

June 15, 1965

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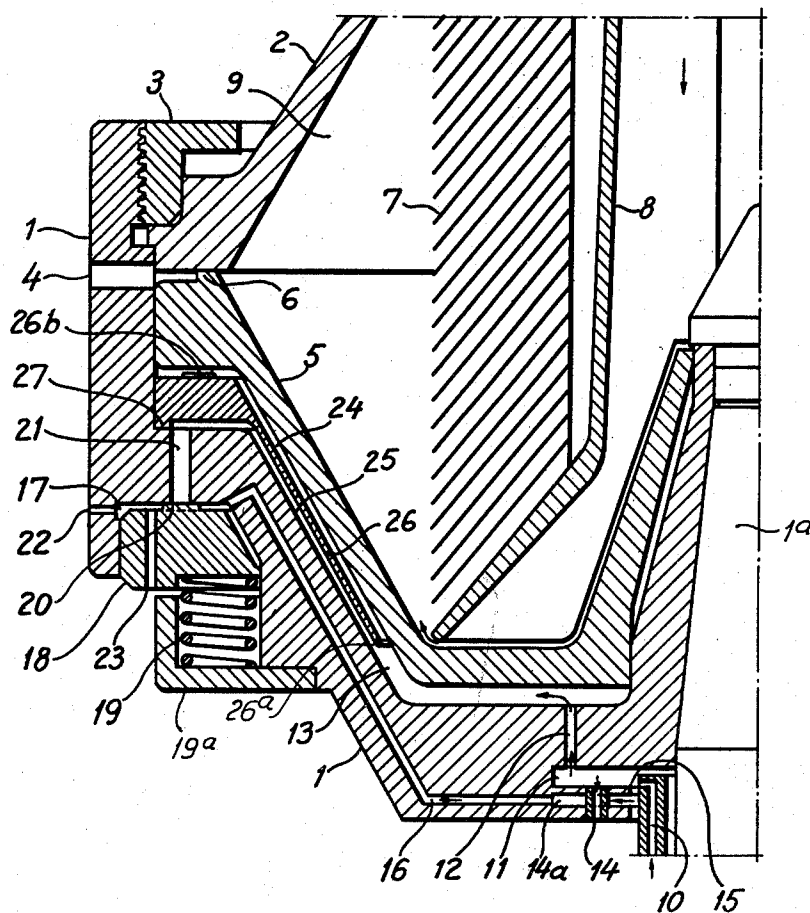
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SLUDGE CENTRIFUGE

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4 Sheets-Sheet 1

Fig. 1



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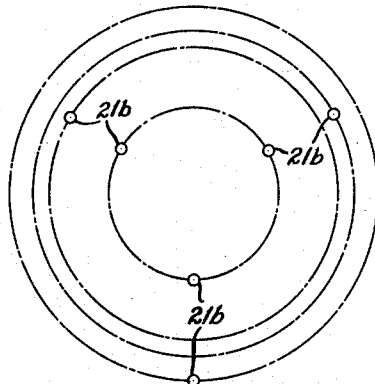


