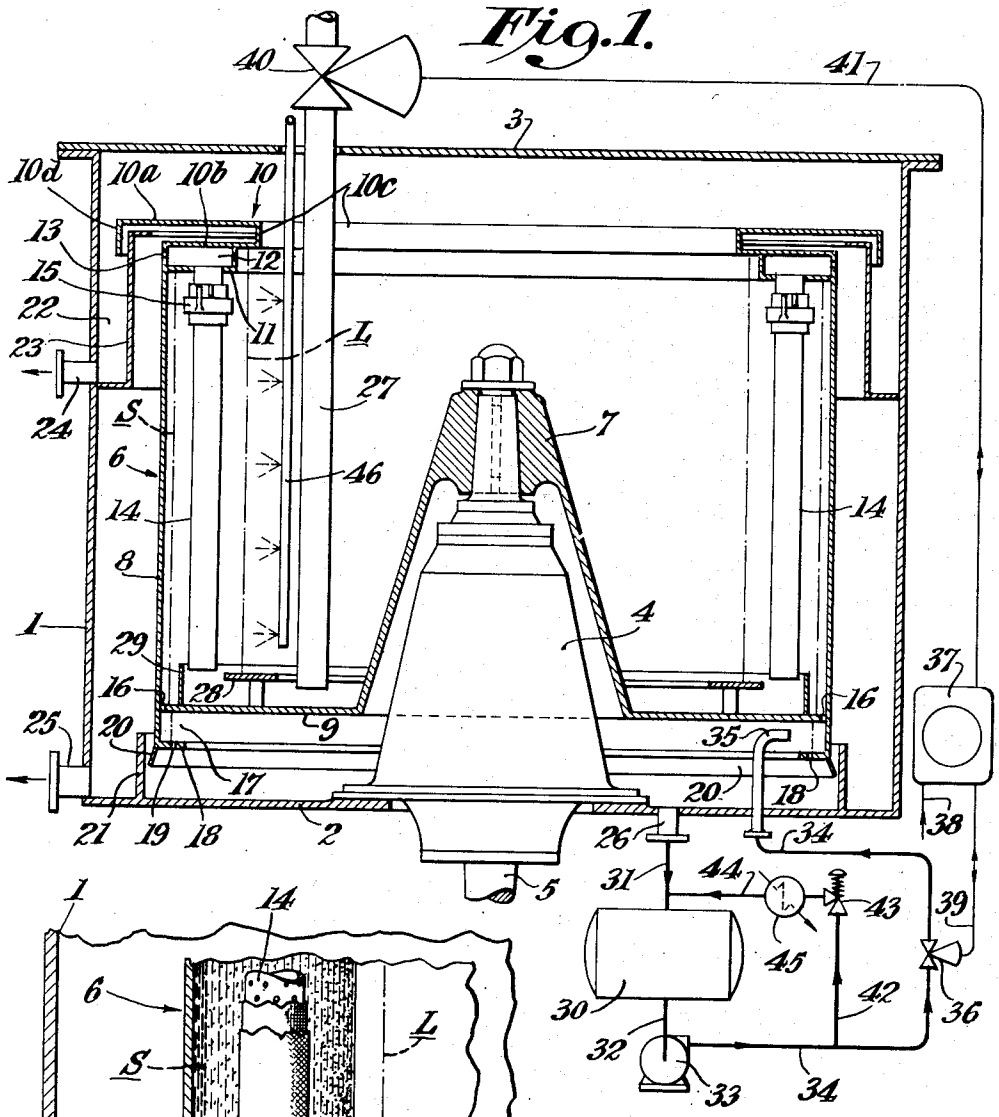
Nov. 3, 1953 A. H. SCHUTTE 2,657,803

CENTRIFUGAL FILTRATION

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Fig. 1.



