Aug. 26, 1969 B. A. FIERSTINE 3,463,316

CENTRIFUGAL SEPARATING SYSTEM

Filed June 19, 1968 3 Sheets-Sheet 1

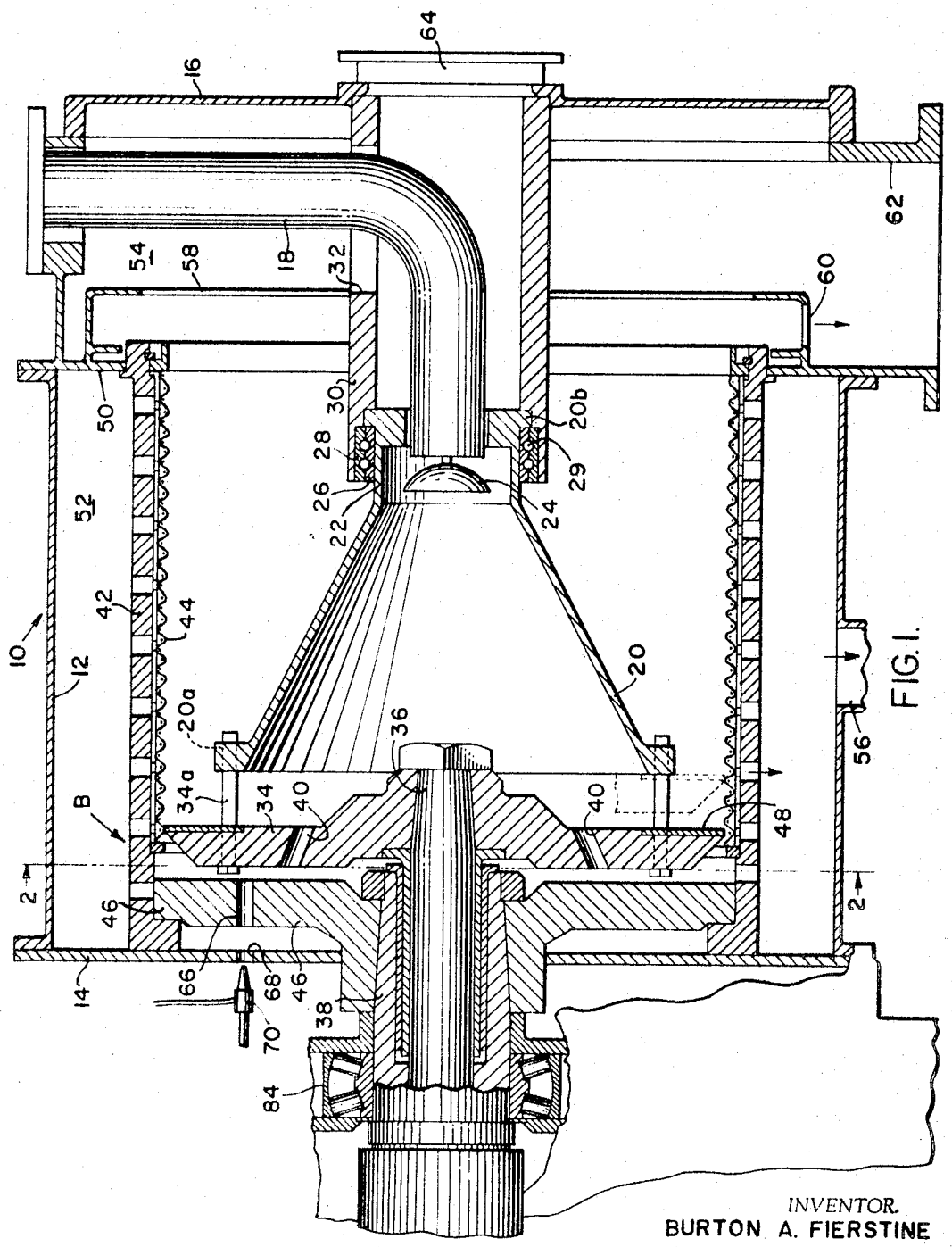

FIG. 1.