Fig. 5

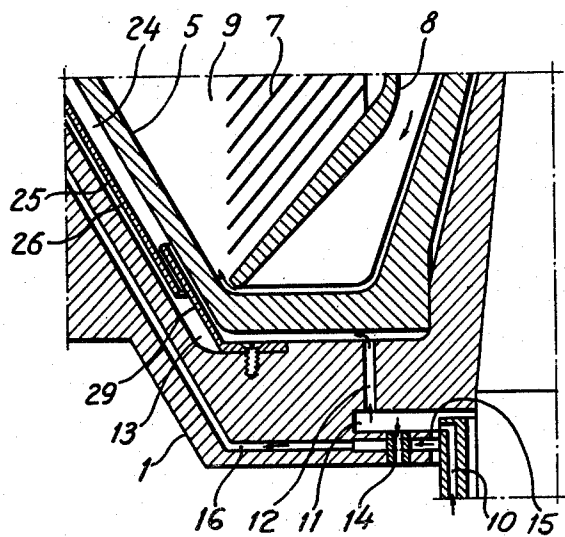


Fig. 2

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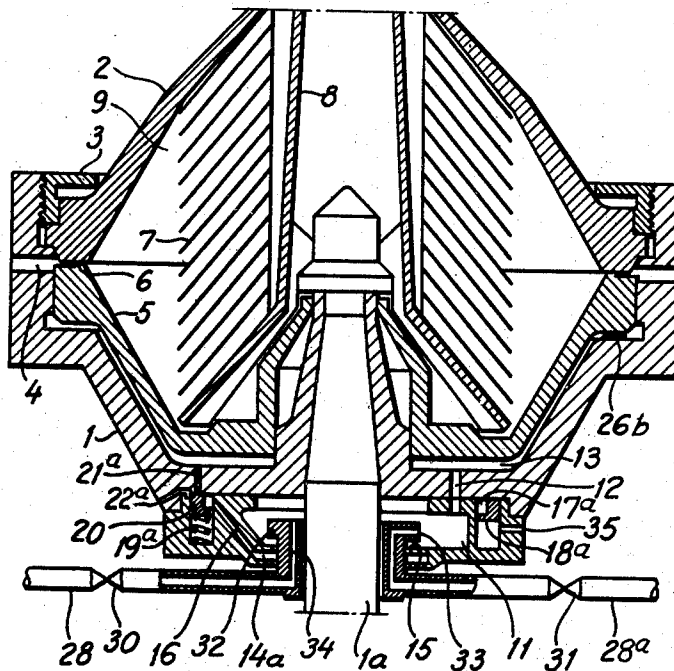
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SLUDGE CENTRIFUGE

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Fig. 3



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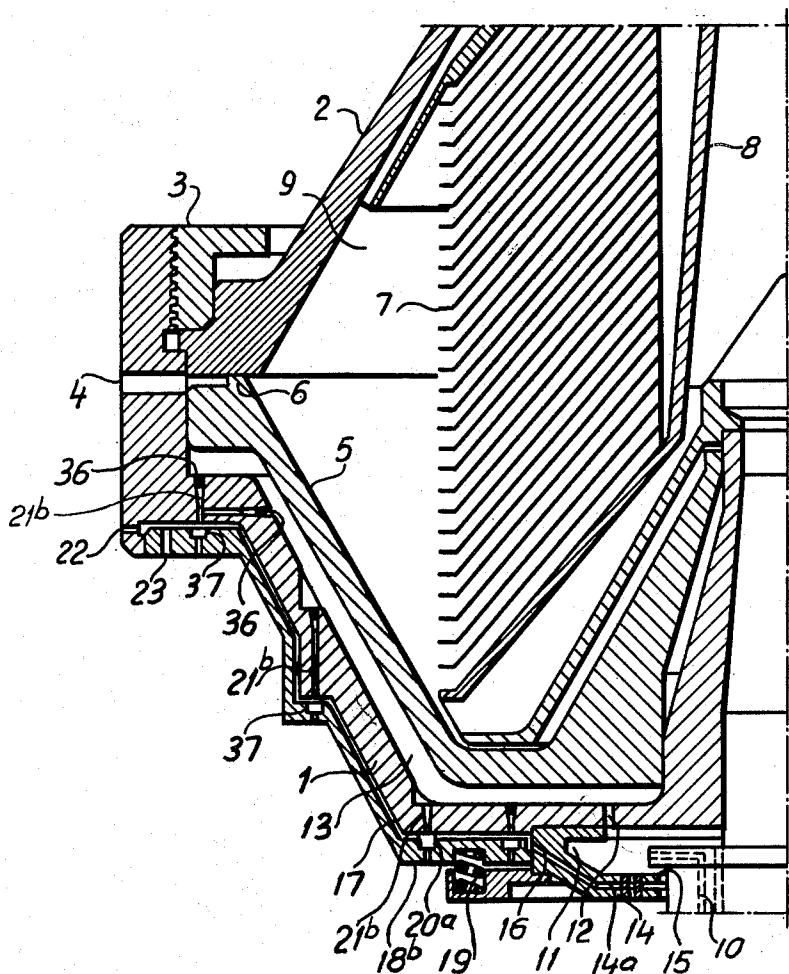
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SLUDGE CENTRIFUGE

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Fig. 4



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## SLUDGE CENTRIFUGE

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Claims priority, application Sweden, Apr. 20, 1960, 3,858/60

8 Claims. (Cl. 233—20)

This invention relates to sludge centrifuges of the type in which the sludge is discharged intermittently through an opening in the wall of the rotor body under control of a slide valve actuated hydraulically in the longitudinal direction of the rotor axis by operating liquid fed to and from a chamber located between the outside of the slide valve and the inside of the rotor body. More particularly, the invention has reference to an improved sludge centrifuge of this type in which the slide valve operates to close the sludge discharge opening before a substantial amount of the liquid can discharge from the separator chamber through this opening.

