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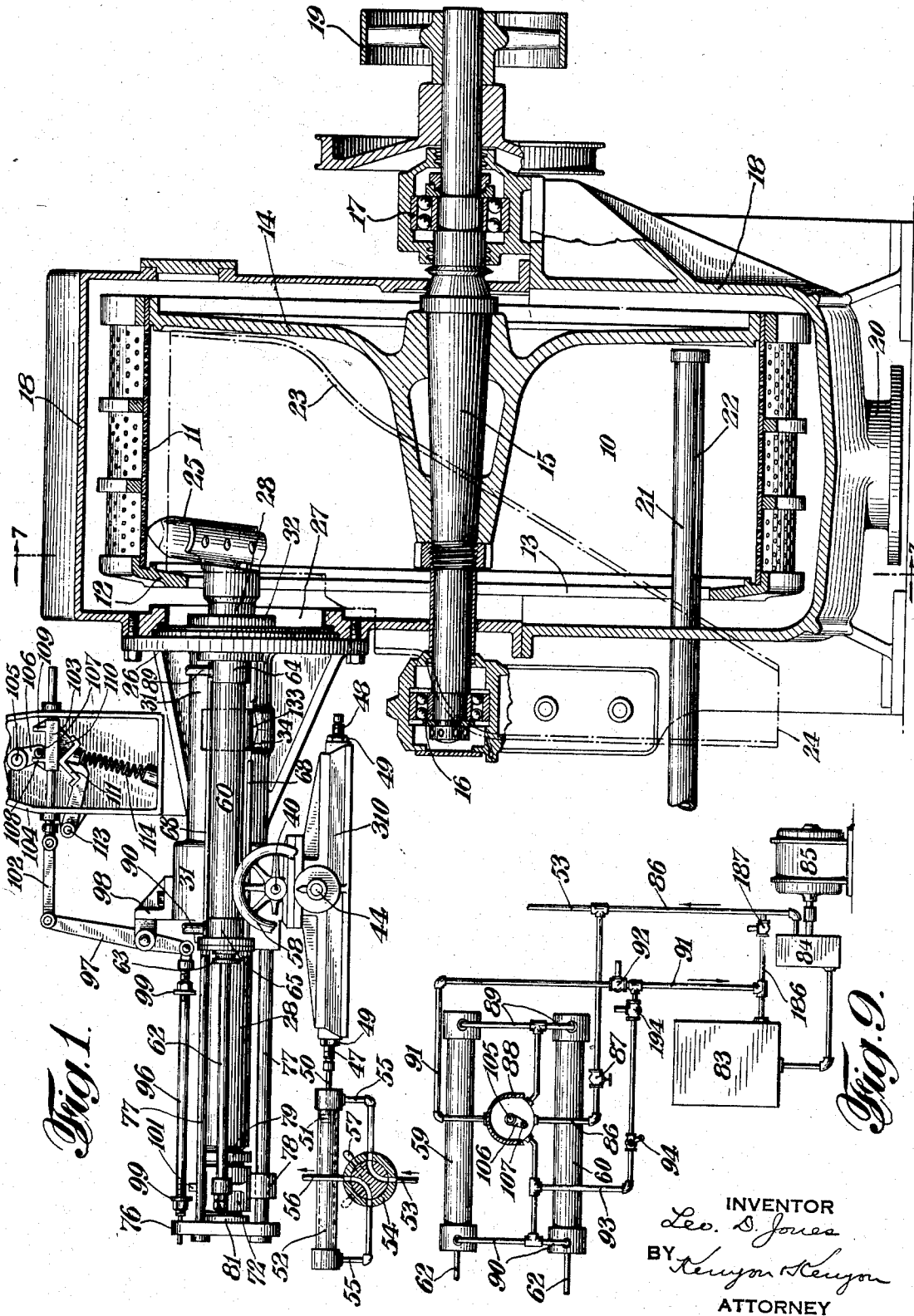
L. D. JONES

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CENTRIFUGAL MACHINE

Filed Sept. 20, 1929

5 Sheets-Sheet 1



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July 31, 1934.