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CENTRIFUGAL SEPARATING SYSTEM

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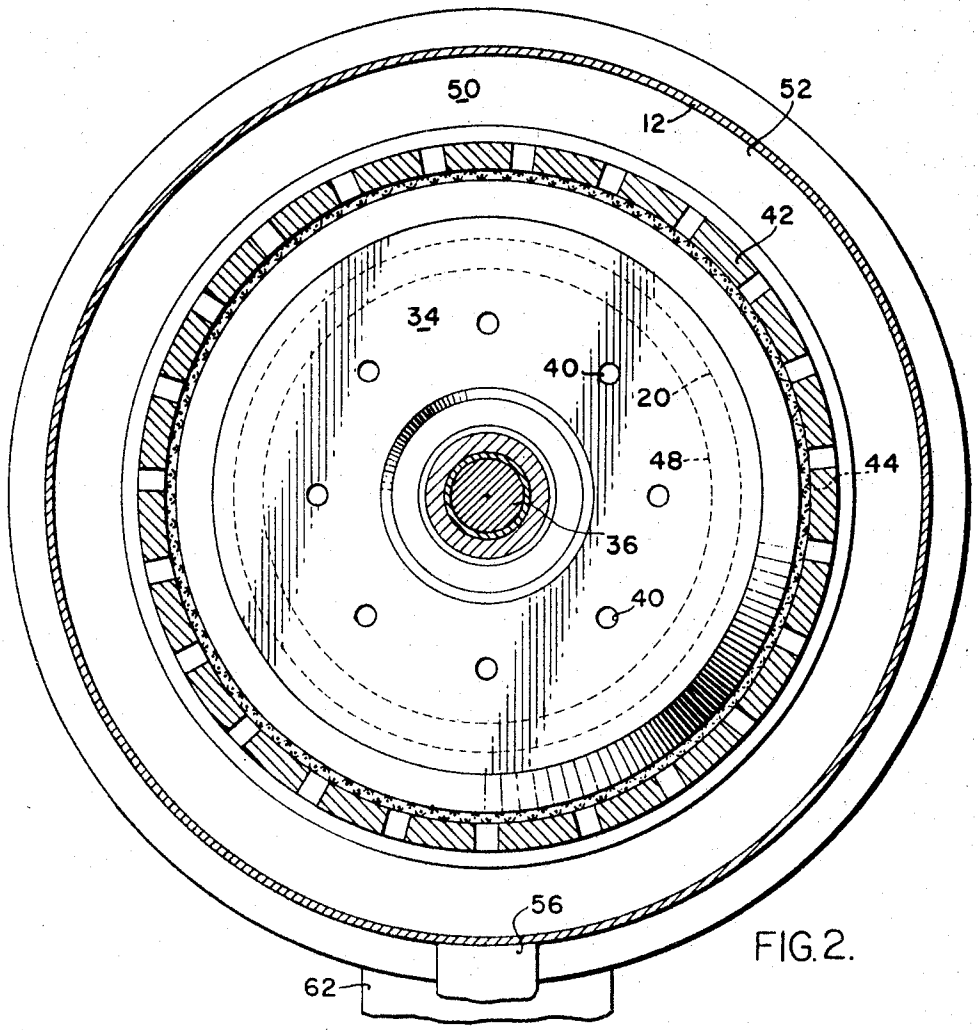

FIG. 2.

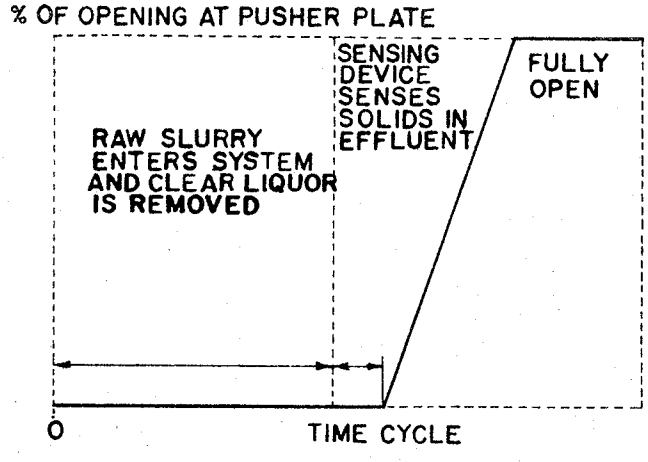

FIG. 4.