Centrifuges of this type, as made heretofore, include a draining outlet from the control chamber between the slide valve and the bowl wall; and during the centrifugal separation, the operating liquid is supplied to this chamber at a rate exceeding the draining outlet capacity. A certain liquid level in this chamber, sufficient to keep the slide valve closed during separation, is established by an overflow outlet from the chamber, through which excess operating liquid discharges. When a certain quantity of separated sludge has accumulated in the centrifugal rotor and is to be discharged therefrom, the supply of the liquid-sludge mixture to be separated as well as the supply of the operating liquid is cut off without stopping the centrifuge. This results in the control chamber being entirely emptied of operating liquid and the slide valve being opened under the pressure of the centrifuge contents. Before re-starting the feed of the mixture and the separation thereof, the slide valve is closed by a new supply of operating liquid.

According to another prior design, the draining outlet is kept closed by a spring-loaded valve body during separation. In this case, a supply of operating liquid to the control chamber is not necessary during separation except to the extent required for counteracting losses of operating liquid through leakage and evaporation. From the control chamber, an overflow outlet communicates with one side of the valve body. When it is desired to empty the centrifuge, the supply of operating liquid is increased so that the liquid passing over the overflow outlet displaces the valve body against the action of the spring pressure, whereby the draining outlet is opened. When it is desired to close the valve again, the supply of operating liquid is cut off or reduced. Any residual operating liquid tending to open the valve body is thereby discharged through another draining outlet of small capacity. Before separating again, the control chamber is refilled with operating liquid so that the slide valve is closed.

A difficulty encountered with these prior centrifuges is that substantial quantities of liquid from the separating chamber of the rotor tend to discharge with the sludge, due to delay in closing the sludge outlet.

The principal object of the present invention is to provide a centrifugal sludge separator of the type described which avoids any substantial discharge of separated liquid with the sludge discharge.

A centrifuge made according to the present invention includes a control chamber on the outside of the slide valve having a valve-controlled outlet located a distance inward-

ly from the periphery of the control chamber, so that the peripheral part of the chamber is never entirely emptied of liquid during operation of the centrifuge. A liquid cushion is therefore always present on the outside of the slide valve while the valve is open, this cushion acting on the slide valve with a closing force. As the liquid level in the separating chamber decreases incident to opening of the slide valve, a pressure balance is established on opposite sides of the slide valve, whereupon the slide valve closes. The slide valve can be caused to close even before all the sludge is discharged from the separation chamber. The maximum liquid pressure maintainable in the control chamber may be limited by means of a level-holding device, such as an overflow outlet or a paring device which lies nearer the rotor axis than does the valve-controlled outlet.

According to a preferred embodiment of the present invention, the control chamber is divided into inner and outer portions, the outer portion being part of the valve-controlled outlet. The chamber may be so divided by a disk or the like extending from the periphery of the chamber toward the rotor axis. Spacing members may be arranged so that the liquid cushion remaining on the outside of the slide valve, upon opening thereof, retains the thickness necessary for the subsequent closing of the valve. The valve slide may be made in the form of a conical valve disk with the chamber in the form of a conical slot. The disk dividing the control chamber may also be made conical.

Another embodiment of the present invention permits the feed of sludge bearing liquid to be continued to the separating chamber during discharge of the sludge, by means of a second disk arranged to lead the operating fluid to the inside of the first disk.

The invention is described in more detail below, reference being made to the accompanying drawings, in which:

FIG. 1 is a vertical sectional view of the lefthand half of a centrifugal separator embodying one form of the invention;

FIG. 2 is a fragmentary vertical sectional view of a modification of the separator shown in FIG. 1;

FIG. 3 is a vertical sectional view of a centrifuge embodying a third form of the invention;

FIG. 4 is a view similar to FIG. 1 but showing a fourth embodiment; and

FIG. 5 is a schematic view showing the location of drainage holes.

