Sept. 12, 1967 J. PUTTERLIK 3,341,093

CENTRIFUGE WITH AUTOMATIC CONTROL OF THE DISCHARGE OF CONCENTRATED SOLIDS

Filed April 12, 1965 3 Sheets-Sheet 1

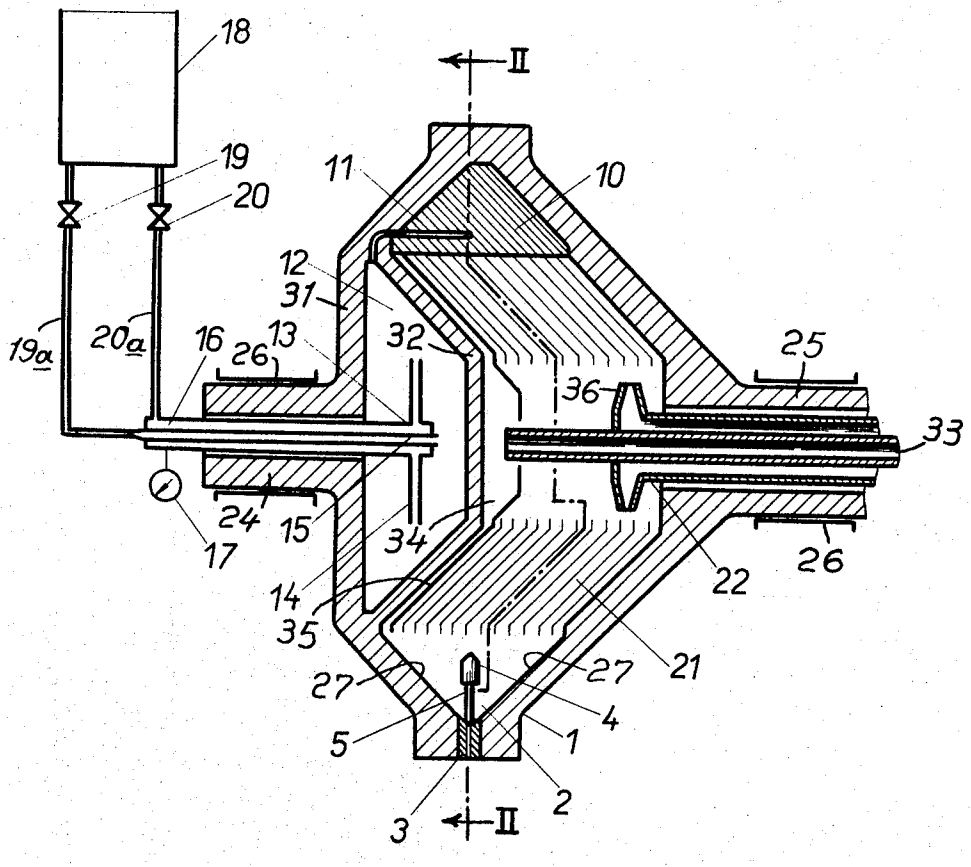


FIG. 1

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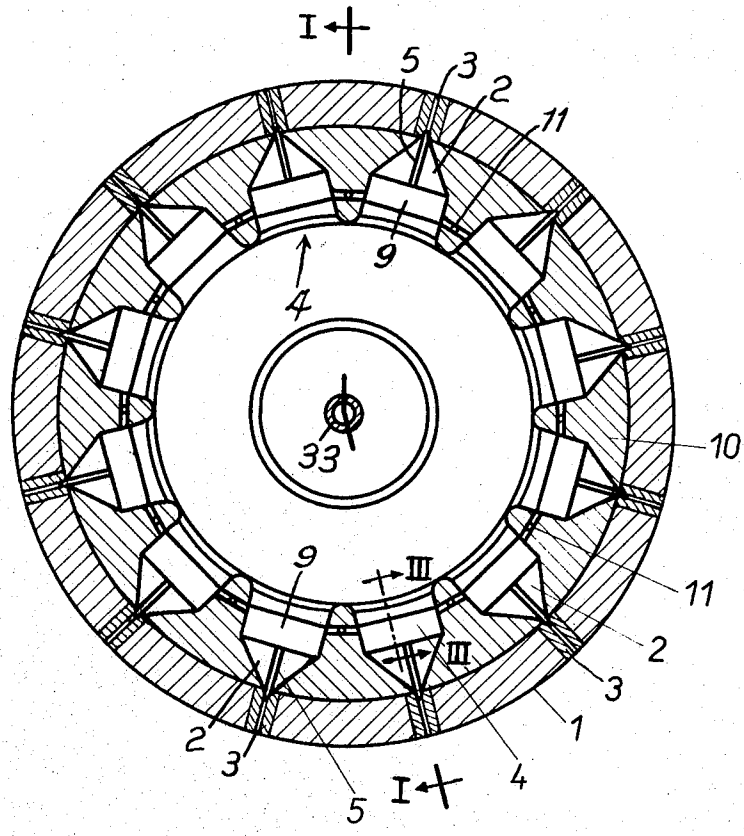


FIG. 2

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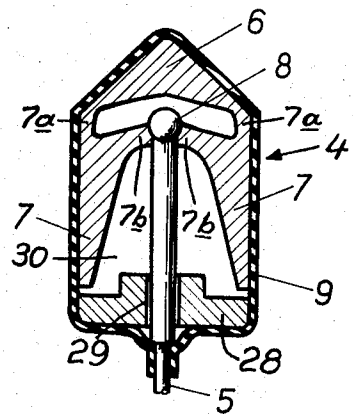


FIG. 3

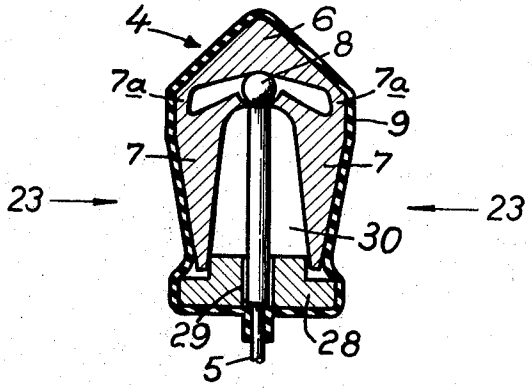


FIG. 4

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3,341,093

CENTRIFUGE WITH AUTOMATIC CONTROL OF THE DISCHARGE OF CONCENTRATED SOLIDS

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4 Claims. (Cl. 233—20)

This invention relates generally to centrifuges of the type employed in connection with a dispersion or suspension of solids in a liquid so as to obtain a concentrated fraction, that is, the solids in a much reduced proportion of the liquid, and a clarified liquid fraction. Such centrifuges usually include a rotated bowl containing spaced, frusto-conically shaped separating disks of smaller diameter than the bowl shell so that concentrated solids may collect in the outer portion of the bowl around the separating disks for discharge through nozzle passages leading from the outer part of the bowl, feed or supply passage means leading the incoming suspension or dispersion near to the outer edges of the disks, and an outlet for the clarified liquid fraction extending from near the axis of rotation of the bowl so that the incoming dispersion or suspension is made to flow centripetally or radially inward in divided flows between the separating disks and is there subjected to the centrifugal action to cause concentrated solids to collect in the outer portion of the bowl. Valves are frequently provided for controlling the discharge of the concentrated solids fraction through the nozzles provided for that purpose in the outer portion of the bowl.

In existing centrifuges, devices for regulating the valves which control the discharge of the concentrated solids fraction are based on the relationship between the hydrostatic pressure in the centrifugal field and the degree of concentration of the dispersion or suspension. Such regulating devices are unsatisfactory under normal operating conditions by reason of the inadequate sensitivity thereof, particularly when relatively high degrees of concentration of the solids are to be attained. This is due to the face that most suspensions produce a deposit of solids in the outer portion of the centrifuge bowl which increasingly resists the transmission of pressure therethrough as the concentration of the solids is increased. Further, the existing devices for regulating the valves controlling the discharge of the concentrated solids fraction cannot be adjusted during operation of the centrifuge, and thus cannot be adapted to variable conditions.

It is a general object of the present invention to provide a device for regulating the discharge control valves, which device avoids the above mentioned disadvantages of existing devices provided for the stated purpose.

A more specific object of the invention is to provide a device for regulating the valves which control the discharge of the concentrated solids fraction from a centrifuge, and wherein such device is adjustable during operation of the centrifuge for adapting the regulation of the valves to variable conditions, and further is capable of effecting reliable regulation of the valves even when the solids are concentrated to a relatively high degree and thus have a decreased capacity to transmit hydrostatic pressure.

In accordance with an aspect of this invention, a centrifuge of the described character has its outer portion divded into a circumferential series of solids collecting chambers which are sector-shaped, that is, provided with side walls converging in the radially outward direction, with a discharge nozzle for concentrated solids opening radially outward from each chamber, and a

reslient regulator means extends across each collecting chamber and is laterally deformable by the force of solids collecting in the respective chamber and sliding along the converging side walls thereof, such resilient regulator means being operatively connected to valve means which normally closes the discharge nozzle of the respective chamber and which opens the discharge nozzle upon lateral deformation of the resilient regulator means by the sliding effect of the collected solids. Since the sliding of the collected solids, and the action thereof in effecting lateral deformation of the resilient regulator means in each solids collecting chamber depends on the quantity of the deposit or collected solids, the fact that the transmission of hydrostatic pressure through the collected solids is attenuated as the concentration of the solids increases will not adversely affect the regulation of the valve means for controlling the discharge of solids.

In accordance with another aspect of this inventon, each resilient regulator means includes a fluid-tight body, for example, in the form of an elastic envelope, sealed with respect to the interior of the respective solids collecting chamber, a container for a regulating liquid is defined within the bowl to rotate therewith and has conduits extending from such container into the fluid-tight bodies of the several resilient regulator means so that the pressure of the regulating liquid can oppose the lateral deformation of the resilient regulator means, and provision is made for varying the quantity of regulating liquid in such container, during operation of the centrifuge, thereby to adjust the pressure of the regulating liquid acting in each resilient regulator means for adapting the discharge of concentrated solids to varying conditions.

In a preferred embodiment of this invention, each resilient regulator means includes a pair of side members resiliently maintained in spaced relation and movable angularly toward each other by the sliding of the collected solids along the converging side walls of the respective chamber, and the valve means associated with each resilient regulator means includes a valve rod extending radially to the respective discharge nozzle and coupled to the angularly movable side members to move radially away from the nozzle upon angular movement of such side members toward each other. The advantage of this preferred embodiment of the invention is that it permits lateral deformation of the resilient regulator means by sliding of the collected solids at the opposite sides thereof, and thereby increases the sensitivity of the regulation of the associated valve means.

The above, and other objects, features and advantages of the invention, will be apparent in the following detailed description of an illustrative embodiment thereof which is to be read in connecton with the accompanying drawings, wherein:

FIG. 1 is an axally sectional view of a centrifuge embodying this invention, which view is partly diagrammatic and taken along the line I—I on FIG. 2;

FIG. 2 is a transverse sectional view taken along the line II—II on FIG. 1;

FIG. 3 is an enlarged detail sectional view taken along the line III—III on FIG. 2, and showing a resilient regulator means in its normal position for closing an associated valve; and

FIG. 4 is a view similar to that of FIG. 3, but showing the resilient regulator means in its laterally deformed position for opening the associated valve.

Referring to FIGS. 1 and 2, it will be seen that a centrifuge embodying this invention generally comprises a bowl 1 which may be arranged with its axis extending horizontally, as shown, and which has tubular trunnions

24 and 25 extending from its opposite ends and journaled in suitable fixed bearings 26. The interior cavity of bowl 1 has side wall surfaces 27 which converge towards each other at the outer peripheral portion of such cavity, and partitioning members 10 are located in the outer peripheral portion of the bowl cavity to define a circumferential series of solids collecting chambers 2 whose walls converge in the radially outward direction, walls of the chamber 2 being formed by the converging wall surfaces 27 and the equally converging partition members 10. Each chamber 2 has a discharge nozzle 3 opening radially outward therefrom though the shell of bowl 1. Further, each chamber 2 has a valve regulator 4 extending between the associated partition members 10 at a location equidistant from the converging wall surfaces 27 and regulating the positioning of a valve rod 5 which extends radially outward from the regulator 4 to normally close the inner end of the nozzle 3 extending from the respective solids collecting chamber 2.

As shown particularly on FIGS. 3 and 4, each valve regulator 4, in a preferred embodiment of this invention, includes a one-piece member or body having a support portion 6 which, at its opposite ends, is secured to the partitioning members 10 defining the related chamber 2, side portions 7 joined to the opposite longitudinal edges of support portion 6 by relatively thin, and hence resilient connecting webs 7*a*, and flanges 7*b* directed inwardly from the side portions 7 substantially at right angles to the latter and being suitably shaped, approximately at their midpoints, to define a hemispherical seat for a ball 8 on the radially inner end of valve rod 5. The resilient connecting webs 7*a* normally urge side portions 7 to the position shown on FIG. 3, where the side portions 7 are spaced laterally apart so as to have their outer surfaces in substantially parallel relation. Each valve regulator 4 further includes a base member 28 also having its opposite ends secured to the adjacent partition members 10 and having a bore 29 which is centrally located to slidably receive and guide the valve rod 5.

Each valve regulator 4 further includes a rubber or other liquid-tight elastic envelope 9 which is in liquid-tight engagement with the adjacent partitions 10 so as to seal the interior cavity 30 between side portions 7 with respect to the space within the associated chamber 2.

The cavity 30 within each valve regulator communicates, at the ends of the valve regulator in sealing engagement with the adjacent partitioning members 10, with ducts 11 extending through such partitioning members and through the shell of bowl 1 to the outer periphery of a container 12 for regulating liquid which is defined within bowl 1 by an end wall 31 of the bowl and a generally frusto-conical partition 32 extending from such end wall (FIG. 1). A stationary tubular member 13 extends axially through the trunnion 24 into container 12 and, at its inner end, fixedly carries a hollow, circular collecting member 14 opening from the interior of tube 13 into container 12. A central tube 15 extends coaxially through tube 13 and opens, at its inner end, into container 12 at the axis of rotation of bowl 1. Tube 15 constitutes an inlet passage for regulating liquid to be supplied to container 12, while the annular space 16 between tubes 13 and 15 constitutes an outlet passage for the regulating liquid, which outlet passage is in communication with the liquid collecting member 14. The ends of inlet passage 15 and outlet passage 16 disposed outide trunnion 24 of bowl 1 are connected, as by conduits 19*a* and 20*a*, to a gravity tank or reservoir 18 containing a supply of the regulating liquid, and valves 19 and 20 are interposed in the conduits 19*a* and 20*a*, to respectively control the supplying of regulating liquid to container 12 and the discharge of regulating liquid from the container 12, and thus to permit adjustment of the quantity of the regulating liquid within container 12. A pressure indicating device 17, which may be a pressure gauge or manometer, is connected to the outlet passage 16 to indicate the pressure of the regulating liquid at the periphery of collecting member 14.

The centrifuge in which the invention is shown incorporated further includes an axial series of nested, spaced apart, frustoconical separating disks 21 disposed within bowl 1 and each having an outer diameter substantially smaller than the inner diameter of the bowl so as to be located radially inward with respect to the solids collecting chambers 2. A feed or supplying tube 33 extends axially into bowl 1 through the hollow trunnion 25 for supplying the dispersion or suspension which is to be centrifuged. The inner end of tube 33 opens adjacent the partition 32 into a feed channel 34 which is defined between partition 32 and an adjacent, spaced, frusto-conical distributing disk 35. Thus, the dispersion or suspension fed into bowl 1 through tube 33 passes outwardly in the feed channel or passage 34 and issues from the latter near to the outer edges of separating disks 21.

The clarified liquid fraction is withdrawn from bowl 1 through a tube 22 extending coaxially around tube 33 and having a hollow liquid collecting member 36 at its inner end which opens near to the inner edges of separating disks 21. As the suspension or dispersion flows inwardly between separating disks 21, the solids are centrifugally acted upon and deposited in the several chambers 2, while the remaining clarified liquid is drawn into the collecting member 36 adjacent the axis of the bowl and withdrawn from the latter through the tube 22.

As centrifuging of the dispersion or suspension continues, the level of solids collected in each chamber 2 rises radially inward along the inclined or converging side wall surfaces 27 of the chamber to form an accumulation which contacts the opposite side surfaces of the regulator 4 in the respective chamber. After reaching a critical height, such accumulation of solids acted upon by centrifugal force loses its coherence and slides in directions parallel to the converging side wall surfaces 27 so as to exert forces in the direction of the arrows 23 on FIG. 4 against the opposite sides of regulator 4, thereby to laterally deform or angularly deflect the side portions 7 toward each other. Each side portion 7 and the associated flange 7*b* constitute a two-armed lever fulcrumed at the web 7*a* so that angular movement of side portions 7 toward each other by the engaged envelope 9 causes the flanges 7*b* to effect radially inward displacement of ball 8 and valve rod 5 so that the latter is displaced from the associated discharge nozzle 3 to open the latter. The collected deposit of solids is then discharged from the chamber 2 through nozzle 3 to the outside of the bowl until the level of solids in the chamber 2 drops, or is decreased radially outward, to clear the free end edges of the angularly displaceable side portions 7 of the regulator. When the level of collected solids in the chamber 2 is thus reduced, side portions 7 of the regulator are returned both by the resilience of the connecting webs 7*a* and also by the pressure of the regulating liquid acting in the cavity 30 until side portions 7 are returned to their original position shown on FIG. 3 so that valve rod 5 again closes the associated discharge nozzle 3. The foregoing cycle of operation of the regulator 4 takes place repeatedly in each chamber 2 at time intervals which depend on the rates at which solids are collected in the respective chambers 2 and the concentrated solids fraction is discharged therefrom as the level of the collected solids in the chambers rises and falls in the radial direction.

The described automatic control of the opening and closing of valve rods 5 can be adjusted during operation of the centrifuge by increasing or decreasing the pressure of the regulating liquid acting in the cavity 30 of each regulator 4. The pressure of the regulating liquid acting in each cavity 30 can be varied merely by adjusting the amount of regulating liquid in the rotary container 12 either by adding liquid from the gravity tank 18 through the valve 19, or by discharging liquid from the rotary container 12 through the valve 20. When regulating liquid

is to be added to the supply in rotary container **12**, such liquid enters the latter through the conduit or tube **15** opening at the axis of rotation of the bowl **1** at which there is no pressure resisting the entry of the additional liquid. On the other hand, at the periphery of the circular collecting member **14**, centrifugal force produces a pressure in the liquid which is dependent upon the distance that the body of liquid within container **12** extends radially inward beyond the periphery of member **14**. Thus, when valve **20** is opened, the pressure of liquid at the periphery of collecting member **14** is sufficient to effect discharge of liquid through collecting member **14** and passage **16** to conduit **20***a* for return to the gravity tank **18**. At any instant, the pressure indicator **17** shows the pressure of liquid at the periphery of collecting member **14** by reason of centrifugal force acting on the body of liquid in container **12**, which pressure indication is a function of the pressure of the regulating liquid acting in the cavity **30** of each regulator **4**.

It will be apparent that the valves **19** and **20** can be controlled from outside the centrifuge during operation of the latter for varying the quantity of liquid in container **12** and thereby adjusting the pressure of the regulating liquid acting in each regulator **4**. Since the pressure of the regulating liquid acting in the cavity **30** of each regulator **4** determines the laterally directed force that must be generated by sliding of the solids collected in each chamber **2** to laterally deform or deflect side portions **7** and thereby effect opening of the associated valve rod **5**, adjustment of the pressure of the regulating liquid, as described above, makes it possible to adapt the automatic control of the discharge of the concentrated solids fraction for suspensions or dispersions having different properties, or for varying degrees of concentration of the solids. Further, before operation of the centrifuge is halted, the pressure of regulating liquid acting in each cavity **30** can be suitably reduced to permit the opening of the valves **5** in response to the centrifugally generated pressure in a rinsing liquid supplied to the bowl **1**, thereby to provide for cleaning or rinsing of the centrifuge.

Since the lateral deformation or deflection of side portions **7** of each regulator is caused by the sliding effect of collected solids at the opposite sides of the regulator, the control of the opening and closing of each valve rod **5** is not affected by the increasing concentration of the collected solids which attenuates the transmission of hydrostatic pressure therethrough. It will also be seen that the elastic envelope **9** of each regulator **4** serves to protect the mechanism contained therein from the abrasive effect of the suspension in the surrounding chamber **2**.

Although an illustrative embodiment of this invention has been described in detail herein with reference to the accompanying drawings, it is to be noted that the invention is not limited to that precise embodiment, and that various changes and modifications may be effected therein by one skilled in the art without departing from

the scope or spirit of the invention, except as defined in the appended claims.

What is claimed is:

1. In a centrifuge, in combination:

(a) a rotary bowl having an axis;

(b) partition means in the outer peripheral portion of said bowl remote from said axis, said partition means defining a peripheral series of solids collecting chambers,

(1) each chamber having two opposite walls converging in a radially outward direction and a discharge nozzle opening radially outward from said chamber;

(c) valve means in each of said chambers and movable in the associated chamber toward and away from said discharge nozzle between a nozzle opening and a nozzle closing position;

(d) valve regulating means mounted in each chamber spacedly intermediate said walls,

(1) said valve regulating means being connected to said valve means in the associated chamber and responsive to pressure in said chamber in a direction transverse of said radially outward direction for moving said valve means from the nozzle closing to the nozzle opening position.

2. In a centrifuge as set forth in claim **1**, each valve regulating means including a resilient fluid-tight body and responding to deformation of said body under said pressure for moving said valve means, and supply means communicating with the interior of said body for supplying fluid to the same.

3. In a centrifuge as set forth in claim **1**, said valve regulating means including a fluid-tight envelope and yieldably resilient support means in said envelope contiguously adjacent said envelope for movement of said support means with said envelope when said envelope is moved by said pressure, said valve means including a valve rod coupled to said support means for joint movement therewith.

4. In a centrifuge as set forth in claim **3**, said support means including two-armed lever means having respective arm portions engaging said envelope and said valve rod for moving said valve rod radially inward of said chamber in response to movement of said envelope in response to said pressure.

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