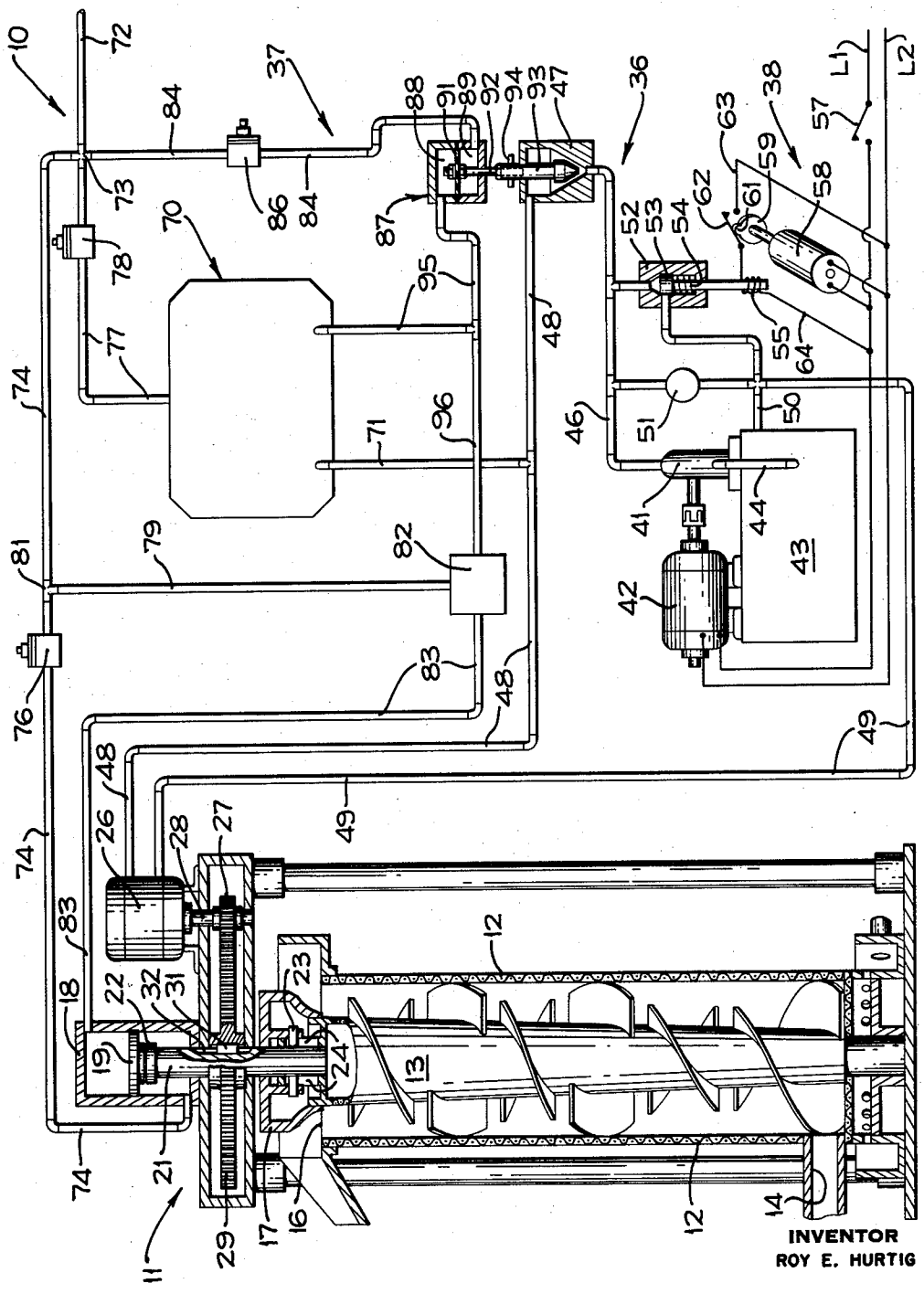
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CONTROL SYSTEM FOR A PRESS

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CONTROL SYSTEM FOR A PRESS

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The present invention pertains to a press and more particularly to a control system for maintaining the density of solid material discharged from a screw press constant.

Since in many cases the slurry entering a screw press varies considerably in liquid content, it has not always been possible to maintain the density of the discharged material constant with certain known density controls. In one well known type of screw press the density of the material expressed from the press is controlled by a choke which varies the size of the opening through which the solid material passes as it is discharged from the press. It will be understood, when handling slurries which are wetter or drier than normal in this type of press, that the choke will be moved toward closed or open positions, respectively, in an attempt to maintain the density of the expressed material constant.