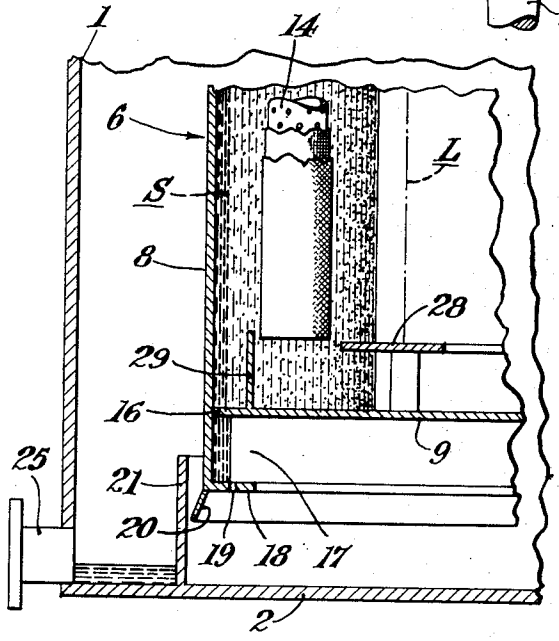


Fig. 2.

INVENTOR.
August Henry Schutte
BY
Nathaniel Ely
ATTORNEY

Nov. 3, 1953 A. H. SCHUTTE 2,657,803

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Fig. 3.

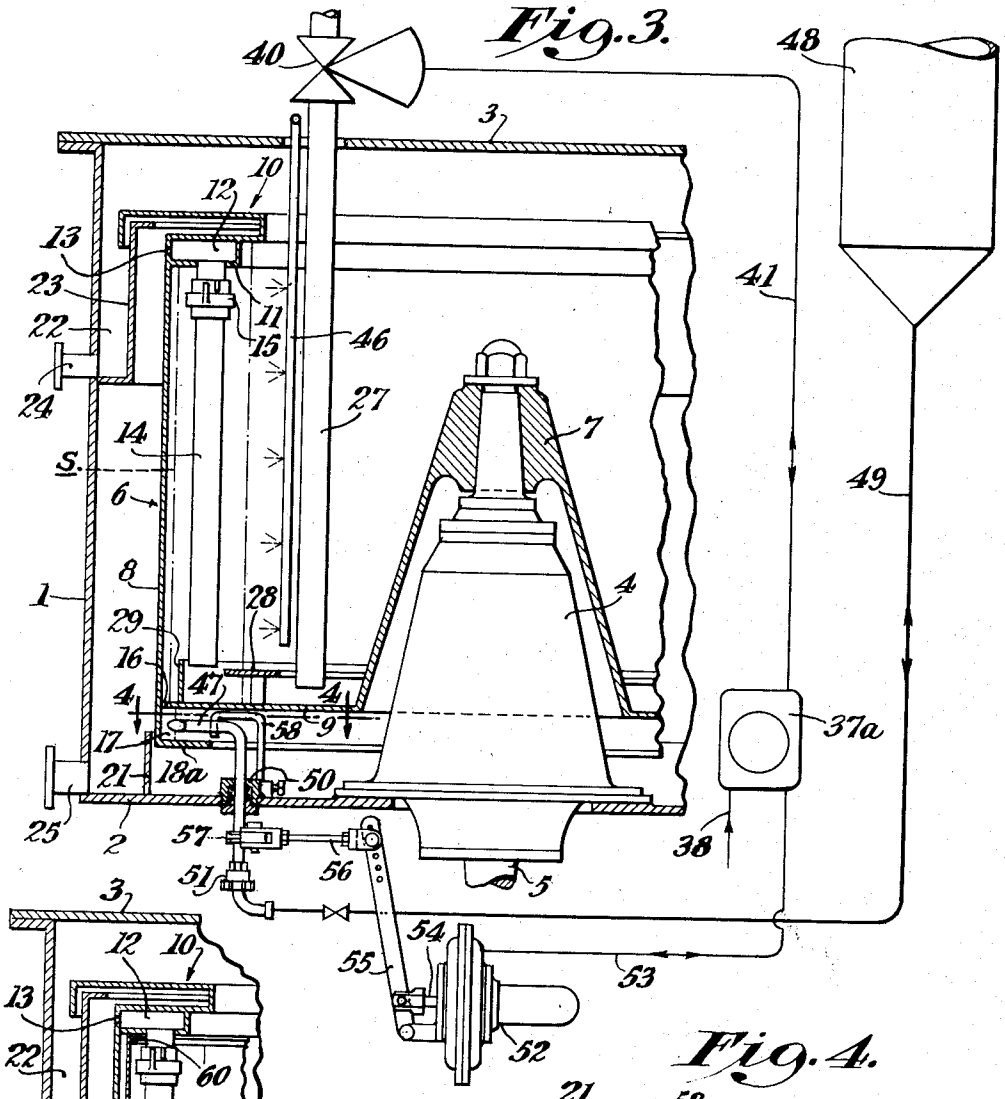


Fig. 4.

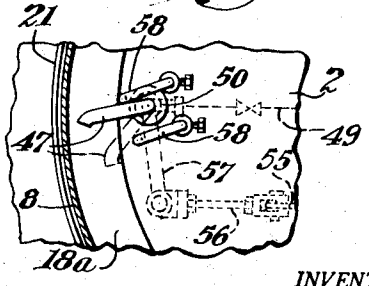
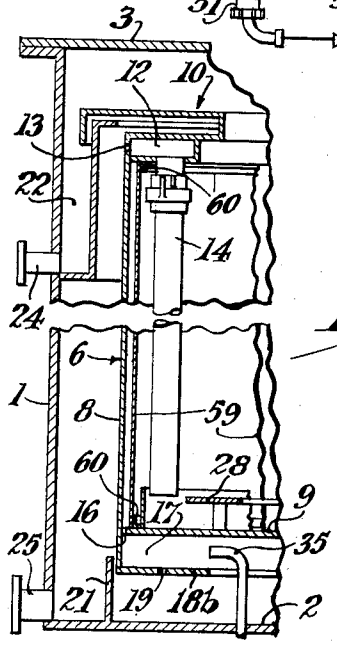


Fig. 5.



INVENTOR.
August Henry Schutte
BY Nathaniel Ely
ATTORNEY

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2,657,803

UNITED STATES PATENT OFFICE

2,657,803

CENTRIFUGAL FILTRATION

August H. Schutte, Hastings on Hudson, N. Y., assignor to The Lummus Company, New York, N. Y., a corporation of Delaware

Application September 1, 1949, Serial No. 113,605

15 Claims. (Cl. 210—67)

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This invention relates to improvements in centrifugal filtration of liquid-solid mixtures and particularly in the filtration of charge slurry which is lighter than the solid particles of the charge. An example of such a charge is a chilled dewaxing mixture containing a solvent such as methyl ethyl ketone-benzol. Heretofore, in the centrifugal filtration of such a charge, serious difficulties have been encountered. A major difficulty has been that upon continuous feeding of the charge to the centrifuge the heavy solid component would build up at a repose angle which permitted the charge slurry to discharge in a thin film and at high velocity through the solids outlet of the centrifuge, with quite insufficient filtration time. Difficulties were also encountered in the removal of the accumulated solids from the centrifuge. Centrifugal separators have been employed which operate on a cyclic basis and remove the accumulated solids by mechanically actuated knives or plows. However, many materials become agglomerated or glazed over by the action of the knives or plows and become impervious to further liquid flow. Wax cake is one of such materials.

Important objects of the present invention are to eliminate the said difficulties; to provide for such elimination in a simple and satisfactory manner; to provide for satisfactory removal of the accumulated solids by hydrostatic means with consequent improvement of filter performance; to provide, in such removal, for the employment of a liquid independent of the charge and for the exclusion of such liquid from the filtration region of the centrifuge; and to provide satisfactory apparatus of simple construction for attaining the desired advantages.

Other objects and advantages of the invention will appear from the following description taken in connection with the accompanying drawings.

In the drawings:

Fig. 1 is a view, partly in section and partly in elevation, showing one form of the improved centrifugal filter apparatus;

Fig. 2 is an enlarged sectional view of a lower portion of the centrifuge;

Fig. 3 is a view similar to Fig. 1, showing a modified form of the apparatus;

Fig. 4 is a detail section on the line 4—4 of Fig. 3; and

Fig. 5 is a sectional view of a side portion of the centrifuge rotor, showing another modification.

The apparatus, in the form shown in Fig. 1, includes a drum-like housing having a circumferential side wall 1, a bottom wall 2 and a removable top closure 3. A bearing 4 for a drive shaft 5 is mounted centrally upon the bottom wall of the housing, and the centrifuge rotor 6 is secured, through a hub portion 7 thereof, to the drive shaft.

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As shown, the rotor 6 has a cylindrical imperforate circumferential side wall 8 and a bottom wall 9 bearing the hub 7. The side wall 8 bears at its upper end an annular lip 10 which extends inwardly toward the axis of the rotor and is of uniform radial width. In the present instance, said lip is formed of spaced upper and lower sheet-like portions 10a and 10b respectively, and a connecting portion 10c which forms the inner edge of the lip. The upper portion 10a extends radially outward beyond the side wall 8 and has a downturned annular flange 10d spaced inwardly from the housing wall 1. Beneath the lip portion 10b an annular member 11 secured thereto forms, with said lip portion and the side wall 8 of the rotor, an annular filtrate outlet channel 12. A circular series of ports 13 in the rotor wall 8 afford outlet for the filtrate. Filter pipes 14, in a circular series around the axis of the rotor, depend from the member 11. In the drawing the pipes in the back are omitted to simplify the illustration. Each pipe is detachably connected to the member 11, as at 15, and is perforated along its length and around its circumference. The pipe is covered with woven wire cloth which is overlaid with a suitable filter medium such as cloth, filter duck, or the like. At their upper end the pipes open into the filtrate channel 12 and they are closed at their lower end and spaced above the bottom wall. The pipes are arranged on close circumferential spacing and at a sufficient distance from the solid wall 8 of the rotor to permit accumulation of heavy scale or dirt without plugging the filter cloth.

The bottom wall 9 of the rotor has a circular series of holes 16 close to the wall 8 of the rotor and, beneath said wall there is an annular channel 17 formed by the wall 9, a portion of the side wall 8 which extends below the wall 9 and an inwardly extending annular flange 18. Said flange has a circular series of bleed holes 19 at a radial distance from the rotor axis intermediate the radial distance of the holes 16 and the radial distance of the inner edge of the flange 18. A narrow flared skirt flange 20 extends from the lower end of the rotor wall 8 and has its lower end adjacent a low annular wall 21 extending upwardly from the bottom wall 2 of the housing. An annular channel 22 for receiving solid

material discharged from the rotor surrounds the upper portion of the rotor. This channel is defined by the side wall 1 of the housing together with an annular member 23 having an outwardly extending lower portion secured to said wall and an inwardly extending upper portion located inwardly of the outer depending flange 10d of the rotor lip 10. The housing wall 1 has a nozzle 24 for draining the channel 22, and also a nozzle 25 for draining the bottom space within the housing, between the wall 1 and the upstanding wall 21. A nozzle 26 is borne by the bottom of the housing for draining the bottom space surrounded by the wall 21.

A charge delivery pipe 27 extends downwardly through the open end of the rotor to a point near the bottom 9 thereof. The charge delivered to the bottom is constrained to flow outwardly therealong by a flat annular baffle 28 borne by the bottom 9 at a level slightly above the lower end of the pipe 27. An upstanding annular baffle 29 is also borne by the bottom of the rotor. This baffle is located directly outside of the filter tubes 14 and extends above the lower end of the tubes. It serves to receive against it the charge passed beneath the baffle 28, and deflect the charge upwardly.

At a lower level than the bottom 2 of the housing there is a reservoir or surge tank 30 for a liquid independent of the charge to be separated and heavier than any component of the charge. A pipe line 31 leads from the bottom drain nozzle 26 of the housing to the upper portion of the tank 30. A pipe line 32 connects the bottom of the tank with the inlet of a pump 33 and, from the pump outlet, a pipe line 34 leads upwardly to the space surrounded by the annular channel 17 at the bottom of the rotor. At the upper end thereof, the line 34 has a discharge end 35 outside of the channel 17 and directed into the open side of the channel to discharge into the channel a jet of the liquid. The pipe line 34 has a valve 36 which may, as indicated, be of an air-operated type. A timer device 37 controls the operation of said valve. Air is admitted to the timer at 38 and is admitted by the timer to the valve through a line 39. The timer may be of a standard type suitable to admit the air to the valve for opening same at suitable intervals. The charge delivery pipe 27 also has an air-operated valve 40 under control of the timer. The timer is adapted to admit air through a line 41 to effect closure of the valve 40 when the valve 36 is opened.