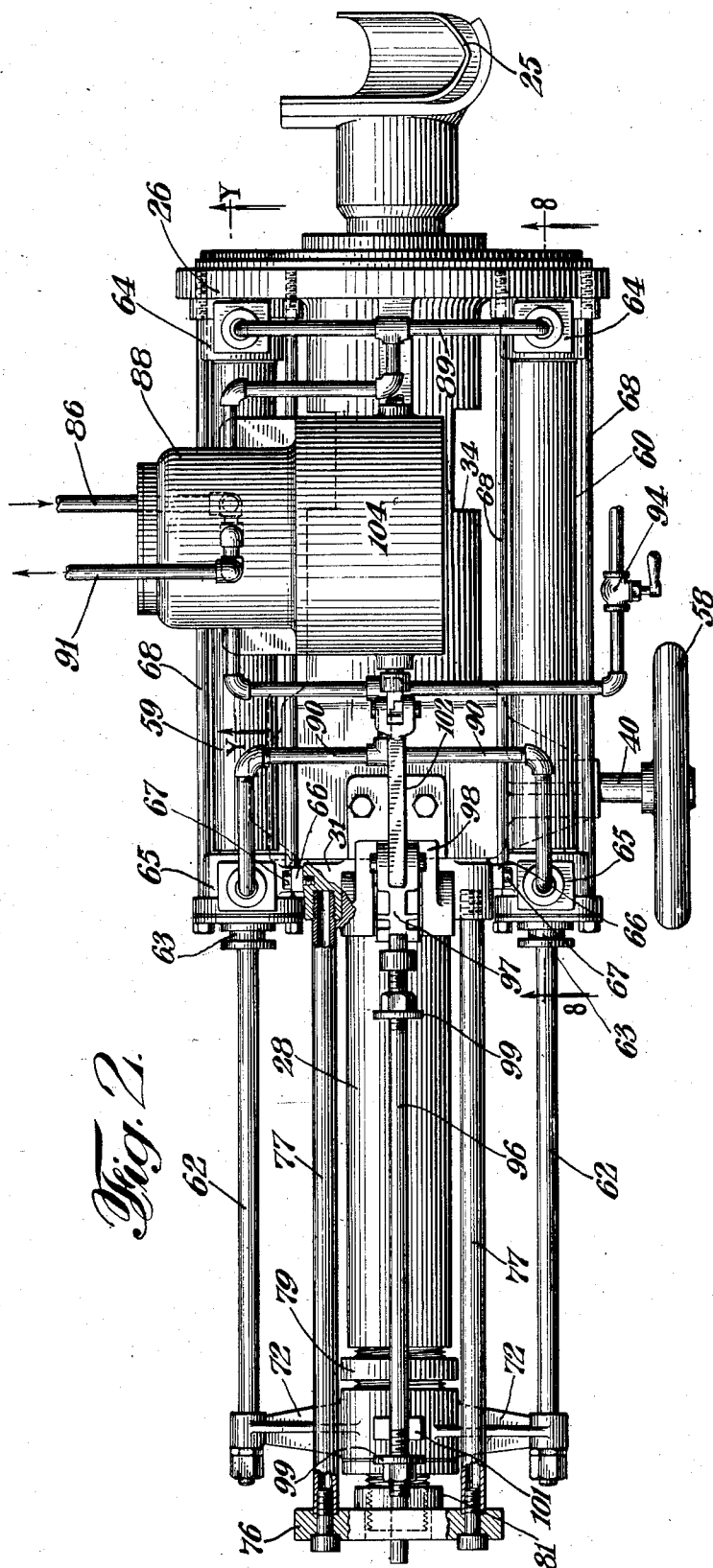
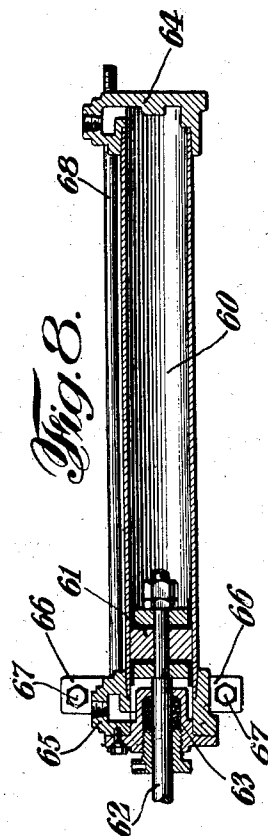
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5 Sheets-Sheet 2