In FIG. 1, numeral 1 designates the rotor body of the centrifugal bowl, 2 its cover and 3 a locking ring which secures the cover to the rotor body. Evenly distributed around the periphery of the rotor body are relatively large sludge discharge openings 4. During separation, these openings are kept closed by means of a conical valve disk 5 which seals against the cover 2 by means of a ridge 6. A sludge-containing liquid to be separated is fed into the separating chamber 9 through a distributor 8, the chamber 9 being provided with the usual set of conical disks 7. Operating liquid (normally water) is injected through a stationary feed channel 10 into a chamber 11 in the bottom of the rotor body. Chamber 11 surrounds and opens inwardly toward a vertical driving spindle or shaft 1<sup>a</sup> which supports the bowl 1-3 and rotates it about its axis, and the stationary feeding device 10 also surrounds spindle 1<sup>a</sup>. From chamber 11, the operating liquid flows through a channel 12 into a conical, slot-shaped chamber 13 on the underside of the valve disk 5 and, during normal operation, fills the latter chamber to a level which is controlled by an overflow outlet 14. The outlet 14 is formed by a small tube extending downward through an annular chamber 14<sup>a</sup> located in the rotor bottom and concentric to the rotor axis.

The operating liquid not consumed to replace losses through leakage and evaporation will discharge through the overflow outlet 14. During normal operation, the supply of operating liquid is kept at a slightly higher rate than necessary to cover these losses. Through centrifugal force, a pressure sufficient to keep the valve disk 5 closed against the action of the liquid pressure in the separation chamber 9 is thus maintained on the underside of the valve disk. After a suitable period which is determined empirically, the separation chamber is emptied of sludge. This is effected, during continued rotation of the centrifugal bowl, by interrupting the supply of the liquid to be separated to distributor 3 and substantially increasing the rate of supply of operating liquid through the channel 10. The operating liquid level thus increases from the overflow outlet 14 to an overflow outlet 15 located at the inner edge of the bottom of chamber 11 and therefore nearer the rotation axis of the bowl; and liquid flows from outlet 15 through chamber 14<sup>a</sup> and a channel 16 to an outer annular space 17 above a ring 18 which is concentric to the rotor axis. This ring 18 is pressed upward by biasing means in the form of coiled compression springs spaced evenly around the rotor axis and one of which is shown at 19, the bottoms of the springs being seated against a flanged ring 19<sup>a</sup> secured to the rotor body 1. The upper surface of ring 18 has a detent or head 20 adapted to seal against and close the lower end of a drain hole 21 extending downward from the peripheral portion of chamber 13, it being understood that a number of drain holes and corresponding heads (similar to hole 21 and head 20) are spaced evenly about the rotor axis. A small drain hole 22 extends radially through the rotor wall from the periphery of chamber 17.

The aforementioned increase in the rate of supply of operating liquid through channel 10 is great enough so that, despite the discharge of liquid through overflow outlet 14 and drain hole 22, the level of the liquid supplied to chamber 17 from overflow outlet 15, chamber 14<sup>a</sup> and channel 16 will rise inward toward a plurality of draining holes of which one is shown at 23. Each hole 23 extends downward through the ring 18, and the holes are evenly spaced about the rotor axis. The upper end of each drain hole 23 is situated at such a radial distance from the rotor axis that the liquid level in chamber 17 can increase (inwardly) enough to provide the liquid cushion above the ring 18 with sufficient pressure to displace ring 18 downward against the action of the springs 19. When the ring 18 is urged away from the holes 21, the chamber 13 is emptied of operating liquid, primarily through the holes 23, and since there will no longer be any flow through overflow outlet 15, the channel 16 will also be emptied. Except at its inner portion, the chamber 13 is divided into one upper part 24 and one lower part 25 by a conical disk 26 which rests on a peripherally extending ridge 27. Liquid remains in the upper part 24 to a level defined by the inner edge 26<sup>a</sup> of the disk 26. The radial distance of this inner edge 26<sup>a</sup> from the rotor axis is such that the liquid cushion remaining in the upper chamber part 24 produces a pressure which is substantially lower than the pressure produced by the liquid and the sludge in separation chamber 9. Consequently, the valve disk 5 is displaced downward in the course of chamber 13 being emptied of operating liquid as previously described. This causes the separated sludge to be expelled through the resulting gap or slot between cover 2 and ridge 6 of valve disk 5, and from this slot out through the openings 4. When a certain amount of sludge has been expelled, the liquid level in the separation chamber 9 will have decreased (moved outwardly) so far that the liquid remaining in the space 24 returns the valve disk 5 upwardly toward cover 2. As valve disk 5 moves upwardly, the volume of the space 24 increases so that the liquid level in it moves further outward, thereby decreasing the pressure from below upon the valve disk 5. However, this pres-