Provision is made for recirculation and cooling of the independent liquid when the separating operation is refrigerated. A pipe line 42 leads from the line 34 at a point between the pump 33 and the valve 36. Through a valve 43, the line 42 is connected to a pipe line 44 leading to the drain line 31. A cooler or refrigerating device 45 is connected into the line 44. Valve 43 is loaded to open under a predetermined pressure in the line 42 when the valve 36 is closed.

A delivery pipe 46 for wash liquid extends into the rotor through the open end of the latter. This pipe extends throughout most of the depth of the rotor and has a series of discharge ports directed outwardly to discharge jets of wash liquid against the separated solids within the rotor.

The apparatus just described is operated as follows: It will be assumed, for example, that the charge to be separated is a chilled dewaxing mixture of wax, oil and a solvent lighter than wax, such as methyl ethyl ketone-benzol. With the valve 36 of the independent liquid line 34 closed, the rotor is operated with a stratum S of the independent heavy liquid at the wall 8 of the rotor. A minimum radial depth of this stratum is maintained owing to the radial location of the bleed holes 19 of the channel so that the stratum is substantially spaced outwardly from the filter tubes 14. Said minimum depth is sufficient to enable the liquid of the stratum to seal the holes 16. The charge delivered through the pipe 27 passes beneath the baffle 28 to the baffle 29 and is directed upwardly thereby along the filter tubes. The liquid component of the charge passed through the filter medium of the tubes flows into the channel 12 at the upper end of the tubes and is discharged through the ports 13. The discharged filtrate is collected within the bottom space of the housing, between the wall 1 and the wall 21 and is discharged through the nozzle 25.

Separated solid material of the charge accumulates and gradually builds up from the stratum S to an inner level indicated by line L in Fig. 1 and forms a cake. During the filtration cycle the cake is washed by liquid discharged from the pipe 46. Before the separated solid reaches the inner edge of lip 10 the filtration cycle is concluded by operation of the timer 37 to close the valve 40 and open the valve 36 and permit delivery of the heavy independent liquid through the line 34 to the channel 17 at the bottom of the rotor. The rate of such delivery exceeds the discharge capacity of the bleed holes 19 of the channel so that the heavy liquid flows through the holes 16 into the rotor and augments the stratum of heavy liquid to increase the radial depth thereof to a substantial extent but insufficient to bring the stratum into contact with the filter medium. Thereby, escape of heavy liquid through the filter pipes is prevented. The increase in the radial depth of the stratum is limited by the radial position of the inner edge of the flange 18. Any additional liquid delivered to the channel after said edge has been reached is discharged past the edge and collected, along with the liquid discharged through the bleed holes 19, within the bottom space of the housing, surrounded by the wall 21. Thence, the liquid drains through the nozzle 26 and the line 31 to the tank 30.

Increase in the radial depth of the stratum of heavy liquid within the rotor, in the manner just described, causes displacement of the separated solid radially inward and advances the relatively dry cake thereof past the inner edge of the lip 10 at the top of the rotor. The inner portion of the cake is then discharged past the lip and radially outward to the wall 1 of the housing along which it falls into the collecting channel 22 from which it is withdrawn through the nozzle 24. After a time sufficient for discharge of an adequately drained portion of the cake, the timer 37 operates to close the valve 36 and stop delivery of the heavy liquid through the line 34. Bleeding of the liquid through the holes 19 of the channel 17 then reduces the radial depth of the stratum of heavy liquid within the rotor to the minimum depth determined by the radial position of the bleed holes. Reduction of the depth of the stratum permits recession of the charge within the rotor radially outward to a position spaced from the inner edge of the lip. The timer also causes opening of the valve 40

and resumption of charge delivery through pipe 27, and the filtration cycle is repeated.

Fig. 3 shows an apparatus similar to the one shown in Figs. 1 and 2 except for modification of the mechanism for increasing and decreasing the radial depth of the stratum of heavy liquid within the rotor. In this modification the bleed holes are omitted from the flange, here designated 18*a*, at the bottom of the rotor and the minimum depth of the liquid within the channel 17 is determined by adjustment of a tubular scoop 47 through which the liquid is both delivered to and withdrawn from the channel.