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CENTRIFUGAL SEPARATING SYSTEM

Filed June 19, 1968 3 Sheets-Sheet 3

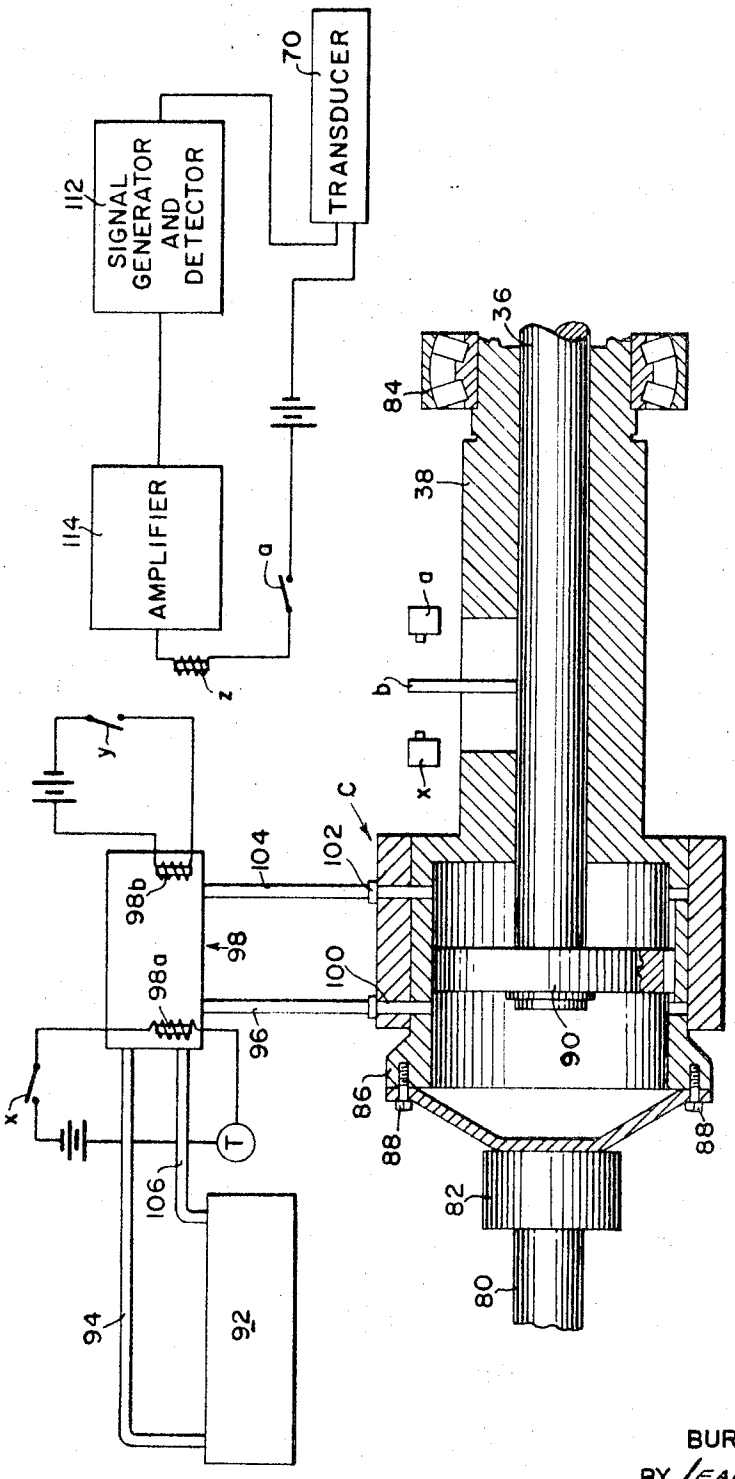

FIG. 3.

