept free, and the solids deposited in the sludge chamber **9** cannot clog the discharge flow passage between dividing plate **7** and drum cover **1**.

In the two communicating annular passages formed by the insert shell **10**, dividing plate **7** and drum cover **1**, solids entrained in the liquid extracted through orifices **13** are returned to the sludge chamber **9** through the orifices **12**.

As can be appreciated by the artisan from the foregoing, the dividing plate **7** and insert shell **10** can be considered as a barrier means disposed within the drum to define a first annular passage, i.e. the insert shell **10**-to-dividing plate **7** spacing, extending from an inlet orifice **13** to the peripheral wall of the drum, and a second annular passage, i.e. the dividing plate **7**-to-drum cover **1** spacing, communicating with the first passage and extending along the drum wall to the outlet **16** at the upper end of the drum. This barrier means also provides a second outlet in the form of one or more orifices **12** located adjacent to the drum wall for the purpose of discharging into the drum solids entrained in the liquid flowing through the first passage, and to prevent entry into the second passage of solids collected within the drum.

The inlet orifices **13** are positioned at a radial distance beyond the separation zone **15** to receive the heavier liquid phase separated from the mixture, which heavier liquid flows radially outward through the first annular passage to and through the second annular passage, with part of the flow being diverted through the outlet orifices **12** prior to entering the second passage so that any solids entrained in the heavier liquid extracted from the drum will be discharged into the sludge chamber **9** and will not appear in the flow discharged at outlet **16**.

It should be noted that the upper portion of the drum is expediently frusto-conical and geometrically similar to the frusto-conical portions of dividing plate **7** and insert shell **10**, the drum wall, dividing plate **7** and insert shell **10** being coaxially disposed about the drum rotation axis X

and decreasing in radial dimensions toward their respective upper ends.

The plate stack 8 is expediently constructed of a plurality of frusto-conical plate members stacked in axially spaced-apart relation to one another and arranged coaxial with the drum axis X, these individual plates of the stack 8 serving to aid in the separation of the liquid mixture.

The inlet 13, can be defined by at least one, and preferably by a plurality of circumferentially spaced apertures in the insert shell 10, as in the case of FIG. 1, or said inlet 13 can be a circumferentially continuous annular inlet 13 defined by the spacing between the lower edge of the uppermost stack plate member and the upper edge of the frusto-conical portion of the shell 10.

An additional set of radially extending vane members 17 can be provided within the second annular passage just as in the case of the radially extending vanes 11 provided within the first annular passage. The vane 17 are expediently connected to the drum wall for support thereby and to the upper side of dividing plate 7 to support same in a radially spaced-apart relation to the wall, and the vane members 11 are likewise connected to the underside of dividing plate 7 for support thereby and connected to the upper side of insert shell 10 to support same in radially spaced-apart relation to dividing plate 7.

From the foregoing description of the invention, it will become apparent to the artisan that the centrifugal separator apparatus according to the invention is susceptible of numerous obvious modifications and variations. However, the invention is intended to be limited only by the following claims in which we have endeavored to claim all inherent novelty.

What is claimed is:

1. A centrifugal separator apparatus which comprises a centrifuge means including a drum disposed for rotation about its central axis to separate a liquid mixture received within the drum into a plurality of component phases arranged radially within the drum according to their specific gravities, a barrier means disposed within said drum to define a first annular passage extending from an inlet located at a predetermined radial distance from said rotation axis to the peripheral wall of the drum and a second annular passage communicating with said first passage and extending along said wall to a first outlet at the upper end of said drum, and accelerating vanes disposed on said barrier means extending radially in the plane of the central axis of rotation for rotation about their central axis to accelerate the heavier fluid entering the first annular passage, said barrier means having a second outlet located adjacent to said drum wall, said inlet being positioned at the locus of the separating zone to receive the heavier phase separated from said liquid mixture for accelerated outward radial flow through said first annular passage wherein a pressure radiant towards the peripheral orifice of said first annular passage develops to and through said second annular passage, with part of said flow being diverted through said second outlet prior to entering said second annular passage to discharge into the drum solids entrained in said heavier phase and to prevent entry of solids collected within the drum into said second annular passage and purifying said heavier phase flowing through said second passage and discharged therefrom at said first outlet.

2. The centrifugal separator apparatus according to claim 1 wherein said barrier means includes a first shell member disposed within the upper portion of said drum and having a frusto-conical portion disposed in radially spaced-apart relation to said drum wall, and a second shell member, also disposed within the upper portion of the drum and having a frusto-conical portion disposed in radially spaced-apart relation to both said drum wall and said first shell member, said second shell member-to-first shell member spacing defining said first annular passage, and said second shell member-to-drum wall spacing defining said second annular passage.

3. The centrifugal separator apparatus according to claim 2 wherein said frusto-conical portion of said first shell member extends below the lower end of the frusto-conical portion of said second shell member, and said first shell member has a flange portion radially extending from the lower end of its frusto-conical portion toward the drum wall to communicate said first and second annular passages.

4. The centrifugal separator apparatus according to claim 3 including a plurality of radially extending vane members disposed within said first annular passage to accelerate fluid flow therethrough and thereby establish a fluid pressure gradient from said inlet to said second outlet.

5. The centrifugal separator apparatus according to claim 4 wherein said frusto-conical portions of said first and second shell members are geometrically similar, and the upper portion of said drum has a frusto-conical wall also geometrically similar to the frusto-conical portions of said first and second shell members, with said frusto-conical wall and shell member portions being coaxially disposed about the drum rotation axis and decreasing in radial dimensions toward their respective upper ends.

6. The centrifugal separator apparatus according to claim 5 wherein said second outlet is defined by at least one aperture to said flange portion of the first shell member.

7. The centrifugal separator apparatus according to claim 5 including a plurality of frusto-conical plate members stacked in axially spaced-apart relation to one another and coaxial with the drum rotation axis to aid in the separation of said liquid mixture.

8. The centrifugal separator apparatus according to claim 7 wherein said inlet to said first annular passage is defined by at least one aperture in said first shell member located at a radial distance from the drum rotation axis greater than the radial dimensions of said plate members.

9. The centrifugal separator apparatus according to claim 7 wherein the uppermost of said frusto-conical plate members has a lower edge disposed in spaced-apart relation to the upper edge of the frusto-conical portion of said first shell member to define an annular inlet to said first annular passage.

10. The centrifugal separator apparatus according to claim 7, wherein radially extending vane members within said second annular passage are connected to the drum wall for support thereby and to said second shell member to support same in a radially spaced-apart relation to said wall, and said radially extending accelerating vane members within said first annular passage support thereby are connected to said first shell member to support same in radially spaced-apart relation to said second shell member.

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U.S. Cl. X.R.

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