One disadvantage of controlling the density of the discharged material by means of a choke alone, is that the expressing force applied to the material is not evenly distributed along the screw but is concentrated near the choke. Accordingly, the choke type control cannot satisfactorily handle large variations in the liquid content of the slurry.

In accordance with the present invention a screw press is provided having a variable speed screw which cooperates with the choke and maintains the density of the discharged material constant when handling an incoming slurry having large variations in the liquid content of the slurry. When the position of the choke is held constant, it has been determined that an increase in the speed of the screw results in a decrease in the density of the expressed material because the material travels through the press at a rate which will not allow ample time for the liquid to be forced from the solids. Conversely, a decrease in the speed of the screw results in an expressed material of higher density since the material remains in the press a longer time permitting more liquid to be forced out of the solid material. By simultaneously varying the position of the choke and the speed of the screw, the compressive force is more evenly distributed along the length of the screw and accordingly the press operates more efficiently.

Furthermore, the control system of the present invention responds to changes in torque demainds of the expressing screw to vary both the size of the discharge opening and the speed of the screw in order to distribute better the forces acting on the material and to achieve an expressed material of constant density.

Accordingly, it is an object of the present invention to provide a control system for maintaining the density of material expelled from a screw press constant regardless of relatively large variations in the liquid content of the processed slurry.

Another object is to provide a control system for continuously maintaining the density of material expelled from a screw press constant in response to incremental changes in reaction torque acting on the screw.

Another object is to provide a control system for maintaining the density of the material expelled from a screw press constant while distributing the expressing force acting on the material more evenly throughout the length of the screw.

These and other objects and advantages of the present invention will become apparent from the following description and the accompanying drawing which is a vertical central section through a screw press, and which diagrammatically illustrates the control system of the present invention.

The embodiment of the invention illustrated in the single drawing includes the control system **10** of the present invention which controls the actuation of a vertical screw press **11**, which can be of the type disclosed in the United States Letters Patent of Dudley W. Hayes, Patent No. 3,035,511, dated May 22, 1962.

The screw press **11** includes a cylindrical screen **12** and a screw **13** mounted for rotation therein. A slurry inlet opening **14** is formed in the screen near the lower end, and the upper end of the screen is open to provide an opening **16** for discharge of the solids expressed from the slurry. A vertically movable cone choke **17** cooperates with the screen **12** to vary the size of the opening **16** through which the expressed material is discharged.

The cone **17** is moved vertically by a pneumatic cylinder **18** which slidably receives a piston **19** connected to a piston rod **21** by a swivel joint **22**. A drive bar **23** is secured to and extends transversely of the piston rod **21** through vertical slots **24** in the upper end of the screw **13** and projects into holes in the cone **17**. It is apparent, therefore, that vertical movement of the piston **19** will cause vertical movement of the cone **17** relative to the screw **13** and screen **12**.

The screw **13** is rotated by a hydraulic motor **26** which has a drive gear **27** keyed to its drive shaft **28**. The drive gear **27** meshes with a driven gear **29** which is connected to the piston rod **21** by a key **31** which rides in an elongate keyway **32** in the piston rod **21**. Accordingly, rotation of the drive shaft **28** by the motor **26** causes rotation of the screw **13** and cone **17**, while the swivel joint **22** permits the piston **19** to be held from rotation. It is also believed understood that the elongate keyway **32** permits vertical movement of the piston rod **21** through the driven gear **29**.

The control system **10** of the present invention includes a hydraulic circuit **36** for controlling the rate of flow of hydraulic fluid to the motor **26**, a pneumatic circuit **37** for effecting the actuation of the pneumatic cylinder **18** and for controlling the rate of flow of hydraulic fluid to the motor **26**, and an electrical circuit **38**.

The hydraulic circuit **36** comprises a hydraulic pump **41** that is coupled to and driven by an electric motor **42**. Hydraulic fluid is drawn into the pump **41** from a supply tank **43** through a conduit **44** and is forced through a pressure conduit **46**, through a flow control valve **47**, and through a second pressure conduit **48** to the hydraulic motor **26** thereby actuating the motor **26** which drives the screw **13**. The hydraulic fluid returning from the motor **26** flows through return conduits **49** and **50** into the supply tank **43**. A relief valve **51**, set at approximately 5000 p.s.i., is connected between the pressure conduit **46** and the return conduit **50** and opens in the event that the pressure should exceed 5000 p.s.i. due to excessive torque acting on the screw **13**. It is to be understood that whereas specific values of pressure, time, and the like, are stated herein in order to facilitate understanding of the invention, the invention is not limited to such values.

In order to prevent an excessive load from being applied to the electric motor **42** during starting of the screw **13**, a flow by-pass valve **52** is connected between the pressure conduit **46** and the return conduit **50**. The valve **52** includes a core **53** which is normally held in flow preventing position by a spring **54** and is moved to a by-pass position by a solenoid **55**. When in the by-pass position, a portion, for example twenty percent, of the hydraulic fluid is by-passed and is returned to the supply tank **43**.

The pump drive motor 42 and a timer motor 58, which are connected to main lines L1 and L2 of the electric circuit 38, are started by closing a start switch 57. Energization of the timer motor 58 effects rotation of a cam 59 through one revolution requiring approximately twenty seconds. The cam 59 is normally held in a position wherein a lobe 61 holds a switch 62 open. During rotation of the cam 59 through its single revolution, the lobe 61 moves away from the switch 62 permitting the switch 62 to close a circuit between the main lines L1 and L2. The circuit includes the main line L2, a lead 63, the switch 62, the solenoid 55 and a lead 64 connected to the main line L1. The solenoid 55 remains energized and the by-pass valve 52 remains open until the single revolution of the cam 59 again moves the lobe 61 into position to open the switch 62. Upon opening the switch 62, a holding circuit, not shown, in the timer motor 58 opens to deenergize the motor 58, and the by-pass valve 52 is closed causing all the fluid from the pump 41 to pass through the hydraulic motor 26.

As mentioned previously, it is significant that both the speed of the hydraulic motor 26 and the position of the cone choke 17 are controlled in response to the changes in torque demands of the screw 13. Changes in the torque demands of the screw 13 effect pressure changes in the pressure conduit 48, and therefore, an air controller 70 of any well known standard design is connected by a conduit 71 to the conduit 48 to sense these pressure changes.

The air controller 70 is a part of the pneumatic circuit 37, which circuit is connected to a source of air at approximately eighty p.s.i. The pneumatic circuit 37 includes a main air supply conduit 72 which directs air into the inlet opening of a pipe cross 73. A conduit 74, having an air pressure regulator 76 therein, connects one outlet of the cross 73 to the lower end of the pneumatic cylinder 18 for supplying air at constant pressure to the lower end of the cylinder 18. A controller air supply conduit 77, having an air regulator 78 therein which reduces the air pressure to approximately twenty p.s.i., is connected between another outlet of the pipe cross 73 and the controller 70. A branch conduit 79 is connected between a T 81 in the high pressure side of the conduit 74 and a three-to-one booster 82 to supply working pressure to the booster 82. The booster 82 has a discharge end connected by a conduit 83 to the upper end of the pneumatic cylinder 18. The other outlet of the cross 73 is connected by a conduit 84, having a pressure regulator 86 therein set for a discharge pressure of approximately twenty p.s.i., to a diaphragm motor 87 of the flow control valve 47. As illustrated, the diaphragm motor 87 includes an upper air chamber 88 and a lower air chamber 89 to which the conduit 84 is connected. The chambers are separated from each other by a diaphragm 91. The diaphragm 91 is connected by an actuating rod 92 to the core 93 of the control valve 47. The actuating rod 92 is preferably of two-piece threaded construction so as to permit adjustment of its length, and is provided with an abutment 94 which limits downward movement of the core 93 and prevents complete closing of the control valve 47. A control conduit 95 is connected between the air controller 70 and the upper air chamber 88 of the diaphragm motor 87, and includes a branch conduit 96 which is connected to the booster 82.

The air controller 70 may be a Taylor Fullscope Pressure Controller, No. 161RF139, Range 0–5000 p.s.i., as described and illustrated in a booklet entitled "Instructions for Taylor Fullscope Indicating Controller," published by Taylor Instrument Companies, Rochester, N.Y. The three-to-one booster 82 may be a Kendall Air Volume Booster Relay, No. 20,232, manufactured by Stratos Industrial Product Branch, Division of Fairchild Engine and Airplane Corporation, New York, N.Y.

The air controller 70 is of the reverse-acting type wherein an above normal pressure in the hydraulic control line 71 will cause a decrease in the air pressure in the control conduit 95. This decreased air pressure reduces the control pressure to the booster 82 and, accordingly, reduces the pressure above the piston 19 permitting the constant pressure of the air below the piston 19, aided by the pressure of the solid material upon the cone choke, to raise the cone choke 17. This decreased control air pressure also reduces the pressure in the upper chamber 88 thereby opening the valve 47 in excess of normal thus increasing the flow of hydraulic fluid to the hydraulic motor 26 which, in turn, increases the speed of the screw 13. Conversely, a below normal pressure in the hydraulic control line 71 will cause an increase in the air pressure in the control conduit 95 thereby lowering the cone 17 and decreasing the flow of hydraulic fluid to the hydraulic motor 26 to decrease the speed of the screw.

In the operation of the screw press 11, air at approximately eighty p.s.i. is directed into the pneumatic circuit 37 through the main conduit 72. With the hydraulic circuit 36 not yet placed in operation, no pressure will be transmitted through the conduit 71 to the air controller 70. Accordingly, the control air in the conduits 95 and 96 will be at a higher than normal pressure and will cause high pressure air to be directed through the booster 82 into the top of the cylinder 18. The pressure of the air entering the top of the cylinder 18 will be three times as great as the approximately twenty p.s.i. control pressure entering the air controller 70 through the conduit 77. This high pressure air acts on the upper surface of the piston 19 at approximately sixty p.s.i. which overcomes the twelve to fifteen p.s.i. pressure acting on the lower surface of the piston 19. These unbalanced forces move the piston 19 down thereby causing the cone choke 17 to restrict the size of the discharge opening 16.

High pressure control air also enters the upper air chamber 88 of the diaphragm motor 87 at approximately twenty p.s.i. and overcome the twelve to fifteen p.s.i. air entering the lower air chamber 89 through the conduit 84 thereby forcing the core 93 of the control valve 47 downwardly to restrict the flow of hydraulic fluid through the valve 47.

With a slurry being directed into the press 11 through the inlet opening 14, the operator starts the press by closing the switch 57. Current flows through the lines L1 and L2 to the motor 42 which drives the hydraulic pump 41, and to the timer motor 58 which rotates the cam 59 through one revolution in twenty seconds. Rotation of the cam 59 moves the lobe 61 out of contact with the switch 62 permitting the switch 62 to close thereby energizing the solenoid 55. Energization of the solenoid 55 opens the by-pass valve 52 for twenty seconds allowing a portion of the high pressure fluid being discharged from the pump 41 into the conduit 46 to flow through the by-pass valve 52 and return to the supply tank 43 through the conduit 50. In this way the initial starting load on the motor 42 is reduced. The remaining portion of the fluid in the conduit 46 flows through the control valve 47.

The hydraulic fluid which passes through the control valve 47 flows through the conduit 48 and the hydraulic motor 26, thereby driving the same, and is returned to the supply tank 43 through the conduit 49. After the screw 13 has been started and has been driven by the motor for twenty seconds, the timer motor 58 completes the single revolution of the cam 59 thereby causing the lobe 61 to open the switch 62 deenergizing the solenoid 55 and closing the by-pass valve 53. All the hydraulic fluid delivered by the pump 41 then flows through the control valve 47 and the hydraulic motor 26.

As the rotating screw 13 begins to advance the slurry upwardly in the screen 12, the liquid in the slurry flows through the screen 12 and the expressed solids move upwardly and are discharged through the opening 16. As long as the slurry contains a predetermined normal amount of liquid, the choke 17 remains stationary and

the speed of the screw 13 is constant thereby expressing material of constant predetermined normal density.

When a slurry having a lower than normal liquid content enters the press 11, the forces resisting rotation of the screw 13 increase. Accordingly, the driving torque delivered by the motor 26 increases and the pressure in the conduits 48 and 71 increases. The increased pressure in the conduit 71 causes the reverse-acting air controller 70 to reduce the pressure of the control air in the conduits 95 and 96. This reduced control air pressure effects a proportional opening of the control valve 47 causing an increase in speed of the hydraulic motor 26 and screw 13. This reduced pressure also acts through the booster 82 to reduce the pressure above the piston 19 and accordingly effects a proportional opening of the choke 17. In this way the expressed material is maintained at the predetermined normal density and the compressive force acting on the material is more evenly distributed throughout the length of the screw.