sure decrease is offset by further reduction of pressure on the upper side of valve disk 5 as sludge continues to discharge through the narrowing gap between parts 2 and 6, until these parts are fully engaged. Any further leakage between parts 2 and 6 from separation chamber 9 will further decrease the liquid level in chamber 9 and cause valve disk 5 to be pressed still more tightly against cover 2. By a suitable adjustment of the position of the inner edge of the disk 26 and the separating period between the evacuations, the centrifuge may be caused to interrupt the sludge discharge automatically before all the separated sludge has been discharged, that is, before any substantial amount of separated liquid can accompany the discharging sludge. If desired, a predetermined minimum thickness of the liquid cushion remaining in the chamber part 24 may be ensured by stops or spacers 26<sup>b</sup>. As shown, these are located on the top of conical disk 26 and limit the downward movement of the valve disk 5.

Before the supply of the sludge-containing liquid to be separated can be resumed, the ring 18 must be raised to close the draining holes 21. This can be effected in various ways. One way is to reduce the rate of supply of operating liquid through the channel 10 to the value it has during separation, whereby the rate of inflow of liquid through the holes 21 to the chamber 17 (which is drained by the hole 22), will be so small that no liquid cushion capable of counteracting the springs 19 can be maintained above ring 18. These springs 19 will therefore displace the ring 18 upward against the holes 21. Thereupon, the continued supply of operating liquid fills the chamber 13 to the level 14. As filling of the chamber 13 in this way takes a relatively long time, an alternative procedure may be followed. In the latter, the supply of operating liquid through channel 10 is entirely cut off after the sludge discharge has started. The ring 18 then closes the holes 21 practically immediately after the supply of operating liquid has been stopped, due to the liquid cushion above ring 18 draining off through hole 22. Thereupon, the chamber 13 is rapidly filled by resuming the supply of operating liquid at an ample rate through channel 10. When the chamber 13 has been filled to near the level 14, the supply of operating liquid is adjusted to the small rate it should have during separation.

If it is desired to empty the centrifuge without having to interrupt the supply of the sludge-containing liquid to be separated, the modification shown in FIG. 2 may be used. Here, too, the rate of supply of operating liquid through the channel 10 is so small during separation that the liquid level in chamber 13 is maintained at the overflow outlet 14. The valve disk 5 opens in the same manner as in the embodiment according to FIG. 1, by substantially increasing the rate of liquid supply through the channel 10. After completion of the sludge discharge, the valve disk 5 returns to its closed position while the operating liquid is supplied at an ample rate. In practice, however, the closing of the valve disk is effected so rapidly that the supply of operating fluid requires some time to compensate for the lowering of the liquid level in space 24 which occurs at the same time. A conical disk 29 screwed to the rotor bottom directs the incoming liquid from channel 10 to the upper portion 24 of the chamber 13. During the time required for the operating liquid to fill the space 24 up to the level defined by the inner edge of disk 26, the liquid cushion in the spaces 25 and 17 (FIG. 1) can escape through the holes 23 and 22. The ring 18, under the action of springs 19, will then close the holes 21 before new operating liquid reaches the holes 21 by way of the inner edge of the disk 26. By supplying the operating liquid at an ample rate, the liquid will then fill chamber 13 rapidly to the level of overflow outlet 14. The rising of the level in the separation chamber 9 due to the uninterrupted supply of the liquid to be separated, and incident to closing of slide valve 5, is accomplished much more slowly than the rising of the level

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in chamber 13, and therefore the valve disk 5 is now kept closed. After the chamber 13 has been filled, the supply of operating liquid is adjusted to the small rate it has during separation.

