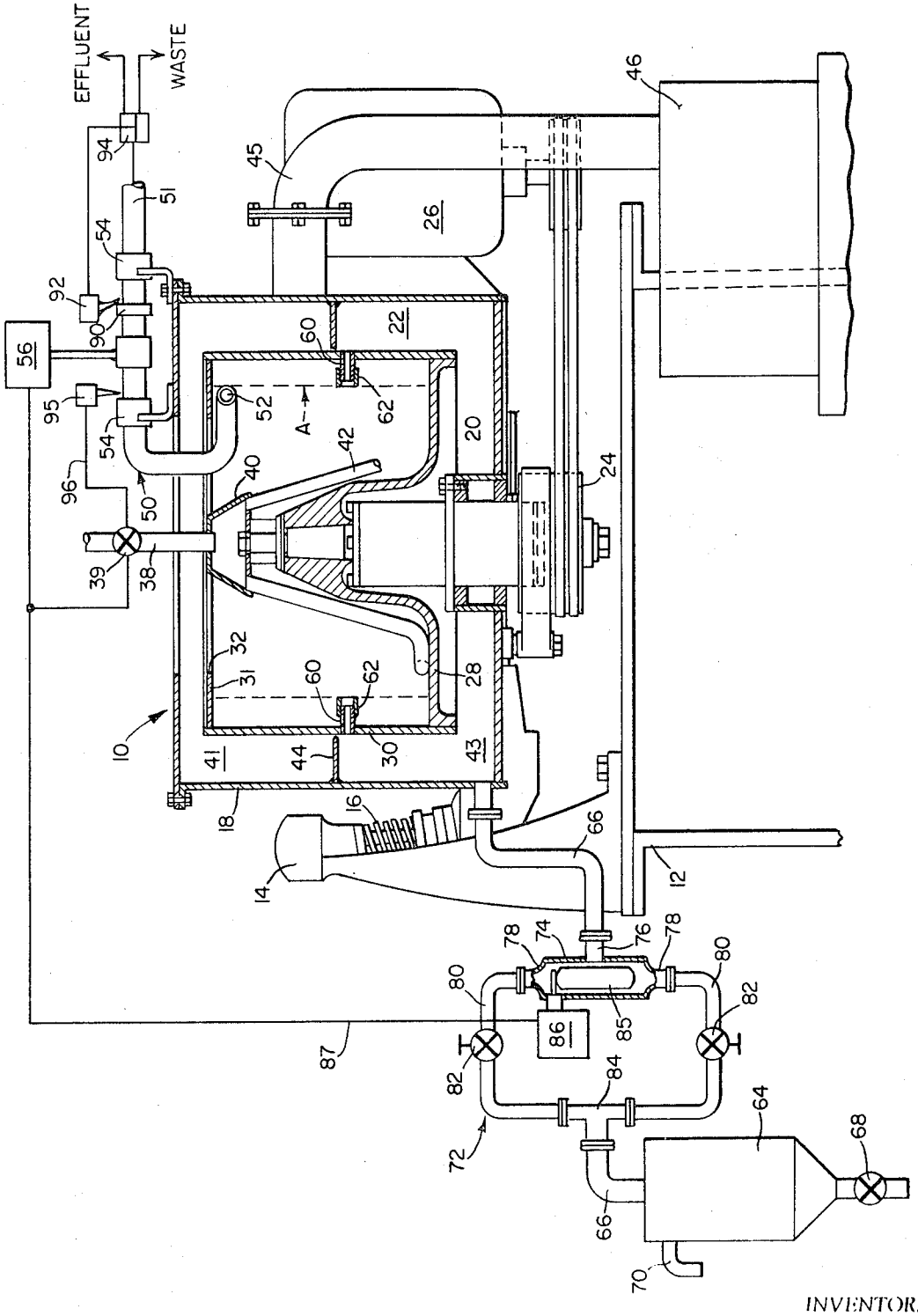
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CENTRIFUGE APPARATUS

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CENTRIFUGE APPARATUS

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ABSTRACT OF THE DISCLOSURE

A heavy phase material, separated from a light phase material and accumulated on the peripheral wall of a centrifuge bowl, is removed from the bowl by a skimmer in response to sensing action of a detector. The latter includes an overflow conduit extending inwardly from an opening in the bowl wall to the maximum desired level of the heavy phase material. The conduit conducts a sample of the material at such level to a gravimetric device which senses an increase in specific gravity above that of the light phase material, as would be occasioned by its contamination with heavy phase material. The device indicates that heavy phase material has accumulated to the maximum desired level and responds by actuating a skimmer for removing the heavy phase material from the bowl.

This invention relates to centrifuge apparatus having a bowl in which light and heavy phase materials are separated from one another and wherein the heavy phase material is discharged from the bowl automatically in response to a signal from specific gravity measuring device located outside the bowl.

The invention is applied to the separation of a light phase material, usually a liquid, from a heavy phase material which may be either a solid material or another liquid of specific gravity greater than the light phase. Therefore, although the invention will be described herein as applied to the separation of solids or sludge from a mixture with a light phase liquid, it is to be understood that it is applicable where two liquids of different specific gravity are separated.

In proir art apparatus, feed is delivered to the bowl and clear effluent is discharged over a lip at one end of the bowl. Accumulated solids often form a cake against the peripheral wall of the centrifuge bowl. After a predetermined period of time, based on experience, which approximates the period required for sludge to build up to the maximum desired level, feed is shut off by the timer and the sludge is discharged. Sludge discharge may be accomplished by a skimmer which first penetrates the inner layer of effluent and discharges the same while the bowl is still rotating; and then as the skimmer reaches the sludge-effluent interface, the operator manually diverts the discharge to waste so as not to comingle the sludge with the effluent already collected. Thereafter, with the sludge removed from the bowl to the extent practicable, the skimmer is returned to its inward rest position and feed to the bowl is resumed.

The foregoing manual or semi-automatic process of the prior art is disadvantageous because the concentration of sludge in the feed is variable and it is therefore not possible to predict with accuracy the time period required to accumulate the maximum desired amount of sludge in the bowl. Thus, if the solids accumulation period is too short the operation of the machine will be inefficient, and if the same period is too long, sludge will contaminate the effluent. In the interest of efficiency, it is also desirable to provide apparatus which discharges solids automatically so that an operator will not be required.

According to the present invention, there is provided inwardly of the bowl an overflow conduit extending

radially inwardly from an opening in the bowl wall to the maximum desired level of the sludge. With this arrangement, a sample of clear effluent will flow through the conduit and out the bowl with low sludge levels. But when the sludge is accumulated to above the maximum desired level, the conduit will discharge a mixture of effluent and sludge to a control tank outwardly of the bowl. It is to be understood, however, that there is also a primary effluent discharge in the form of an overflow lip at one end of the bowl, so that the overflow conduit serves only to extract a small sample of the material in the bowl at the inner end of the overflow conduit. It is contemplated that the control tank will overflow its contents to either the effluent collecting tank, the sludge collecting tank, or the feed supply tank, depending upon the particular process and the composition of the feed. As a novel feature of the invention, a gravimetric type swich is installed in the control tank, or otherwise operatively associated with the sample control liquid, for the purpose of sensing the increased specific gravity of the control material which results when solids are first discharged from the bowl with the effluent. When this condition occurs, the gravimetric switch can automatically terminate introduction of feed to the centrifuge bowl and also initiate the discharge of solids from the bowl.

Various objects, features and advantages of the invention will appear more fully from the detailed description which follows, taken in connection with the accompanying single figure drawing, in which there is shown a partly schematic and partly sectional view of a centrifuge and associated apparatus embodying the invention.

As shown in the drawing, the centrifuge is generally designated by the numeral **10**. The latter includes a base **12** with a plurality of upright standards **14**, only one of which is shown, together with means for suspending a centrifuge housing **18** from the standards. At the lower end of the housing **18** is a bearing **20** which is mounted with a centrifuge bowl **22** on a shaft, the latter having a lower end extending downwardly through the bearing for reception in a pulley **24** driven by motor **26** by suitable belt means.

Preferably the centrifuge bowl **22** is a cylindrical shell including an imperforate bottom wall **28** and a peripheral wall **30**, also preferably imperforate—but not necessarily so. The upper end wall is also imperforate, with an inner annular edge thereof providing a discharge overflow lip **32**. For some applications radial vanes extending in axial direction may be provided interiorly of the bowl **22**, but these are omitted from the present illustration for the sake of brevity and clearness.

Feed slurry is introduced to the bowl **22** through a stationary feed tube **38**, mounted in spaced and coaxial relationship with the upper end of the bowl. The tube **38** is provided with a normally closed solenoid-operated valve **39** which opens when electrically energized. At the top of a bowl hub is provided a feed-receiving cup **40** which rotates with the bowl and receives feed for distribution downwardly and outwardly toward the bottom of the bowl through a plurality of feed conduits **42**, each having outlet openings at their remote ends.

Between the bowl housing **18** and the peripheral wall **30** of the bowl **22**, is an annular space divided into upper and lower portions **41** and **43** by a horizontal annular partition **44**. Preferably, the outer end of the partition **44** is rigidly secured to the housing **18**; and the inner end thereof establishes a seal with the peripheral wall **30** of the bowl **22**. With this arrangement, the upper annular space **41** receives clarified effluent flowing over the overflow lip **32**.

Further provided is an effluent outlet conduit **45** connected to the upper end of the centrifuge bowl housing **18**

for communication with the upper annular space **41**. The conduit **45** connects to an effluent tank **46** for receiving and collecting clarified effluent from the centrifuge bowl.

For removing the sludge in the cyclical operation, the centrifuge is provided with a skimming device **50**. This device includes a tube **51** of substantially J shape which presents an open mouth **52** facing the direction of rotation of the bowl **22**. This skimmer tube **51** is mounted on the housing **18** in a plurality of bosses **54** in which it is longitudinally movable to position the open mouth **52** in various radial positions between the peripheral bowl wall **30** and locations inwardly thereof. Skimming devices are well known in the art, and therefore it will suffice to say that as the skimmer is moved outwardly, deeper into the rotating bowl, a combination of the velocity of the liquid passing into the stationary skimmer tube **51** and the centrifugal pressure head of the material being removed, causes the material to be pumped into and through the skimmer device **50**.

Means for driving the skimmer device **50** are provided in the form of a traversing mechanism indicated generally by the numeral **56**. Such means may comprise a pair of pneumatic piston-cylinder assemblies which are well known as suitable to drive the skimmer tube **51** alternately forward and back. The arrangement is such that, at one extreme of movement, the skimmer tube **51** is disposed with its mouth **52** inwardly of the lip **32** and therefore out of contact with the material in the centrifuge bowl **22**. At the other end of its travel the skimmer mouth **52** has small clearance, e.g. ¼ inch, between its structure and the peripheral wall **30** so that it is capable of removing virtually all of the sludge accumulated within the bowl. Limit switches or valves may be provided for cooperation with the skimming device **50** at opposite ends of travel, together with reversing valves or switches for effecting reverse movement of the driving means.

Referring now more particularly to the inventive subject matter, the control device includes one or more control tubes **60** leading from an opening in the peripheral wall **30** in which it is sealed, securely mounted as by a threaded connection, and oriented in radial and horizontal direction to extend inwardly of the bowl **22**. The inner end of each tube **60** may be threaded and fitted, as shown, with a nozzle **62**. It is contemplated that nozzles **62** of various lengths and orifice size will be provided with the apparatus so that the total radial extent of the tube **60** and also its flow area can be adjusted.

As will appear more fully, adjustment of the radial inward extent of tube **60** is to the level of the maximum desired accumulated sludge within the bowl **22**, as indicated by the broken line designated A. Since such maximum desired accumulation can vary from application to application, this means of adjustment is believed to be economical, convenient, and effective. With this arrangement, the tubes **60** conduct a sample of material, taken from the inner end of the nozzle **62**, and discharge it into the lower annular space **43**. This sample material, which may be also termed "control liquid," is conducted to a control tank **64** by means of a conduit **66** connected between the centrifuge housing **18** and the tank **64** for communication with the lower annular space **43** and the interior of the tank **64**.

At the bottom of the tank **64** is a discharge valve **68** which is normally closed but which may be opened to discharge accumulated sludge. At the top of the tank **64** is an overflow pipe **70** for discharging control liquid, from which solids may have settled, either to the effluent collecting tank **46**, to a feed supply tank (not shown), or to a sludge receiving tank (not shown).

Connected between the opposite ends of the conduit **66** is a detecting device generally indicated by the numeral **72**. Such device is commercially available from the Fisher Governor Company and, as described in their Bulletin F–4–C, as on pages 32 and 33, their type 2500–259–B control is responsive to changes in specific gravity of liquid flowing therethrough. The device **72** may include an elongated tubular member **74** having an inlet **76** midway along its length to provide for divided flow toward opposite outlet ends **78** thereof. Parallel pipes **80** are connected to the respective outlet ends **78** and each are provided with manually operable flow valves **82** which are adjustable to effect balanced outlet flow through the pipes **80**. A downstream T connection **84** to the pipes **80**, merges the divided flows for continued conduction through the balance of the conduit **66** to the tank **64**. Disposed in the tubular member **74** is a float or displacer **85** which is displaced to an extent related to the specific gravity of the flowing material conducted thereby and transmits small changes in specific gravity by mechanical means to a control box **86**. The control box **86** is suitably energized by a source of electrical power (not shown) and responds to a predetermined displacement of the float **85** by transmitting an electrical signal through line **87** to the solenoid-operated valve **39** and the traversing mechanism **56**.

From the foregoing it can be seen that, in operation, when accumulated sludge or heavy phase material is acculated above the level A, it will be discharged at least in part with the light phase effluent through the control tube **60** for passage through the lower annular space **43**, thence through the conduit **66** and the tubular member **74** where an increase in specific gravity is detected. Flow continues on to the tank **64**, with effluent overflowing through the pipe **70** and solids settling to the bottom of the tank **64**. The control box **86** responds to the detected increase in specific gravity by effecting closure of the valve **39** to interrupt the inflow of feed to the centrifuge bowl **22**. The control **86** also effects outward traversing movement of the skimmer device **50** in order to empty the bowl **22** of both effluent and accumulated solids.

Optionally, valve **68** can be a normally closed solenoid-actuated valve which is connected by a suitable lead to control **86** to be opened when energized for automatically draining the contents of tank **64**.

In order to segregate the clarified effluent from the accumulated solids removed by the skimming device **50**, a lug or protuberance **90** is rigidly or adjustably mounted on the skimming device between the bosses **54**. Also provided, is a limit switch **92** which is actuated by the lug **90** in either direction of travel of the skimming device. The limit switch **92** is connected, as shown, to a solenoid-operated diversional valve **94** arranged so that when the limit switch **92** is tripped in one direciton, as when the skimmer is driven outward toward the bowl wall, the solenoid-operated diversional valve **94** is thrown to the "waste" position to discharge heavy phase material as the mouth **52** of the skimmer reaches the line A. By return of the skimmer when the lug **90** engages the limit switch **92**, the solenoid-operated diversional valve **94** is operated in the reverse direction to divert the flow of discharging material to the "effluent" position. With this arrangement, effective segregation of clarified effluent and accumulated solids is effected, since the light phase material is discharged to one discharge line and the heavy phase is discharged to another discharge line. The light phase effluent thus discharged can be conducted to the tank **46**.

Further provided is a limit switch **95** which is actuated by the traversing mechanism as it returns with the skimming device **50** to the reset or innermost position. Actuation of the limit switch **95** resets the valve **39** and the control **86** for the next cycle. In addition, if valve **68** is a solenoid-actuated valve, according to the option described above, the limit switch **95** also serves to close the drain valve **68** by deenergizing its solenoid.

It is also optional, in some applications, to eliminate the tank **64** and discharge the sample material from the end of conduit **66** after flowing through the tubular member **74** and the pipes **82**.

It is to be understood that, although the invention has been shown and described as having a particular kind of detecting device **72**, the invention can be practiced with other kinds of devices which are responsive to changes in specific gravity of the control material. For example, a

float type gravimetric switch can be disposed in the tank **64**. Likewise, various other changes and modifications can be made to the illustrated arrangement without departing from the broad concept of the invention.

What is claimed is:

1. In centrifuge apparatus including a rotatably mounted centrifuge bowl having an annular inwardly extending liquid overflow lip formed about the rotational axis at at least one end, means for feeding to the bowl a mixture of at least two materials wherein the first material thereof has a higher specific gravity than the second material therof and whereby said first material builds up against the peripheral wall of the bowl, means for discharging an accumulation of said first material from the bowl, and that improvement comprising means for indicating when said first material has accumulated in the bowl to a predetermined level inward of the peripheral wall and outward of said lip, and means responsive to indication by said indicating means for initiating said means for discharging said first material from the bowl, said indicating means including a tubular passageway extending through the peripheral wall of the bowl inwardly of the bowl to said predetermined level for conducting material out of the bowl, means for receiving the material conducted out of the bowl by said passageway, and means operatively associated with said receiving means for detecting an increase in specific gravity of the material in said receiving means above the specific gravity of said second material for indicating to said initiating means that the material in said receiving means includes at least some of said first material together with said second material, whereby said second material is automatically discharged by said discharging means from said bowl when the accumulation of said first material in said bowl reaches said predetermined level.

2. Centrifuge apparatus according to claim **1** further including valve means for interrupting the operation of said feeding means in response to an indication by said indicating means.

3. Centrifuge apparatus according to claim **1** wherein said tubular passageway includes a removable nozzle on the inner end thereof.

4. Centrifuge apparatus according to claim **1** wherein the indicating means is a float member displaced to an extent related to the specific gravity of the material contacted thereby, and an electrical device responsive to a predetermined displacement of said float member for transmitting a signal to initiating means.

5. Centrifuge apparatus according to claim **4** further including means for collecting said second material outside said bowl, and a housing for said bowl disposed about said rotational axis and defining an annular space about said bowl, a partition dividing said annular space into upper and lower portions, one of said portions of said annular space communicating between said passageway and said receiving means, and the other of said portions of said annular space communicating between the overflow lip and said collecting means.

6. Centrifuge apparatus according to claim **1** wherein said peripheral wall of said bowl is of imperforate construction, the buildup of said first material against the peripheral wall taking place beneath an inwardly disposed layer of said second mateiral, and wherein a major portion of said second material overflows said lip as said first material is accumulating in said bowl.

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