When a slurry having a higher than normal liquid content enters the press 11, the reaction torque acting on the screw 13 is reduced resulting in a decrease in pressure in the conduits 48 and 71. The decreased pressure in the conduit 71 causes the reverse-acting air controller 70 to increase the pressure of the control air in the conduits 95 and 96. This increased pressure effects a proportional closing of the control valve 47 causing a decrease in speed of the hydraulic motor 26 and screw 13. This increased pressure also acts through the booster 82 to increase the pressure above the piston 19 and accordingly effects a proportional closing of the choke 17. The decreased speed of the screw 13 and proportional closing of the choke 17 are sufficient to maintain the expressed material at the predetermined normal density and to distribute the force acting on the material evenly along the length of the screw.

Consequently with the controller 70 and the regulators 76 and 86 pre-set so as to express a material of a predetermined density, it will be recognized that an increase in torque applied to the hydraulic motor 26, due to a drier than normal slurry, will cause a simultaneous enlargement of the discharge opening 16 and an increase in the speed of the screw 13. Conversely, a decrease in the torque applied to the hydraulic motor 26 due to a wetter than normal slurry, will cause a simultaneous reduction in size of the discharge opening 16 and a decrease in the speed of the screw 13. Thus, both the screw speed and the size of the discharge opening varies in direct proportion to the resistance torque acting on the screw. It is to be understood that these proportional changes are not necessarily linear.

It will be understood that the air controllers 76, 78 and 86 will be pre-set for obtaining a predetermined density of expressed material. It will also be understood that the pressure regulators 76 and 86 can be adjusted to change the relationship between the speed of the screw and the size of the discharge opening 16 so as to readily adapt the press to handle different materials and different density requirements of the expressed material.

From the foregoing description it is apparent that the control system of the present invention is adapted to maintain the density of the expressed material constant even though the liquid content of the slurry being processed varies considerably. The density is continuously controlled in response to incremental changes in the resistance or reaction torque acting on the screw and such control is achieved by simultaneously changing the size of the discharge opening through which the expressed material passes and varying the speed of the screw.

While one embodiment of the present invention has been shown and described, it will be understood that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

Having thus described the present invention, what is claimed as new and desired to be protected by Letters Patent is:

1. In a press of the type having perforate wall means having an inlet passage and defining a compression chamber which leads to a discharge opening, means in said chamber for advancing material from said inlet passage under pressure toward said opening, said means developing a reaction pressure which varies in accordance with the density of the advancing material, and a choke movable in said discharge opening for varying the size of the opening; a control system for maintaining a constant density of the expressed material comprising first drive means for actuating said material advancing means, second drive means for moving the choke in said opening, and means responsive to changes in said reaction pressure for actuating said first and second drive means and thereby to vary the speed at which said material advancing means moves the material toward said opening in direct relation to the change in said reaction pressure and also to change the size of said opening in direct relation to the change in said reaction pressure.

2. In a press including a tubular screen having an inlet opening through which material may enter the tubular screen and a discharge opening through which compressed material is discharged, a choke mounted for movement toward and away from said discharge opening, a screw rotatable within said screen for developing pressure on material in the screen between said screw and said choke, drive means for rotating said screw, said drive means developing a reaction torque which varies as said pressure changes during operation of the press, and means responsive to variations in said reaction torque for concurrently moving said choke toward and away from said discharge opening in direct relation to the change in torque and for controlling said drive means to vary the speed of rotation of said screw in direct relation to the charge in torque so as to maintain the density of the discharged material substantially constant.

3. In a press of the type having a screen with an inlet opening through which material may enter the tubular screen and a discharge opening, rotary means in the screen for expressing material through the discharge opening, and a choke movable in said discharge opening for varying the size of the discharge opening; a control system for maintaining a constant density of the expressed material comprising first drive means for applying torque to and rotating said rotary means, said torque changing as the density of the material in the press changes, second drive means for moving the choke in said discharge opening, and means responsive to said changes in the torque for actuating said first and second drive means and thereby to vary the speed of rotation of said rotary means in direct relation to the change in torque and also to change the size of said discharge opening in direct relation to the change in said torque.

4. In a press of the type having a screen with an inlet opening through which material may enter the tubular screen and a discharge opening, a rotary screw in the screen for expressing material through the discharge opening, and a choke movable in said discharge opening for varying the size of the opening; a control system for maintaining a constant density of the expressed material comprising first drive means for applying torque to and rotating said screw, said torque changing as the density of the material in the press changes, second drive means for moving said choke in said discharge opening, and means responsive to said changes in the torque for simultaneously actuating said first and second drive means and thereby to vary the speed of rotation of said screw in direct proportion to the change in said torque and also to change the size of said discharge opening in direct proportion to the change in said torque.