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3,463,316

CENTRIFUGAL SEPARATING SYSTEM

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Int. Cl. B04b 3/00; B01d 33/02
U.S. Cl. 210—78 19 Claims

ABSTRACT OF THE DISCLOSURE

A centrifugal separating system for separating solid materials from liquid slurries or mixtures containing the same wherein the slurry or mixture is rotated in a circumferentially enclosed space for a time interval while liquid is axially drawn off and then is released to a rotating perforated surface for another time interval during which the remainder of the liquid is drawn off. The efficiency of the separating function in the first instance is controlled by a transducer which monitors the density of the effluent liquid of the system.

BACKGROUND OF THE INVENTION

Field of the invention

A liquid-solid separating system employing a centrifugal separator having an axially movable means for controlling the preremoval or separation function automatically.

Description of the prior art

Continuously operating push-type, single stage centrifuge systems have long been employed for effecting the separation of liquid and solids. Since many of the mixtures and slurries to be separated are quite viscous, many of the known push-type single stage centrifuge systems employed long baskets or screens to retain the caked solids collected thereon for a sufficient amount of time to achieve the desired degree of dryness. Another factor influencing the length of the basket or screens deals with a preliminary separating step which may be performed initially as the slurry enters the system. During this initial period, a preremoval of the greater proportion of the mother liquor may be effected prior to the admission of the material into the main centrifugal basket or screen. Manifestly, if the preremoval function is reasonably efficient, a shorter basket or screen can be utilized in the main centrifuge station. Thus, by restricting the size of the basket or screen, less force will be required to discharge the solid caked material therefrom.

Summary

One of the primary objects of the invention is to produce a centrifugal liquid-solid separating system which incorporates means for preremoval of a maximum portion of the liquid from a liquid-solid mixture prior to the time the mixture is allowed to pass to the main centrifugal separating basket and senses solid content in the effluent to automatically admit the pretreated mixture to the main separating basket to allow the solids to immediately form a firm cake thereon which can be readily removed.

Other objects of the invention may be achieved by a centrifugal separating system having a separating drum and an end wall therefor, drive means for moving one of said end wall and drum axially relative to one another; means for rotatably supporting said drum; and an imperforate distributor shell disposed in concentric relation with said drum and mounted for rotation therewith, said shell having a tapering interior surface with its end of largest diameter spaced from said end wall to

form a feed passage therebetween; means revolving said drum and end wall; means for feeding a liquid and solid mixture to the opposite end of said distributor; signal generating means connected to said drive means for monitoring a solids content in the effluent flowing through said feed passage whereby when a predetermined quantity of solids is sensed by said signal generating means, a signal is generated to effect energization of said drive to move said end wall relative to said drum.

Brief description of the drawings

The above, as well as other, objects and advantages of the invention will be readily apparent to those skilled in the art from considering the following detailed description of an embodiment of the invention in the light of the accompanying drawings, in which:

FIGURE 1 is a fragmentary elevational view, partly in section, illustrating a centrifugal separating apparatus embodying the features of the invention;

FIGURE 2 is a sectional view of the apparatus illustrated in FIGURE 1 taken along line **2—2** thereof;

FIGURE 3 is a schematic illustration of the circuitry involved for effecting the energization of the drive means for controlling the preremoval of liquor from the liquid-solid mixture being treated; and

FIGURE 4 is a diagram illustrating a portion of the duty cycle of the apparatus illustrated in FIGURES 1, 2 and 3.

Description of the preferred embodiment

Referring to FIGURES 1 to 3 of the drawings, there is illustrated a centrifugal separating system including a centrifugal separating machine having a main liquid housing **10**. The main housing **10** is provided with a substantially cylindrical side wall **12**, a back plate or end wall **14**, and an access plate or panel **16**. The housing **10** is further provided with a charging pipe **18** for the introduction of the liquid- solid slurry to be treated. The charging pipe **18** is disposed centrally of an opening in the apex end of a frustoconically shaped accelerating funnel member **20**. A flow distributing device **24** is mounted at the outlet end of the charging pipe **18** adjacent the apex of the funnel member **20**. A cylindrical extension **22** of the apex end of the funnel member **20** is mounted within an inner race **26** of a bearing structure, while an associated outer race **28** is mounted within the innermost end of a horizontally disposed support tube **30**. Ball bearings **29** are disposed between the inner race **26** and the outer race **28** to enable the accelerating funnel member **20** to be rotated relative to the support tube **30**. It will be seen from an examination of FIGURE 1 that the support tube **30** is provided with an aperture **32** through which extends the charging pipe **18**.