FIG. 3 shows an embodiment in which the disk 26 has been omitted and instead holes 21<sup>a</sup> are located nearer the rotor shaft than are the holes 21 in FIG. 1. This makes it possible, when emptying the centrifuge, to maintain a liquid cushion on the lower side of the valve disk 5, the holes 21<sup>a</sup> forming an overflow outlet for this liquid cushion and thus controlling its level. In FIG. 3, numerals 28 and 28<sup>a</sup> designate pipe lines which communicate with a common supply vessel (not shown) for operating liquid. This vessel is situated on a higher level than the centrifuge so that the liquid can flow by gravity through the lines 28-28<sup>a</sup> leading into the centrifuge. Inserted in these lines are valves 30 and 31. The lines open into a stationary paring disk 32 which surrounds and is concentric to the rotor shaft 1<sup>a</sup>. The paring-out channel is shown at 33. During separation, the valve 30 is kept closed while valve 31 is open and the chamber 11 is filled with liquid to a level which is controlled by the paring disk 32, the pumping pressure of the paring disk balancing the pressure of the liquid column in the line 28<sup>a</sup> up to the vessel which supplies the operating liquid. Under these circumstances, the valve disk 5 is kept in a closed position by the liquid pressure in the chamber 13. When it is desired to empty the centrifuge, the valve 31 is closed and the valve 30 is opened. Liquid then passes through the line 28 and a channel 34 in the paring disk into the chamber 11. The liquid level in this chamber rises to the overflow outlet 15, and liquid then overflows into chamber 14<sup>a</sup> and passes through the channel 16 to the chamber 17<sup>a</sup> where a liquid ring is formed. This liquid ring presses the ring 18<sup>a</sup> downwards. The holes 21<sup>a</sup> are thereby opened and liquid in the chamber 13 is evacuated through the holes 21<sup>a</sup> to the same level as these holes. The valve disk 5 opens through this liquid level reduction. The liquid from the chamber 13 flows into the chamber where the springs 19<sup>a</sup> are arranged and from this chamber out through draining holes 35. The valve disk 5 closes when the valve 30 is closed, the liquid remaining in the chamber 17<sup>a</sup> discharging via channels (not shown) in the upper side of the ring 18<sup>a</sup> through the hole 22<sup>a</sup>. The valve 31 is then opened, whereby the chamber 13 and thus the chamber 11 are filled to the level controlled by the paring disk 32. Under influence of the liquid pressure in the chamber 13, the valve disk 5 is pressed upward into contact with the cover 2.

The embodiment of FIG. 4, with reference to parts 1-23, operates in the same way as the embodiment shown in FIG. 1 but, with reference to the location of the holes 21, is a modification of the embodiment illustrated in FIG. 3. In the case where the centrifuge is intended to be used under such varying operating conditions that the liquid cushion remaining in the chamber 13 during the sludge discharges must generate substantially different compressive forces, disks 26 with various inner diameters must be available when using the embodiment illustrated in FIG. 1. However, such a stock of disks increases the costs and, furthermore, each disk involves structural complications such as packings and fastening means. According to the present invention, it is proposed instead to provide several series of holes 21 on different radii. It is then possible to plug the holes which in a certain operating condition are not suitable and leave open the holes at the desired radius. This is illustrated in FIG. 4, where holes 21<sup>b</sup> which have been put out of operation are obstructed by means of plugs 36. Each hole 21<sup>b</sup> has in ring valve 18<sup>b</sup> a corresponding recess 37 which is empty in the plugged holes 21 but contains pads 20<sup>a</sup> of suitable packing material for the open holes 21. These pads 20<sup>a</sup> close the latter holes when the ring 18<sup>b</sup> moves upwards. On each radius three holes can be evenly distributed (120° angle between the holes) so that the corresponding pads 20<sup>a</sup>

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form a three-point support when the ring 18<sup>b</sup> is resting against the rotor bottom.

FIG. 5 shows a modification of the embodiment according to FIG. 4. More precisely FIG. 5 shows schematically the location of the holes 21<sup>b</sup> on various radii. There are three holes 21<sup>b</sup> on the shortest radius and only one hole 21<sup>b</sup> on each one of the other radii. On the required radius only one hole needs to remain unplugged and on the shorter radii two further holes may remain unplugged. All three holes which are not plugged serve as outlets at the beginning of a discharge of operating liquid from chamber 13 but at the end of the discharge only the outermost hole serves as an outlet. This will, however, be sufficient. As shown in FIG. 5, it is possible to obtain the desired three-point support if the outer holes 21 are located at an angle of 120° from each other. The triangle formed by the three-point support will not be equilateral but this feature is not crucial.