5. In a press of the type having a screen with an inlet opening through which material may enter the tubular screen and a discharge opening, a rotatable screw in the

screen for expressing material through the discharge opening, and a choke movable in said discharge opening for varying the size of the discharge opening; a control system for maintaining a constant density of the expressed material comprising hydraulic drive means for applying torque to and rotating said screw, said torque changing as the density of the material in the press changes, pneumatic drive means for moving said choke in said discharge opening, and means responsive to said changes in torque for simultaneously actuating said hydraulic and pneumatic drive means and thereby to vary the speed of rotation of said screw in direct proportion to the change in said torque and also to change the size of said discharge opening in direct proportion to the change in said torque.

6. In a press of the type having a screen with an inlet opening through which material may enter the tubular screen and a discharge opening, a rotatable screw in the screen for expressing material through the discharge opening, and a choke movable in said discharge opening for varying the size of the discharge opening; a control system for maintaining a constant density of the expressed material comprising hydraulic drive means for applying torque to and rotating said screw, said torque changing as the density of the material in the press changes, pneumatic drive means for moving said choke in said discharge opening, means responsive to said changes in torque for simultaneously actuating said hydraulic and pneumatic drive means and thereby to vary the speed of rotation of said screw in direct proportion to the change in said torque and also to change the size of said discharge opening in direct proportion to the change in said torque, and means for reducing the starting load acting on said hydraulic drive means.

7. In a press of the type having a screen with an inlet opening for receiving a slurry and a discharge opening for discharging the expressed material therefrom, rotary means in said screen for moving material through said discharge opening, and choke means movable in said discharge opening for varying the size of said discharge opening; a control system for maintaining a constant density of the expressed material comprising first drive means for applying a torque to and rotating said rotary means, second drive means for moving said choke means in said opening, said torque changing as the density of the material in the press changes, pneumatic means responsive to said changes in torque acting on said rotary means for actuating said second drive means thereby changing the position of said choke means, hydraulic means for activating said first drive means to vary the speed of said expressing means, and means included in said hydraulic means and responsive to said changes of pressure in said pneumatic means for controlling the flow of fluid in said hydraulic means and for varying the speed of said rotary means in direct proportion to said torque change.

8. In a screw press of the type having a screen with an inlet opening for receiving a slurry and a discharge opening for discharging expressed material therefrom, rotatable expressing means in said screen for moving the slurry along said screen and for expressing solid material through said discharge opening, and choke means movable in said discharge opening for varying the size of said discharge opening; a control system for maintaining

a constant density of the expressed material comprising a pressure controller, hydraulic drive means for applying a torque to said expressing means, a hydraulic control circuit connected to said pressure controller and to said hydraulic drive means for directing hydraulic fluid under high pressure into said hydraulic drive means, a control valve in said hydraulic circuit for controlling the flow of fluid to said hydraulic drive means, pneumatic drive means connected to said choke for operating the choke, pneumatic valve actuating means connected to said control valve, and a pneumatic circuit connected to said valve actuating means, said pneumatic drive means and to said pressure controller, said pressure controller being sensitive to incremental pressure changes in said hydraulic circuit for controlling actuation of said valve actuating means so that said valve regulates the flow of hydraulic fluid into said hydraulic drive means to vary the speed of said expressing means in direct proportion to said pressure changes and simultaneously for controlling the pneumatic pressure in said pneumatic drive means so as to operate said choke to vary the size of said discharge opening in direct proportion to said pressure changes.

9. In a press for expelling liquid from a slurry, said press including a screw, a variable speed drive motor connected to said screw for rotating the same and for developing a reaction torque which changes as the density of the slurry being acted upon changes, a source of energy for rotating the motor, a perforate wall circumscribing said screw and having in inlet opening through which material may enter said perforated wall and a discharge opening through which solid material is expressed during rotation of said screw, a choke movable in said discharge opening for varying the size thereof, and a fluid operated device connected to said choke for moving the same in response to fluid pressure changes applied to said device; a control system for stabilizing the density of the discharged material comprising pressure responsive means having an input connected to said motor so that changes in said reaction torque are applied to said input and an output where pressures are developed which vary inversely with increases and decreases in said reaction torque applied to said input, means interconnecting said output and said fluid operated device for moving said choke in response to variations in pressure at said output, a fluid circuit interconnecting said source and said motor, a valve in said circuit which is movable between open and closed positions to vary the amount of energy applied by said source to said motor so as to vary the speed of rotation of said screw, and means interconnecting said valve and said output for opening and closing said valve in response to variations in pressure at said output.

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