Immediately adjacent the larger open end of the funnel member **20** is a pusher plate **34** secured to one end of a shaft **36** which extends into and through an exterior shaft **38**. The pusher plate **34** is provided with an annular array of radially inwardly disposed fluid passages **40** extending therethrough. Pusher plate **34** and the accelerating funnel member **20** are interconnected in such fashion that they rotate in unison by any suitable means such as pins **34***a* of square cross section fixed on the pusher plates **34** which are slidably received in openings **20***a* of like cross section in the funnel **20** so that the pusher plate **34** may be moved axially relative to the funnel member **20**. At its front end funnel **20** is prevented from moving axially by the flange **20***b*.

Within the housing **10**, coaxially of the cylindrical side wall **12**, is a drum or basket B which includes a perforated cage **42** having a cylindrical formed interior screen **44** supported therein. The basket B further includes a hub **46** which is keyed or otherwise suitably affixed to the

end of the shaft **38**. The coaxially arranged shafts **36** and **38** are drivingly connected to a prime mover, not shown, which is capable of imparting rotary movement thereto. The shaft **36** is also movable axially with respect to the shaft **38** and is operated by circuits illustrated in FIGURE 3 to be explained in greater detail hereinafter.

The pusher plate **34** is provided with a pusher ring **48** suitably affixed to the peripheral marginal edges thereof. The marginal edge of the pusher ring **48** is in close proximity to the innermost surface of the screen **44**. It will be noted that the face of the pusher plate **34** facing the hub **46** is spaced sufficiently from the facing surface of the hub **46** to provide a fluid passage therebetween which communicates with the interior of the funnel member **20** through the fluid passages **40**.

The main housing **10** is partitioned by an apertured partitional wall **50** into a wet housing **52** and a dry housing **54**. The wet housing **52** is typically drained off through a discharge pipe **56**. While the wet housing **52** is illustrated as a single unobstructed chamber with a single outlet, it will be understood that in certain applications of the apparatus of the invention, the wet housing **52** may be divided into a plurality of individual chambers all in communication with the perforated cage **42** of the drum or basket B. In such an embodiment, each of the chambers is provided with a separate discharge pipe.

Communicating with the open end of the drum or basket B and disposed within the dry housing **54** is a discharge ring **58** having an opening **60** at the bottom thereof. Further, the dry housing **54** is provided with a solids material discharge opening **62**.

The structure thus far described may typically contain a sight glass assembly **64** disposed in the access plate **16** for visual inspection of a portion of the interior of the main housing **10** particularly in the region of the dry housing **54**.

The basket hub **46** is bored as at **66** in radial alignment with a sighting aperture **68** formed in the end wall **14** of the main housing **10**. A transducer device **70** is mounted exteriorly of the main housing **10** in alignment with the aperture **68** and the bore hole **66**.

The shafts **36** and **38** are drivingly interconnected through a pusher control assembly C (illustrated in FIGURE 3) to the output shaft **80** of a prime mover capable of driving the shafts at any desired speed. Spaced apart bearing assemblies **82** and **84** are employed to rotatingly support the shafts **36**, **38** and the control assemblyy C. Formed as an integral portion of the shaft **38** is a fluid actuated cylinder **86**, the two portions of which are suitably secured together by threaded fasteners **88**. A piston **90**, keyed to the cylinder **86** so as to rotate therewith, is disposed within the cylinder **86** and is caused to reciprocate therein as will be explained hereinafter. The pusher control assembly C is of conventional design and is provided to control the forward movement of the piston **90** and the associated shaft **36** by admission or introduction of pressure fluid from a reservoir **92** provided with a suitable pump, through lines **94**, **96**, solenoid actuated valve **98**, and the port **100**. Upon such actuation, pressure fluid is admitted to the interior of the cylinder **86** to act against the outer face of the piston **90**, causing the shaft **36** to force the pusher plate toward the accelerating funnel member **20**. Simultaneously, fluid on the opposite face of the piston **90** is allowed to return to the reservoir **92** through the port **102**, lines **104**, **106**, and the solenoid actuated valve **98**. The opposite movement of the piston **90** and associated shaft **36** is controlled by the introduction of pressure fluid from the reservoir **92** through the lines **106**, **104**, the solenoid actuated valve **98**, and the port **102**. Simultaneously, pressure fluid is allowed to return to the reservoir **92** from the other face of the piston **90** through the port **100**, lines **96**, **106**, and the solenoid actuated valve **98**. The reciprocal movement of the piston **90** and the associated shaft **36** is typically limited by appropriate stops, not shown.

The solenoid actuated valve unit **98** includes solenoids **98***a* and **98***b* which are operative to actuate suitable valves upon an energization thereof through closing of switches *x* and *y*. The normally open switch *x* is closed by the return of pusher **34** to outward position and closes a time delay switch or timer T. The normally open switch *y* is closed by a relay *z* energized by the transducer device **70** which is electrically coupled thereto through a signal generator and detector circuit **112** and an amplifier circuit **114**. The switch *x* and a switch *a* may be provided in the path of an actuator bar *b*, as shown in FIGURE 3. The transducer **70** may be of an ultrasonic type such as is illustrated and described in United States Patent No. 2,966,057 entitled "Apparatus for Measuring Attenuation of Ultrasonic Energy," Robert B. Heller. More specifically, the transducer **70** includes an electromagnetic stage for converting electric energy into mechanical energy which is transmitted through the aperture **68** of the back plate **14** of the housing **10** and the bore hole **66** of the hub **46**, and thence through the effluent liquor traveling through the fluid passage between the pusher plate **34** and the hub **46**. A second stage of the transducer **70** receives the mechanical vibrations transmitted through the material being treated which is reflected back from the pusher plate **34**.

The effluent liquor and solids (when they appear)

These vibrations are then converted into electrical oscillations, the frequency of which is measured and is an indication of the attenuation or reflection suffered by the transmitted ultrasonic energy. The frequency of the chopped signal output is a function of the density of the transient fluid flowing through the fluid passage between the pusher plate **34** and the hub **46**. Accordingly, the frequency of the reflected or retransmitted energy becomes a function of the solids content in the transient fluid being sensed by the transducer **70**.

In operation, as indicated generally in the diagram illustrated in FIGURE 4, the raw slurry to be treated continuously enters the rotating accelerating funnel member **20** at its small end where the peripheral speed is relatively low through the feed or charging pipe **18**. As the slurry passes down the inner face of the rotating funnel member **20**, it is gradually accelerated until it reaches the large end thereof. At the start up of the operating cycle, the piston **90** of the cylinder **86** has forced the pusher plate **34** against the larger end of the funnel member **20** as shown in dotted lines in FIGURE 1. At this time the rotating slurry initially comprises a radially outer annulus of liquid rich in solids and a radially inner annulus of liquid. The output shaft **80** has caused the cooperatng shafts **36** and **38** to rotate, thereby simultaneously rotating the hub **46** and the associated basket B, the pusher plate **34**, and the associated accelerating funnel member **20**. During this preremoval or preconcentration period, a portion of the liquid content which has been centrifugally separated from the slurry is caused to flow through the fluid passage between the pusher plate **34** and the hub **46** and thence to the wet housing **52** through the screen **44** and the perforated cage **42** of the rotating drum or basket B. Finally, the liquid is carried from the system through the outlet pipe **56**. As the solids content in the transient liquid increases because the outer annulus is entrapped, such increase is sensed by the scanner **70** and when the density thereof reaches a predetermined level the scanner **70** energizes the relay *z* to close switch *y* and energize solenoid **98***b* to actuate the valve **98** to allow pressure fluid to be admitted into the cylinder **86** through the lines **104** and inlet **102**. At the same time, pressure fluid discharges through lines **96** and **106** and the piston and associated shaft **36** are moved to the left as illustrated in FIGURE 3, causing the associated pusher plate **34** to move to the full line position illustrated in

FIGURE 1. Through the centrifugal action, the slurry is now deposited on the internal screen surface **44** which lines the inner face of the basket B and the liquid content thereof is spun outwardly into the wet housing **52**. This procedure is carried on for a predetermined timed cycle. When the plate **34** is moved outwardly switch *x* was closed and the timer T is started so that after a predetermined interval solenoid **98***a* is energized when time delay device T times out. Valve **98** is accordingly actuated to cause pressure fluid to be admitted to the cylinder **86** through the line **96** and inlet **100** once again while discharging through lines **102** and **94**, forcing the pusher plate **34** again into position against the ring of the rotating accelerating funnel member **20**. As the pusher plate **34** and associated pusher ring **48** moves forward, it forces the solids material which have formed a cake on the internal screen **44** across the face of the rotating basket B. The filter cake (equal in thickness to the difference in the diameter of the outer edge of the funnel member **20** and the screen lining **44** of the basket B) is gradually pushed across the screen, and flies off into the dry collector housing **54** through the outlet ring **58** and is finally exhausted from the system through the outlet **62**. Obviously, simultaneously the mother liquor after passing through the screen **44** and the openings in the perforated cage **42** is collected in the wet housing **52** and discharged through the outlet **56**. If washing is desired, a wash spray may be provided for even distribution of the wash liquid into the cake. While the transducer system is preferred, it may be possible with slurries having a very uniform character to substitute a time delay device T for the members **70**, **112**, and **114**.

I claim:

1. A method of separating the components of a slurry having liquid and solid components comprising the steps of:

rotating the slurry in a circumferentially enclosed space to tend to form a radially outer rotating slurry annulus enriched in solids and a radially inner rotating slurry annulus more free of solids while blocking the discharge end of said space adjacent the outer annulus for a period of time;

removing liquid components axially from the inner annulus during said period of time;

opening the discharge end of said space adjacent said outer annulus during another interval of time to release concentrated slurry;

and receiving the concentrated slurry on a perforate revolving surface to radially express liquid remaining in the slurry therethrough by centrifugal force.

2. The method of claim **1** wherein slurry is continuously fed to a charge end of the space.

3. In a centrifugal separating system:

perforate drum means;

pusher wall means therein;

a frustoconical accelerator tube in said drum means having one end connected to said pusher wall means for rotary movement therewith;

means for rotating said perforate drum means and for rotating said pusher wall means;

and means for moving said pusher wall means toward said tube for a concentrating interval and thence moving it away from said tube for an interval during which concentrated slurry is released from the tube radially to the perforate drum means.

4. A method of separating the components of a slurry having liquid and solid components comprising the steps of:

rotating the slurry in a circumferentially enclosed space having a restricted discharge;

monitoring the discharge to determine when a predetermined concentration of one component has been reached therein;

and, when said concentration is reached, rotating the concentrated slurry in a perforate peripheral drum portion to separate the liquid components radially through the perforate portion while the heavy components remain therein.

5. In a centrifugal separating system for slurries having solid and liquid components:

a separating drum assembly including a radially outer perforate peripheral portion and a radially inner imperforate peripheral portion;

means for rotating said assembly;

generally radial wall means for substantially closing the imperforate portion but leaving passage means leading to said perforate portion;

means mounting said wall means and imperforate portion for relative axial movement;

means for sensing when the content of one of the components moving through said passage means reaches a predetermined concentration value; and

means operated responsively to said sensing means for moving said wall means and imperforate portion relatively axially apart when said value is reached.

6. The system of claim **5** wherein said imperforate portion comprises a tube inside said perforate portion and into one end of which said slurry is fed.

7. The system of claim **6** wherein said wall means comprises a pusher wall received within said perforate portion to scrape the inner peripheral wall thereof; and means is provided for moving said wall toward and away from the opposite end of said tube.

8. The system of claim **7** wherein said tube is frustoconical in shape and flares in a direction toward said pusher wall.

9. The system of claim **7** wherein, when said wall is adjacent the tube, said perforate portion is behind the wall and passage means is provided through said wall to communicate with said perforate portion.

10. The system of claim **7** wherein means feeds slurry continuously to said one end of the tube; and said means for moving said wall is governed by timer means which holds said wall away from said opposite end of the tube for a predetermined time after which said wall is moved again toward said tube.

11. The system of claim **7** wherein said tube is connected to said wall for rotary movement therewith.

12. A method of preconcentrating a mixture of liquids and solids which includes the steps of:

introducing a mixture of liquid and solids to an enclosure having outlet means which is enlargeable;

subjecting the mixture to centrifugal action to remove a substantial portion of the liquid content from the mixture within the enclosure through the outlet means before it is enlarged; and

sensing the density of the effluent liquid and enlarging the outlet means of the enclosure upon an increase in density thereof above a predetermined level.

13. The method defined in claim **12** which includes the step of closing the outlet after a predetermined timed interval.

14. A centrifugal separating system having:

a separating drum;

a pusher plate assembly forming an end wall therefor;

drive means for moving one of said drum and said pusher plate axially relative to one another;

means for rotatably supporting said drum and said pusher plate;

an imperforate distributor shell disposed in concentric relation with said drum and mounted for rotation therewith, said shell having a tapering interior surface with its end of largest diameter disposed in facing relation with said pusher plate whereby when said pusher plate is moved axially away from the shell by said drive means a fluid material passageway is formed therebetween;

means for feeding a liquid and solid mixture into the interior of said distributor shell through the opposite end;

means for imparting rotating movement to said drum, pusher plate, and distributor shell; and

signal generating means connected to said drive means for monitoring the solids content in the fluid material flowing through said fluid material passageway whereby when said signal generating means senses a predetermined density of the fluid material a signal is generated to effective energization of said drive means to move said pusher plate axially relative to said drum.

15. The system defined in claim **14** wherein said pusher plate is provided with a plurality of passageways therein for the passage of the fluid material from the interior of the distributor shell to a sensing relation with said signal generating means.

16. The system defined in claim **14** wherein a timer effects reverse axial movement of said pusher plate to return the same to its initial position upon the expiration of a timed cycle.

17. Apparatus for separating the components of a slurry having liquid and solid components comprising:

concentrating housing means providing a circumferentially enclosed space having a discharge end;

means for rotating the housing and thereby said slurry in said circumferentially enclosed space to tend to form a radially outer rotating slurry annulus enriched in solids and a radially inner rotating slurry annulus more free of solids;

means for substantially blocking the discharge end of said space adjacent the radially outer portion of the housing means and outer annulus for a period of time;

means for receiving liquid components from the inner annulus during said period of time;

means for unblocking the discharge end of said space adjacent said radially outer portion of the housing and outer annulus during another interval of time to release concentrated slurry; and

a perforate revolving surface for receiving the concentrated slurry to radially express liquid remaining in the slurry therethrough by centrifugal force.

18. Apparatus for separating the components of a slurry having liquid and solid components comprising:

housing means having a chamber with a discharge opening;

means for rotating said housing means and the slurry in said chamber and centrifugally separating it into more and less liquid annulus portions;

means for receiving the more liquid portion out said discharge opening;

means for monitoring one of said portions to determine when a predetermined concentration of one component has been reached therein;

a perforate peripheral revolvable drum portion for receiving the less liquid portions to separate the liquid components radially through the perforate portion while the heavy components remain thereon;

means controlled by said monitoring means for passing the less liquid portions to said drum portion when said concentration is reached;

and means for revolving said drum portion at a speed to centrifugally separate liquid components from the solid components.

19. Apparatus for preconcentrating a mixture of liquids and solids comprising:

an enclosure having outlet means which is enlargeable;

means for introducing a mixture of liquids and solids thereto;

means for revolving the enclosure and subjecting the mixture to centrifugal action to remove a substantial portion of the liquid content from the mixture within the enclosure through the outlet means before it is enlarged;

and means for sensing the density of the effluent liquid and enlarging the outlet means of the enclosure upon an increase in density thereof above a predetermined level.

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JAMES L. DECESARE, Primary Examiner

U.S. Cl. X.R.

210—96, 376, 377