The discharge of the centrifuge at specific intervals and the regulation of the liquid supply in connection therewith can be arranged to take place automatically according to an empirically adjusted scheme.

It will be apparent that the rotor 1-2 has means 26, 25, 21-23 in FIGS. 1-2, 21<sup>a</sup>, 35 in FIG. 3, and 21<sup>b</sup>, 17 in FIG. 4, forming an outlet leading from control chamber 13 between its inner and outer portions.

I claim:

1. In a sludge centrifuge of the type adapted for intermittent discharge of separated sludge, the combination of a hollow rotor having a separating space for a feed material to be separated, and also having a sludge discharge opening leading through the rotor wall from said space, a slide valve in the rotor movable lengthwise of the rotor axis to positions for opening and closing said discharge opening, the slide valve having an inner surface partly defining said separating space and having an outer surface partly defining a control chamber located between said outer surface and the rotor wall, said control chamber including an inner portion having an inlet and also including an outer portion extending radially inward from the rotor wall to a radius substantially shorter than the maximum radius of said separating space, a device for supplying an operating liquid to said inlet to accumulate in said chamber a body of liquid operable under centrifugal force to hold the slide valve in its closing position against the pressure in the separating chamber, the rotor having means forming an outlet leading from said chamber between its inner and outer portions, whereby discharge of liquid through said outlet is operable to reduce said liquid body and effect movement of the slide valve to its opening position while retaining liquid in said outer portion of the chamber, and a control valve carried by the rotor for opening and closing said outlet to control said liquid discharge, said outer portion of the chamber having sufficient volumetric capacity and radial extent that, in said opening position of the slide valve, said retained liquid is operable to return the slide valve to its closing position automatically when the separation material in said space has receded to a predetermined level.

2. The combination according to claim 1, in which said control chamber has a liquid level-holding outlet located nearer the rotor axis than is said first-mentioned outlet.

3. The combination according to claim 1, in which said outlet forming means include a disk extending generally radially inward toward the rotor axis from the rotor wall and having a free inner edge, said outer portion of the chamber being located between the slide valve and one side of the disk, the other side of the disk partly defining said outlet leading outwardly from said inner edge.

4. The combination according to claim 1, in which said outlet forming means include a disk extending generally radially inward toward the rotor axis from the rotor wall and having a free inner edge, said outer portion of the chamber being located between the slide valve and one side of the disk, the other side of the disk partly defining

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said outlet leading outwardly from said inner edge, the combination comprising also spacers between said disk and slide valve for limiting movement of the slide valve toward the disk and thereby ensuring a liquid cushion of predetermined minimum depth in said chamber part lying adjacent the slide valve.

5. The combination according to claim 1, in which said outlet forming means include a disk extending generally radially inward toward the rotor axis from the rotor wall and having a free inner edge, said outer portion of the chamber being located between the slide valve and one side of the disk, the other side of the disk partly defining said outlet leading outwardly from said inner edge, said outer portion of the chamber as well as the disk and the adjacent portion of the slide valve being generally conical.

6. The combination according to claim 1, in which said outlet forming means include a disk extending generally radially inward toward the rotor axis from the rotor wall and having a free inner edge, said outer portion of the chamber being located between the slide valve and one side of the disk, the other side of the disk partly defining said outlet leading outwardly from said inner edge, the combination comprising also a second disk disposed in said control chamber in position to direct the operating liquid from said inlet into said chamber part lying adjacent the slide valve.

7. The combination according to claim 1, in which said outlet includes a plurality of holes extending through the

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rotor wall at different radial distances from the rotor axis.

8. The combination according to claim 1, in which said control valve is a ring surrounding the rotor axis and partly defining a valve chamber, the bowl having a passage leading to said valve chamber and positioned to receive overflow from said inlet of the control chamber.

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HARRY B. THORNTON, *Primary Examiner*.

HERBERT L. MARTIN, *Examiner*.

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,189,267

June 15, 1965

Henric Wilhelm Thylefors

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 23, for "622,451" read -- 662,451 --.

Signed and sealed this 15th day of February 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents