Nov. 15, 1955 L. P. SHARPLES 2,723,799

CENTRIFUGAL SEPARATION

Filed Feb. 3, 1951 3 Sheets-Sheet 1

Fig. 1

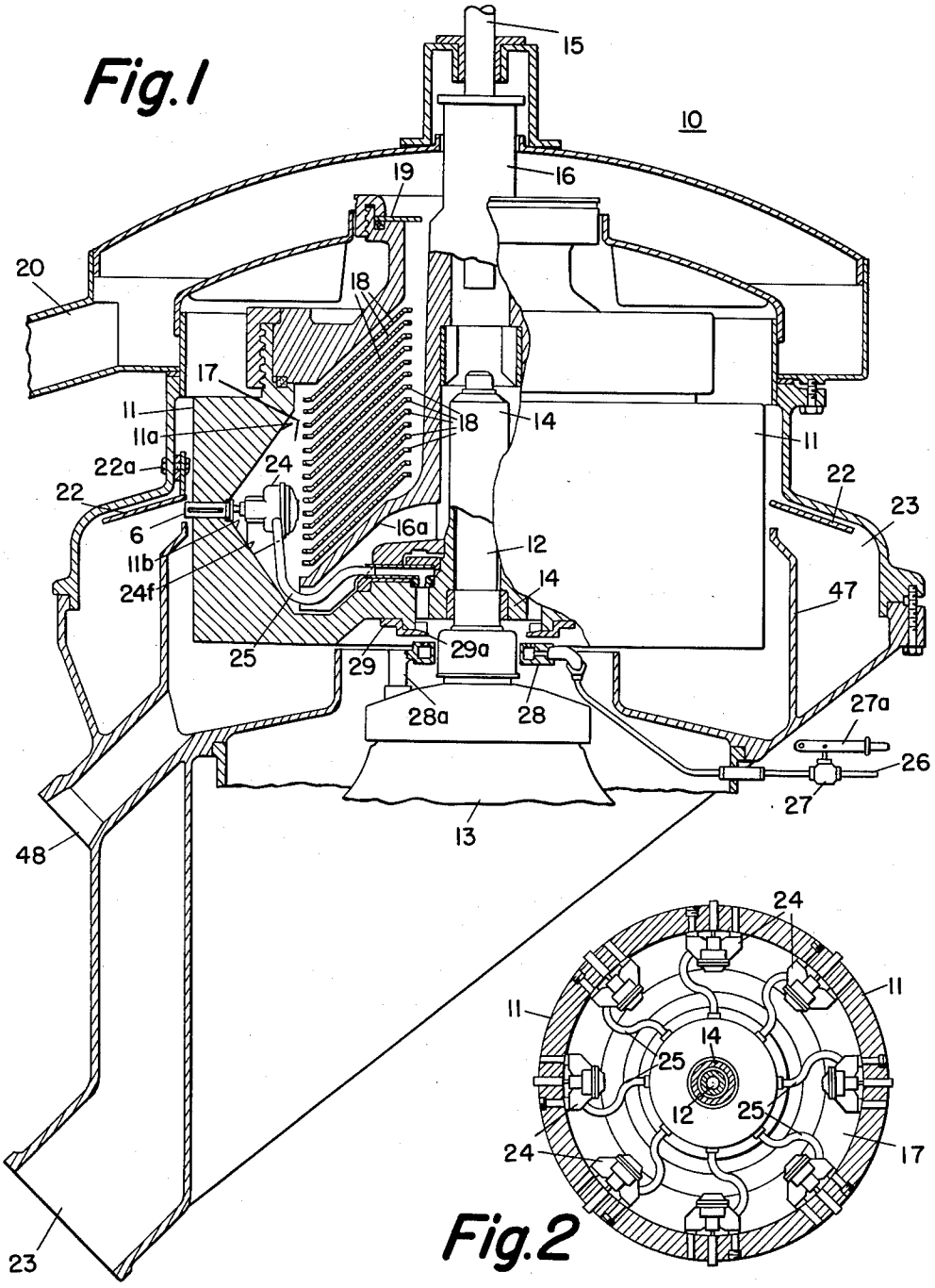


Fig. 2

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3 Sheets-Sheet 2

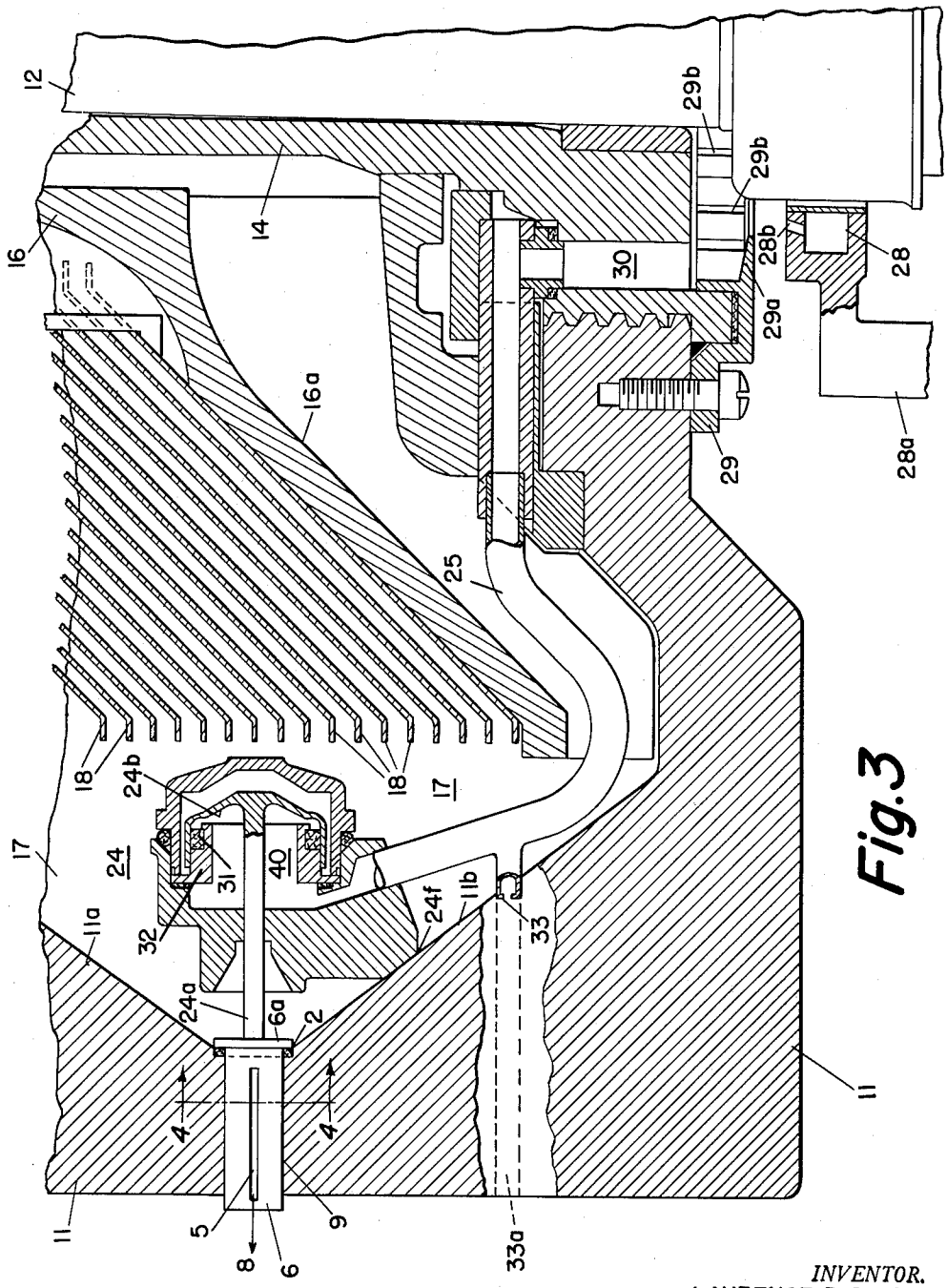


Fig. 3

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3 Sheets-Sheet 3

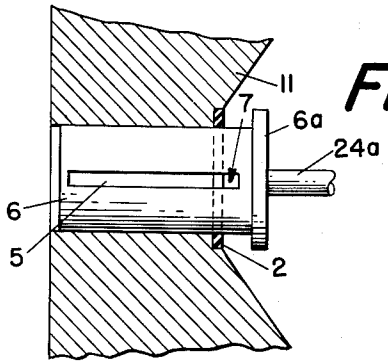


Fig.3-A

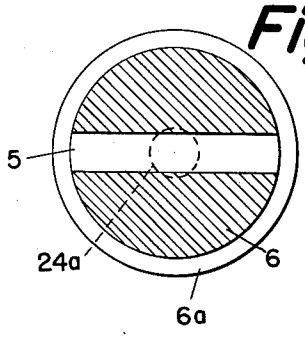


Fig.4

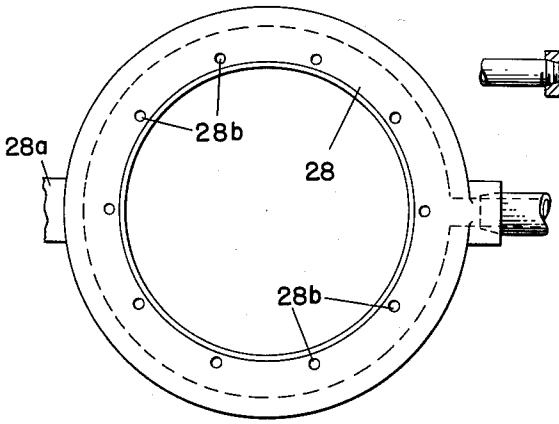


Fig.5

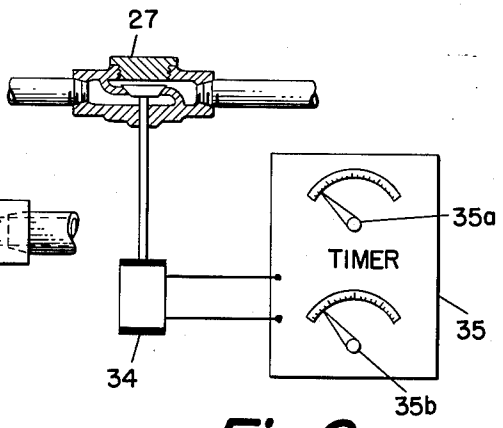


Fig.6

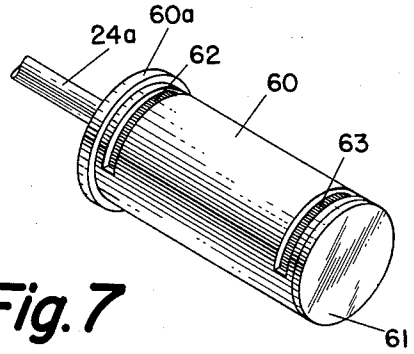


Fig.7

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2,723,799

CENTRIFUGAL SEPARATION

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Application February 3, 1951, Serial No. 209,218

10 Claims. (Cl. 233—20)

This invention relates generally to centrifuges and it relates particularly to centrifuges of the type designed to effect sedimentation or separation of solids from liquids and the intermittent discharge of metered amounts of the separated solids through the wall of the centrifugal rotor. More specifically, the invention relates to a centrifuge provided with one or more solids discharge valves which are adapted to accumulate metered amounts of solids which are discharged at suitably timed intervals.

For convenience the separated solids or high-density materials will be referred to herein as sludge, and the lower-density materials will be called the liquid, although it is to be understood that the liquid may be separated by the centrifuge into various phases of different densities. Thus, the primary purpose of the centrifuge may be to remove sludge from a liquid, or the removal of sludge may be incidental to the centrifugal separation of the liquid into two or more phases. It has heretofore been proposed to remove sludge from a rapidly rotating centrifuge rotor through a plurality of sludge valves spaced around the periphery of the rotor, the inner surfaces of the rotor sloping toward the valves in order that the sludge will be carried to the valves by centrifugal force. Of course, the valves should not remain open unnecessarily, since it is desirable to minimize outward flow through them of substantial quantities of the liquid. It is thus desired to open the sludge valves at intervals for only sufficient time for the sludge accumulation to pass through them. The opening of the sludge valves is a matter of considerable difficulty because of the high speed of rotation of the rotor in which they are located and the consequent large mechanical forces encountered. Electrically operated valves have not proven feasible because of the required slip rings and brushes operating at speeds far above those commonly used in electrical equipment and because of the required location of such slip rings on rotating parts where they may be subject to steam, other objectionable vapors, water, and even to the sludge being separated in the rotor.

In prior valve constructions for removing separated sludge the passageways for removing the sludge are usually small in size so that they tend to plug and thus become inoperative. Furthermore, these passageways and associated parts tend to wear on account of the high discharge pressures of the sludge passing therethrough. In prior constructions, furthermore, all the valves do not always have the same sensitivity. Some valves for example in a given centrifuge may be more sluggish in opening and closing than others so that unequal amounts of sludge pass out through the valves in the same centrifuge thus causing an unbalanced operation of the centrifuge.

It is also desirable that the rate of discharge of the sludge through the valves should be substantially equal to the rate of separation of the sludge from the feed mixture passing through the centrifuge rotor. When using timed valves as now presently in use, it is sometimes difficult to properly adjust the rate of discharge

of the separated sludge from the rotor, so that it will equal the rate of separation of the sludge in the rotor. As a result, the rate of discharge of sludge through the valves is either too high or too low. In the former case, more or less lighter material is discharged from the rotor together with the heavier separated material, and in the latter case, the amount of separated sludge gradually builds up in the rotor until it interferes with the efficiency of the separation in the rotor, and also with the operation of the valves.

According to the present invention there is provided a solids discharge valve construction for a centrifugal clarifier or separator which overcomes these disadvantages. The sludge valve comprises one or more chambers, which, when the valve is in the open position, fill with sludge material separated by the centrifugal rotor, and when the valve is in the closed position, permits a measured amount of the sludge to discharge from the rotor. The sludge valve is operated by any suitable motor means, such as by a fluid pressure actuated motor which is connected to the valve for regulating intermittent discharge of the separated sludge or sedimented solids through peripheral openings in the wall of the rotor, by alternately moving the valve into the open and closed positions. The sludge valve proper comprises one or more chambers for receiving the sludge which communicate with suitable inlet and outlet passageways or openings for the separated sludge. The sludge valve may be provided with means, such as a stem, which is connected to a suitable motor actuating means for moving the valve at predetermined timed intervals into open and closed positions. The relative dimensions of the sludge valve and associated parts are such that when the valve is in the open position, the chambers therein communicate with the inside of the rotor to permit the chambers to fill with separated sludge; and when the sludge valve is in the closed position, the chambers are in such a position as to communicate with a zone outside the rotor and permit the accumulated sludge contents from the sludge chambers to be discharged.

According to the present invention, metered or predetermined amounts of separated sludge are removed from the centrifuge at suitable time intervals. The openings provided for removal of the sludge are fully opened during the discharge cycle so that no clogging will occur. The discharge of sludge is fully controlled and is substantially uniform at all the valves. The centrifuge thus operates more uniformly in balance and this balance is less upset when solids are removed than in prior constructions. The sludge discharged by the present construction is generally also higher in solid content and the amount of liquid discharged with the solids can be better controlled. There is also considerably less wear on the valve parts since the sludge is discharged by the sludge valve without the hydraulic pressure from the interior of the centrifuge acting thereon, since the sludge chambers are not in communication with the interior of the rotor at the time of discharge therefrom. Also the balanced sensitivity of a plurality of motor means when employed for simultaneously actuating a plurality of sludge valves is not as important as in prior constructions since in the present invention these motor means, when used in plurality, operate to merely actuate metering means. Therefore, the amount of sludge discharged at each valve is not dependent upon the relation between the various valve operating pressures and the resistance to motion of the various valves.

Further objects and advantages of the invention will be apparent from the following more detailed description thereof with reference to the accompanying drawings, in which:

Figure 1 is a side elevational view, partly in section,

of a centrifuge embodying the invention with portions thereof shown broken away to disclose internal structure thereof;

Figure 2 is a horizontal sectional view taken just above the sludge valves of Figure 1 with other parts omitted;

Figure 3 is an enlarged sectional view similar to Figure 1, but with actuation mechanism of the sludge valve simplified and partly diagrammatically shown in closed position;

Figure 3A is a fragmental view of the same sludge valve shown in Figure 3 but shown in open position;

Figure 4 is an enlarged sectional view of the sludge valve assembly taken on the line 4—4 of Figure 3;

Figure 5 is an enlarged plan view of the liquid feed-collar shown in Figure 1;

Figure 6 is a fragmentary diagrammatic view of a timer-control of the supply valve shown in Figure 1; and

Figure 7 is a perspective view of a modified sludge valve construction.

Referring to the drawings, the invention in one form has been shown as applied to a centrifuge **10** of the type shown in Patent 2,286,354. The rotor **11** is driven by a shaft **12**, mounted for rotation within a support **13**, and itself driven by any suitable form of motor. The rotor **11** is secured to a sleeve **14** which is secured to and rotates with shaft **12**.

As more fully explained in said patent, the mixture of liquids and solids supplied through a feed or inlet pipe **15** flows downwardly through the space between tube **16** and sleeve **14** and outwardly below the skirt **16***a* of tube **16**. The easily separable solids move into the space or chamber **17** formed by the inclined walls **11***a* and **11***b* of the rotor **11**. Efficient separation or sedimentation of the remaining solids takes place as liquid flows inwardly of the stratifying discs **18** and the sludge or heavier solid material flows outwardly therefrom. For purposes of clarity a limited number of discs **18** is shown, it being understood that a considerably larger number of discs in compact spaced relationship would be normally employed as is well understood by persons skilled in the art. The liquid flows upwardly in the space adjacent the periphery of the tube **16** and over a ring dam **19** for discharge by way of stationary outlet **20**.

Sludge collecting anywhere in the region of intersection of walls **11***a* and **11***b* is discharged into the sludge collecting chambers **5** provided in slidable cylindrical sludge discharge valves **6**. A plurality, such as eight, equally spaced sludge discharge valves are positioned in circular openings **9** provided in the wall of the rotor **11**. The sludge discharge valves **6** are dimensioned so as to slidably fit in the openings **9**. The sludge valves **6** are provided with a collecting chamber **5** of the same capacity in which sludge is collected. The valves **6** are provided with a shoulder portion **6***a* adapted to seat against sealing gasket **2** positioned in a recess provided about openings **9**. When the sludge discharge valve **6** is in the open position, as shown in Figure 3A, the sludge will be discharged through passageways indicated by arrows **7** into the sludge chamber **5**. At the same time the other end of valve **6** is in closed relation to opening **9** in the rotor **11** so that no sludge in chamber **5** can pass out therefrom. When the sludge chamber **5** is filled with sludge, the sludge valve **6** is moved by suitable motor means, to be described later, to its closed position, as shown in Figure 3. The sludge accumulated in chamber **5** is then discharged through passageways, indicated by arrows **8**, while the shoulder portion **6***a* of the other end of the valve **6** is sealed by gasket **2** against entry of any materials from the interior of the centrifuge. The sludge discharged from the sludge chamber **5** is deflected downward by conical skirt or ring **22** and is discharged from a chute **23**. The deflecting skirt **22** may be supported in any suitable way such as by bolts **22***a* extending through the stationary housing.

From the foregoing description of the sludge discharge valves **6**, it will be understood that such valve in its function amounts to one or more movable sludge collecting chambers which can be selectively positioned so as to communicate either with the interior of the centrifugal rotor or bowl to collect the sludge separated at the periphery of the rotor while being closed to communication with the exterior of the rotor, or the sludge collecting chambers can be positioned so as not to communicate with the interior of the rotor, but can communicate only with the exterior zone thereof. The passageways indicated by arrows **7** and **8** in Figures 3 and 3A can thus be considered as openings communicating with the chamber **5** to provide the selective communication of chamber **5** either with the interior or exterior of the rotor as previously explained. When the rotor of the centrifuge is rotated in normal operation sludge valves **6** will be in the closed position shown in Figure 3, the centrifugal force being sufficient to maintain sludge valves **6** and the associated motor parts in closed position.

A modified sludge valve construction is shown in Figure 7, wherein the sludge valve is formed from a hollow cylinder **60** closed at one end by a plate **61**, and having a flange portion **60***a* at the other end adapted to engage gasket **2** about opening **9**. Said other end of cylinder **60** is connected to valve stem **24***a* of valve actuating motor **24**. The cylinder is provided with sludge inlet opening **62** and a sludge outlet opening **63**. These openings are adapted to be closed or opened by the walls of the openings **9** of the rotor depending upon the position of the valve in opening **9** of the rotor.

Associated with each of the slidable valves **6**, eight of them being shown in Figure 2, is a sludge valve motor assembly **24**. Each motor assembly **24** has connected thereto a tube or pipe **25** forming a passageway in flow communication with an external source of an auxiliary liquid. In Figure 1 the auxiliary liquid from a supply pipe **26**, under control of a manually operable valve **27** of the fast opening and closing type, is directed upwardly by a spray ring **28** into proximity with the overhanging lip **29***a* of a cup **29** secured to the rotor **11**. The ring **28**, a plan view of which appears in Figure 5, is supported as by a bracket **28***a* secured to the stationary support **13**.

In accordance with the present invention, each of the sludge valves **6** is operated into closed and open position as may be desired. Upon opening of valve **27** as by a lever **27***a*, the auxiliary liquid such as water is directed through each of a plurality of openings **28***b* upwardly passed the inner edge of lip **29***a* and into the annular recess formed thereby, which may be best seen in Figure 3. With the aid of a plurality of fins **29***b*, the auxiliary liquid is quickly brought up to the speed of the rotor **11**. The liquid flows upwardly through each flow channel **30** into one of the connecting passageways or tubes **25**.

Before valve **27** of Figure 1 is opened to admit the auxiliary liquid, centrifugal force, due to the high speed rotation of rotor **11**, developed by motor valve stem **24***a* and piston **24***b*, Figure 3, is effective in maintaining the valve stem **24***a* in the closed position, as shown in Figure 3. Valve stem **24***a* is connected to sludge valve **6** and is of such length as to permit sludge valve **6** to be in closed position as shown in Figure 3, thus permitting the sludge chambers **5** to communicate outside the rotor **11**. Each motor valve-operating assembly **24** is supported by tube **25** brazed to the valve body and it is also supported from inclined surface **11***b* as by the angularly disposed surface **24***f* of the motor valve body. The piston **24***b* is provided with a skirt, the inner finished surface of which slides in substantially liquid-tight engagement with a packing or piston ring **31** supported by the cylinder wall **32**. The diameter of piston **24***b* should be greater than the diameter of valve **6** in order to permit piston **24***b* to move the valve **6** against the existing hydraulic pressure.

An orifice or leak-port **33** is provided in a flow channel or pipe **33***a* diagrammatically shown in Figure 3 as communicating with the pipe or passageway **25**.

With the above explanation of the functional relation of the parts in mind, it will now be assumed valve **27** is opened to admit auxiliary liquid to the annular chamber formed by the skirt **29***a*. As the liquid comes up to speed, it flows upwardly through channel **30** of Figure 3 and outwardly through passageway **25** to the inner chamber **40** of the motor cylinder. Within a short interval of time, of the order of a tenth of a second, the pressure head exerted by the liquid upon the inner face of piston **24***b* due to centrifugal force is adequate to move the piston **24***b* and connected valve stem **24***a* toward the axis of the rotor to the open position, as shown in Figure 3A, to position sludge valve **6** in position so as to permit separated sludge to pass into chambers **5** through paths indicated by arrows **7**.

While the motor pistons are in open position, it will be understood auxiliary liquid will be continuously discharged through orifice **33**, but since the admission of liquid is at a rate materially greater than its flow through orifice **33** the leak-port or orifice does not affect valve operation. However, as soon as supply valve **27** is closed, the passageway **25** is quickly emptied through orifice or leak-port **33** and the motor cylinder moves to the closed position in a time interval of the order of a tenth of a second after closure of supply valve **27**.

As shown in Figure 6, the supply valve **27** may be automatically opened and closed by a timing mechanism shown as including a solenoid **34** whose energization is under the control of a timer **35** of any suitable type of which there are several readily available on the market and known to those skilled in the art. The timer **35** includes a knob **35***a* for adjusting the "on" time of valve **27**, that is, the duration of the period during which it is open, while a knob **35***b* adjusts the "off" time or the period during which the valve **27** is closed. Each period may be readily predetermined by means of the index driven by each knob and the associated scale, suitably calibrated as in minutes and seconds. Thus the "on" and "off" times will be selected in conformity with the requirements of the required operation, whether the main function of the centrifuge be the recovery of sludge present in large quantity, or whether it be clarification of liquids containing only a small amount of sludge, or otherwise. The flexibility and simplicity of the apparatus embodying the present invention makes it particularly useful for a wide variety of applications.

In operation of the apparatus, feed mixture is introduced through feed inlet pipe **15** into the rotor **11**, solids are separated therein and accumulate in the region of the intersection of walls **11***a* and **11***b* adjacent the openings **9** in the rotor wall. When the separated sludge is to be removed, valve **27** is turned on, as previously explained, to feed auxiliary liquid to the inner chamber **40** of the motor cylinder. The sludge chambers **5** are then filled with sludge by action of centrifugal force thereon. Inasmuch as the sludge chambers are preferably of the same capacity, it will be obvious that predetermined or metered amounts of sludge or of sludge plus liquid, will be removed from the rotor each time the sludge valves are moved into closed position. The timer may be set to operate at such a rate that the hourly capacity of the valve chambers will be somewhat greater than the amount of sludge to be discharged per hour, thus assuring that all the sludge will be continually evacuated from the rotor and with no more than a predetermined amount of additional liquids from the rotor. In order to move sludge valves into closed position, the valve **27** is closed whereupon pistons **24***b* are forced outward and away from the axis of the rotor by the action of centrifugal force. The sludge valves **6** are thus moved to their closed position, as shown in Figure 3, whereby the sludge in chambers **5** is discharged outside of the rotor. The sludge in chambers **5** will be rapidly discharged due to the centrifugal force exerted thereon.

The features of the present invention pertain to a process and apparatus for intermittently discharging from a centrifugal rotor a heavier phase such as sludge, and are

not limited to the particular steps, construction or details illustrated and described such as of feed of the mixture to the rotor or discharge of the subsided liquid constituents separately from the rotor, or to the particular construction or type of centrifuges illustrated, or to the shape or construction of the valves or their operating means, or the like. Thus the invention may be employed in connection with a centrifugal rotor of the so-called clarifier type, as illustrated in Figure 2, in which a solid constituent is separated from only a single liquid, or may be employed in connection with a rotor designed to separate two immiscible liquids from each other during intermittent discharge of separated solids, or in connection with any other type of rotor, and irrespective of whether provided with a disc stack, wings, or otherwise.

While for convenience the invention has been more particularly described in connection with the intermittent discharge of measured amounts of sludge from a centrifugal rotor, it is to be understood that it is equally applicable to the intermittent discharge from the rotor of measured amounts of separated heavy liquid phase, such as for example small amounts of aqueous caustic soda which frequently accumulate in a centrifugal rotor as the heaviest phase in the centrifugal separation of soap stock from treated oil in the refining of vegetable oil, or for example for the intermittent discharge of measured amounts of accumulated residual acid such as sulfuric acid in the centrifugal separation of sludge from acid treated mineral oil in the refining of the latter. The invention is likewise applicable to operations wherein a single liquid phase is clarified by the removal of residual amounts of a second heavier liquid phase suspended therein, such as for example in the separation of emulsions. While in the foregoing I have spoken of the intermittent discharge of a heavy solid phase, or a heavy liquid phase, it is to be understood that mixtures of the two are included, and that in fact when a solid phase is intermittently discharged, it is normally in a wet condition due to its contact with the liquid phase or phases from which it has been separated.

The operation and advantages of the present invention will be apparent from the foregoing description. While preferred embodiments of the invention have been described herein, it will be understood that changes, omissions, additions, substitutions and/or modifications may be made within the scope of the claims without departing from the spirit of the invention. Accordingly it is intended that the patent shall cover, by suitable expression in the claims, whatever features of patentable novelty reside in the invention.

I claim:

1. A centrifuge comprising a rotor for effecting centrifugal sedimentation of solids from an admixture with liquid, a radially movable metering member disposed in and extending through the peripheral wall of said rotor, said metering member being closed to the exterior of said rotor and opened to the interior of said rotor for measuring thereinto a quantity of said solids when said metering member is moved radially inward, said metering member being closed to the interior of said rotor and opened to the exterior of said rotor for discharging said measured quantity of said solids when said metering member is moved radially outward, and means for controlling the radial position of said metering member.

2. A centrifuge comprising a rotor for effecting centrifugal sedimentation of solids from an admixture with liquid, a plurality of spaced discharge openings in the periphery of said rotor, a plurality of radially movable solids discharge valves fitted in said openings for controlling the discharge of separated solids through said discharge openings, each of said valves comprising a sludge accumulating chamber, means for moving said valves radially inward to selectively place each of said sludge accumulating chambers substantially simultaneously in communication with the interior of said rotor and to close said chambers against communication with the exterior of said rotor,

and means for moving said valves radially outward to close each of said sludge accumulating chambers substantially simultaneously against communication with the interior of said rotor and to place said chambers substantially simultaneously into communication with the exterior of said rotor to discharge sludge accumulated therein.

3. A centrifuge as defined in claim 2 wherein each of the solids discharge valves are actuated in timed relation by motor means connected thereto.

4. A centrifuge as defined in claim 2 wherein each of the solids discharge valves is cylindrical in shape and provided with a chamber for accumulating solids therein, each of said chambers being of substantially the same capacity, and each said chamber extending to the periphery of the cylindrical valve but spaced inwardly from each end thereof.

5. In a centrifugal separator adapted to effect centrifugal sedimentation of solids from an admixture with liquid and to effect peripheral discharge of said sedimented solids from the rotor of said separator, a discharge passage in the wall of said rotor, a solids discharge valve radially slidable in said discharge passage, said discharge valve comprising a sludge accumulating chamber having passageways adjacent each end thereof and spaced in relation to the wall of said rotor so that when the passageway nearest the axis of rotation of said rotor communicates with the interior of said rotor by movement of said valve radially inward the other opening is closed by the wall of said rotor and when the said other passageway communicates with the exterior of said rotor by movement of said valve radially outward the opening nearest the axis of rotation of said rotor is closed by the wall of said rotor, means for moving said solids discharge valve toward the axis of rotation of said rotor until one of the passageways of said chamber communicates with the interior of said rotor to accumulate sludge therein and means for moving said solids discharge valve away from the axis of rotation of said rotor until the other passageway of said chamber communicates with the exterior of said rotor to discharge accumulated solids therefrom.

6. The combination comprising a centrifugal rotor, means for rotating said rotor, means for feeding into said rotor a mixture of immiscible phases to be separated including at least one liquid phase, means for removing from said rotor adjacent the axis of rotation thereof at least one liquid phase after its separation, means disposed about the inner peripheral wall of said rotor for accumulating a heavy phase, a radially movable metering member disposed in and extending through the peripheral wall of said rotor, said metering member being closed to the exterior of said rotor and opened to the interior of said rotor for measuring thereinto a quantity of said heavy phase when said metering member is moved radially inward, said metering member being closed to the interior of said rotor and opened to the exterior of said rotor for discharging said measured quantity of said heavy phase when said metering member is moved radially outward, and means for establishing and disestablishing within said rotor a liquid column under centrifugal force for radially moving said metering member.

7. The apparatus of claim 6 wherein the means for radially moving the metering member is controlled exteriorly of said rotor.

8. The apparatus of claim 6 including a sealing member at the inner periphery of said rotor for engagement by said metering member when the latter is in radially outward position to seal the interior of said rotor from the exterior thereof by centrifugal force.

9. A centrifuge having a rotor for effecting centrifugal separation of phases, an opening extending through the peripheral wall of said rotor, a metering member disposed in said opening and radially movable therein, said metering member being closed to the exterior of said rotor and opened to the interior of said rotor for measuring thereunto a quantity of separated heavy phase when said metering member is moved radially inward, said metering member being closed to the interior of said rotor and opened to the exterior of said rotor for discharging said measured quantity of said heavy phase when said metering member is moved radially outward, and means for controlling the radial position of said metering member.

10. Apparatus in accordance with claim 9 having a plurality of said metering members substantially equally spaced about the circumference of the rotor, and means for radially moving said metering members.

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