For supplying the heavy liquid there is a tank 48 substantially elevated above the level of the channel 17. A pipe line 49 leads from said tank to the scoop 47. The scoop has a vertical portion with a swivel mounting 50 on the bottom wall 2 of the housing and a swivel connection 51 with the pipe line 49. For turning the scoop on its axis there is a reciprocating fluid motor 52 or other suitable device controlled by a timer 37*a*. The motor may, as indicated, be operated by air delivered, as at 38, to the timer and, under control of the timer, delivered by a pipe line 53 to the motor. A plunger 54 of the motor is operatively connected to the scoop 47 through a lever 55 which is operatively connected by a link 56 to a crank arm 57 fixed to the vertical portion of the scoop. As shown, the timer is also operatively connected to the charge delivery valve 40 through the air pipe line 41, as in the form of the apparatus previously described.

In the operation of the apparatus shown in Fig. 3 the scoop 47 is adjusted radially depthwise of the channel 17 to a position for maintaining within the channel the depth of liquid required to determine the minimum radial depth of the stratum of heavy liquid within the rotor. Contact of the rapidly rotating body of liquid in the channel with the scoop then obstructs flow of liquid from the scoop into the channel. The filtration cycle will be concluded by operation of the timer 37*a* to effect, through the motor 52, withdrawal of the scoop from the channel. Then, the liquid will flow through the line 49 and be discharged by the scoop into the channel to increase the radial depth of the stratum S within the rotor to a level short of the filter pipes 14, for effecting discharge of the solid material, as previously described herein. The extent of said withdrawal of the scoop determines the increase in depth of the stratum through control of the depth of the liquid within the channel 17. This depth, as determined by the withdrawn position of the scoop, is less than the total depth of the channel so that before the liquid reaches the inner edge of the flange 18*a* contact of the rapidly rotating body of liquid within the channel with the scoop again obstructs further delivery of liquid from the tank 48.

At the conclusion of a suitable period for discharge of the solid material, the timer 37*a* operates to cause movement of the scoop 47 deeper into the channel 17 to the first-mentioned position. As the scoop is so moved, the liquid within the channel and the liquid flowing into the channel from the stratum S is forced by its rapid rotation, through the scoop and the pipe 49 back to the tank 48 against the resistance of the head afforded by the elevated position of the tank. Thereby, the depth of the stratum S is reduced to the desired minimum. Adjustable stops 58 are provided to limit the movement of the scoop in both directions and determine accurately the

required maximum and minimum levels of the liquid. As in the form of the invention first described, the timer controls the charge valve 40 to discontinue delivery of the charge to the rotor during increase of the stratum S for discharge of the solid material and to cause resumption of delivery when the depth of the stratum is reduced.

In the modification shown in Fig. 5, provision is made for segregation of the independent liquid from the charge within the rotor. For that purpose, the rotor is provided with a cylindrical membrane 59 of material impermeable to said liquid and to the charge. The membrane is located radially outside of the filter tubes and its upper and lower edges are secured by annular clips 60, in sealed connection to the member 11 at the under side of the lip 10 and to the bottom 9 of the rotor, respectively. The material of the membrane is flexible. It may also be stretchable and resilient, or else the membrane may be sufficiently slack, to permit displacement of the body thereof radially inward as the stratum of independent liquid outside of the membrane is increased. As shown, the membrane is located inwardly of the holes 16 through which the channel 17 communicates with the space between the rotor wall 8 and the membrane. The membrane may be made of sheet rubber, neoprene, kolutol or impregnated fabric, for examples.

By provision of the membrane greater choice of independent liquids is afforded and the necessity for exact determination of the liquid levels within the rotor is avoided. In the forms of the invention shown in Figs. 1 and 3 it is necessary to employ an independent liquid heavier than any component of the charge. For example, in wax-oil separation with a solvent such as methyl-ethyl ketone-benzol, water or brine may be employed as the independent liquid. In the form of apparatus shown in Fig. 5 a liquid either heavier or lighter than the charge components may be employed and the necessity for maintaining the liquid at a level clear of the filter tubes is avoided since the membrane will exclude the independent liquid from the filter tubes even if the depth of the liquid within the rotor should exceed the radial depth of the space between the wall 8 and the filter tubes. For the purpose of employing a lighter liquid the flange forming the under side of the channel and here designated 18*b* may, as shown, be of substantially increased radial width. That enables the building up of a sufficient radial head of a lighter liquid within the channel for a required increase of the radial depth of the liquid around the outer side of the membrane to effect cake discharge. The membrane is under balanced pressure at all times and is not subjected to erosion so that it should remain serviceable for a long time.

The modification shown in Fig. 5 may be employed in either the apparatus shown in Fig. 1 or that shown in Fig. 3.

In all forms of the apparatus the tank for the independent liquid and the timer may serve for control of a battery of separators.

The apparatus is particularly suited for large scale performance employing, for example, a rotor 84 inches in diameter and 60 inches in depth and wherein the tubes 14 afford approximately 200 sq. ft. of filter surface, and a displacement of approximately 2 inches by the independent liquid for cake discharge is provided for. The cake discharge step may be timed to occur every nine or ten minutes, for example.

The invention provides in a simple manner for

more complete separation and avoids the difficulties previously mentioned herein as incurred in the centrifugal filtration of a mixture containing a solid component heavier than the liquid component, such as the charge mentioned herein. Very simple and reliable apparatus is also provided by the invention for obtaining the desired advantages. While wax-oil separation is mentioned herein as an example of a particularly satisfactory employment of the invention its utility is by no means limited to such separation. It has general industrial utility in the solids-liquid separation field as, for examples, in the separation of chemical salts from slurries and in sugar refining.

While very satisfactory forms of the invention are disclosed, modification of details is possible within the scope of the invention. The present disclosure is merely illustrative and in nowise limiting and the invention comprehends such modifications as will fall within the scope of the following claims.

I claim:

1. A centrifugal filter apparatus for separating a charge mixture including a liquid and a heavier solid, comprising a centrifuge rotor having an imperforate circumferential wall, and a wall at one end thereof to prevent discharge at said end, the rotor being open at its opposite end and there having an annular lip extending from said circumferential wall inwardly toward the axis of the rotor, a plurality of filter conduits within the rotor extending along and spaced around the rotor axis and located intermediate the radial width of said lip and each having a longitudinal filter wall, means for progressively delivering the charge to the region of said filter conduits, channel means for discharge of filtrate from said conduits to the exterior of the rotor, an annular channel borne by the rotor at one end thereof with its center on the rotor axis, said annular channel being open at its side toward the rotor axis, means defiining a liquid admission and discharge port connecting said annular channel with a region of the interior of the rotor located at said imperforate wall and spaced radially outward from said filter conduits, said port being independent of said filtrate discharge channel means and the annular channel extending nearer to the rotor axis than said port and said region, a conduit to supply to said annular channel through said open side thereof a liquid independent of the charge from outside of the rotor during rotation of the rotor, for flow through said passage to build up an annular stratum for displacement of separated solid material radially inward for discharge past the inner edge of said lip, means to limit approach of said stratum toward said filter walls to prevent escape of the independent liquid therethrough, and means to effect limited discharge of the independent liquid from said stratum, through said connected port and channel during rotation of the rotor, the said port and the annular channel being correlated with said internal region of the rotor to retain a predetermined minimum radial thickness of said stratum during rotation of the rotor.

2. The centrifugal apparatus of claim 1 wherein the said channel means for discharge of the filtrate and the said annular channel are located at opposite ends of the rotor.

3. The apparatus of claim 1 including means to control delivery of the independent liquid to the annular channel by said supply conduit including a timer operative to periodically interrupt said delivery, for reduction of the radial depth of said stratum.

4. The apparatus of claim 1 including a valve in said conduit for supplying said independent liquid to the annular channel, and mechanism including a timer for periodically opening and closing said valve, for increasing or decreasing the radial depth of said stratum.

5. The centrifugal apparatus of claim 1 wherein the means to limit approach of said stratum to the filter walls comprises an annular flexible membrane impermeable to the liquid of the stratum, borne by the rotor and disposed radially inward of said admission and discharge port, to exclude the liquid from the charge and from the filter walls.

6. The centrifugal filter apparatus of claim 1 including a reservoir for said independent liquid in delivery connection with said supply conduit for the annular channel, and means for effecting return of said liquid, through the said channel, to the reservoir, to alternately increase and reduce the radial depth of said stratum.

7. The centrifugal filter apparatus of claim 1 wherein said means for effecting limited discharge of the independent liquid comprises a bleed port in a side wall of the annular channel and located nearer to the rotor axis than said liquid admission and discharge port.

8. The centrifugal apparatus of claim 1 wherein said supply conduit for the annular channel has a scoop end adjustable to dip into the channel through the open side thereof during rotation of the rotor to remove liquid from the channel and determine the minimum radial depth of said stratum and adjustable reversely for discharge of the liquid into the channel to increase the radial depth of the liquid within the channel.

9. The centrifugal filter apparatus of claim 1 wherein said channel means for discharge of filtrate is located at said lip, the said annular channel is located at the opposite end of the end of the rotor, the said filter conduits are in the form of tubular units borne at one end by said lip and in delivery connection through said end with said channel means for discharge of the filtrate, said units being free at the opposite end thereof, and the apparatus includes releasable couplings between said tubular units and said lip providing for detachment of said units individually.

10. The centrifugal apparatus of claim 1 wherein the open inner side of said annular channel is radially farther from the rotor axis than said filter walls to limit the maximum radial depth of said stratum and a side wall of said channel has a bleed port at a radial position between that of said liquid admission and discharge port and the open side of the channel to determine the minimum depth of said stratum.

11. The centrifugal apparatus of claim 10 including a reservoir for said independent liquid in delivery connection to said supply conduit for the annular channel and elevated above the said channel to provide a head, and means to conduct the liquid discharged from the open side of the channel and from said bleed port to said reservoir.

12. The method of separating components of a charge of a mixture including a liquid and a heavier solid, comprising progressively delivering said charge along a course to a centrifuging zone, continuously centrifuging the charge

and a liquid independent of the charge and heavier than any component of the charge and, during the centrifuging, maintaining an annular stratum of said heavy liquid around the outer side of the charge, filtering the liquid component from the charge within a region of said zone spaced radially inward from said stratum of heavy liquid, directing the charge delivery to said filtration region, discharging the filtrate from the centrifuging zone, accumulating the separated solid material in the zone to a radial depth extending inward from said filtration region, halting said charge delivery, delivering additional heavy liquid directly to said stratum along a course independent of the said charge course and clear of said filtration region and of the charge and the separated components of the charge, restraining discharge of the additional liquid from the stratum and establishing a liquid head on the added liquid to augment the radial depth of the stratum to a point closer to but still spaced radially outward from said filtering region and thereby displacing the accumulated separated solid material radially inward, and discharging from the centrifuging step the inner portion of the solid material so displaced.

13. The method of separating components of charge of a mixture including a liquid and a heavier solid, comprising progressively delivering said charge along a course to a centrifuging zone, continuously centrifuging the charge and a liquid independent of the charge and, during the centrifuging maintaining an annular stratum of said independent liquid around the outer side of the charge, filtering the liquid component from the charge within a region of said zone spaced radially inwardly from said stratum of independent liquid, directing the charge delivery to said filtration region, discharging the filtrate from the centrifuging zone, accumulating the separated solid material in the zone to a radial depth extending inward from said filtration region, halting said charge delivery, delivering additional independent liquid directly to said stratum along a course independent of the said charge course and clear of said filtration region and of the charge and the separated components of the charge, restraining discharge of the added liquid from said stratum and establishing a liquid head on the added liquid to augment the radial depth of the stratum and thereby displacing the accumulated separated solid material radially inward, preventing discharge of the independent liquid at the filtering region, and discharging from the centrifuging zone the inner portion of the solid material so displaced.

14. The method of claim 13 including periodically halting said charge delivery and effecting said displacement of the separated solid component as defined in said claim, and, after each discharge of the inner portion of the separated solid material, reducing the radial depth of the said stratum of independent liquid by discharge of the liquid therefrom, and resuming said delivery of the charge to the centrifuging zone.

15. The method of claim 13 including maintaining said stratum of independent liquid segregated from the charge and its components at all times.

AUGUST H. SCHUTTE.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,492,168	Hapgood	Apr. 29, 1924
1,749,057	Armentrout	Mar. 4, 1930
2,165,807	Murphree et al.	July 11, 1939
2,370,999	Schutte	Mar. 6, 1945
2,394,016	Schutte et al.	Feb. 5, 1946
2,398,967	Schutte	Apr. 23, 1946
2,431,142	Schutte	Nov. 18, 1947
2,440,487	Rayburn	Apr. 27, 1948