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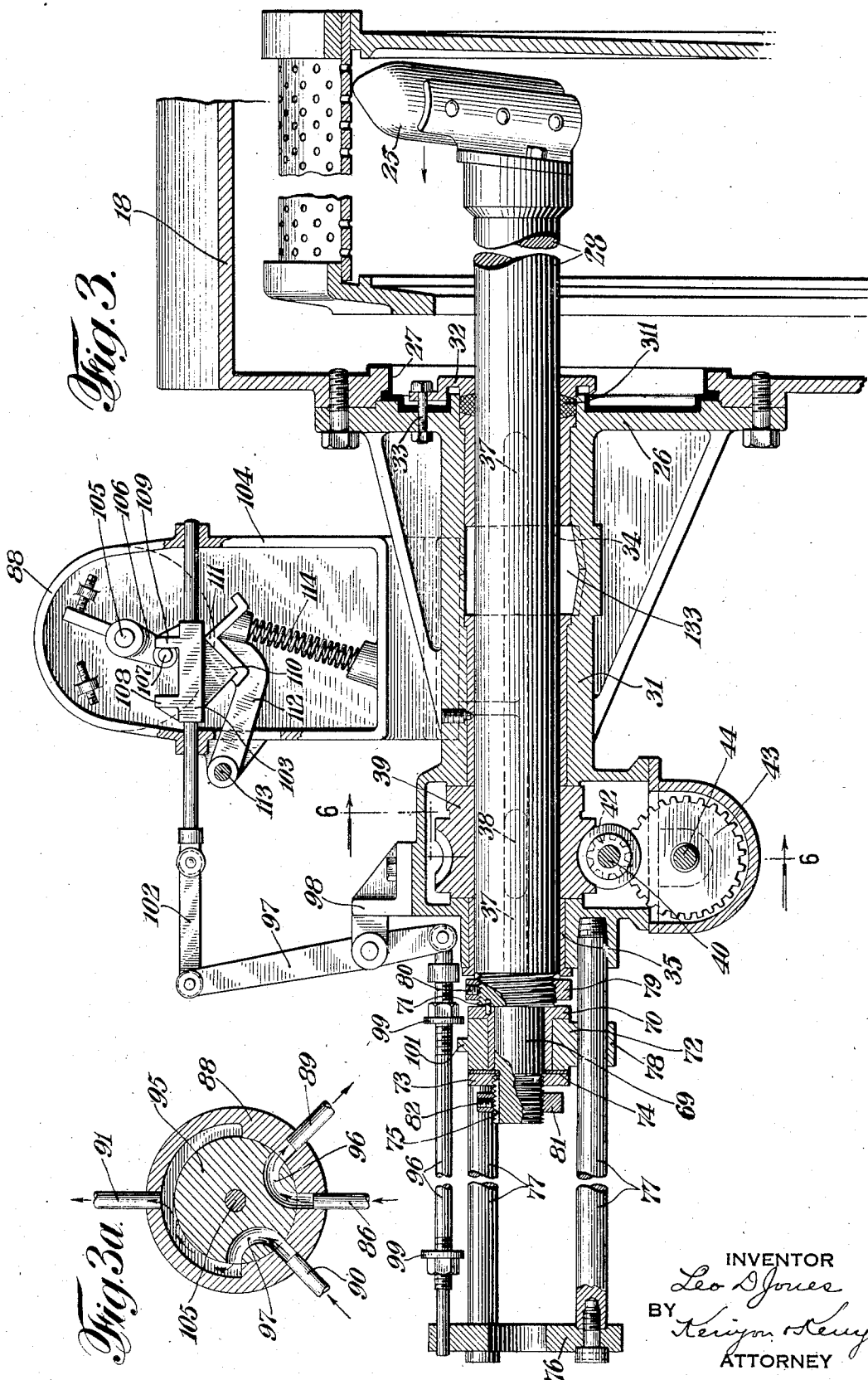
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CENTRIFUGAL MACHINE

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July 31, 1934.

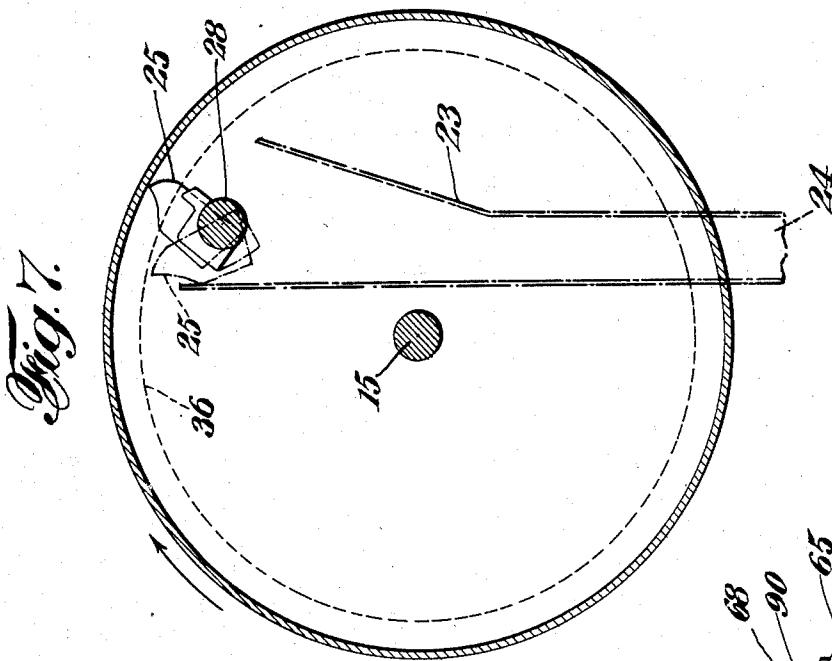
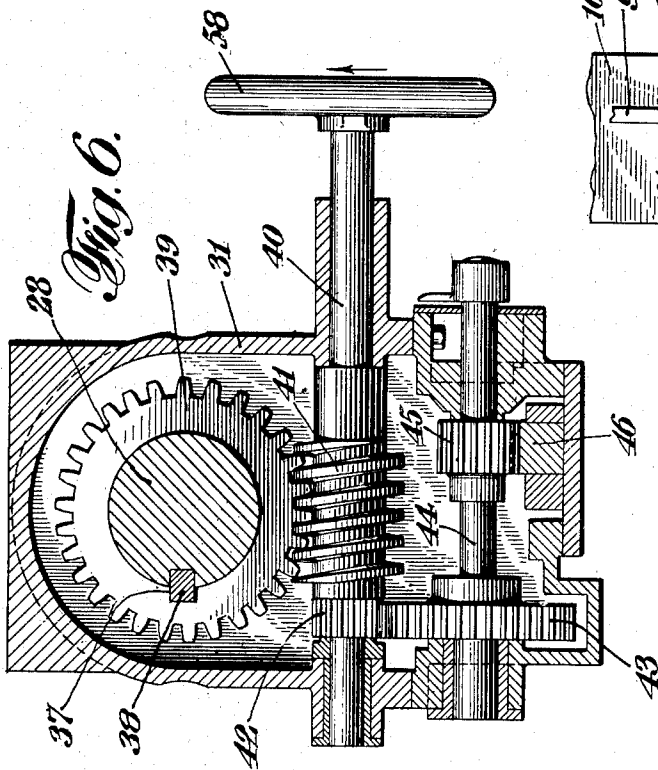
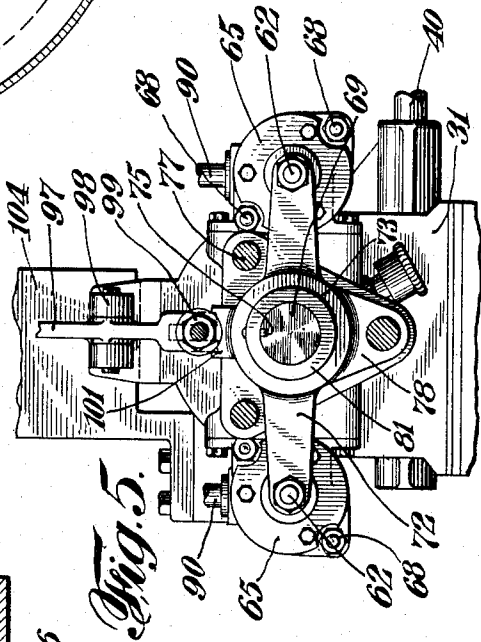
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CENTRIFUGAL MACHINE

Filed Sept. 20, 1929

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

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CENTRIFUGAL MACHINE

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Application September 20, 1929, Serial No. 393,870

15 Claims. (Cl. 210—70)

This invention relates to centrifugal machines and particularly to mechanism for dislodging or unloading from the rotor thereof solids collected therein as a result of separating solids from liquids centrifugally.

In the separation of solids from liquids centrifugally the removal from the rotor of the solids from which liquid has been separated, in such a manner that the separating operation may be subject to a minimum interruption is a difficult problem and even though apparatus may be found that is satisfactory with some materials that apparatus will not be satisfactory with other materials. Efforts have been made to provide apparatus capable of removing solids continuously from centrifugal rotors but such apparatus is subject to similar defects.

It has been proposed to provide a dislodging or cutting tool for removing solids from centrifugal rotors during the rotation thereof, but devices that have been proposed require extensive and careful control by the operator and they are likely to injure the rotor without effecting the desired removal of solids therefrom. It has been proposed to employ a dislodging or cutting tool that is provided with belt-driven operating and reversing mechanism, but such devices require considerable skill and attention on the part of the operator; and, particularly when the tool is thought to be acting on cake but is not, the inertia of the moving parts carries the tool past the points at which it should come to rest and leads to injury or destruction of the rotor as a result of unintended and unavoidable contact of the tool therewith, or the tool, particularly when acting upon cake, is not carried far enough and removal of cake is incomplete. Attempts to limit tool movement in such devices by stops cause either binding or shocks difficult to absorb.

A feature of this invention is that a tool is employed whereby the solids collected in a centrifugal rotor may be dislodged therefrom quickly without materially reducing the speed of rotation of the rotor or stopping it, and that tool is provided with operating mechanism whereby the tool may be operated by an unskilled workman to effect the desired removal of solids from the rotor without danger of injury to the rotor. Thus, features of this invention are that the means for moving the tool is free of inertia that will tend to carry the tool into engagement with the rotor; that the tool is prevented from moving into engagement with the rotor by stops that do not cause binding or wedging when they come into operation; that the operating mechanism

carries the tool back and forth along the cylindrical interior surface of the solids in the rotor and automatically reverses such motion of the tool before it comes into engagement with the rotor; that the depth of cut made by the tool is readily adjusted and the means for adjusting the depth of cut is provided with effective stops that cannot produce wedging or binding; that in the automatic reversal of the motion of the tool, the reversal of the force upon it is full and complete and automatic; that the control of the movement of the tool back and forth across the bed of solids in the rotor can be effected by a single control member, and that the automatic mechanism can be so controlled as to bring the tool to rest in a desired position at the end of each dislodging operation.

This invention includes various features, some of which are set out above and some of which are described hereinafter, which can be used conjointly with advantage but which are also capable of separate use. Another feature of this invention is that the cutting or dislodging tool is fed by hydraulic means, back and forth, across the inner cylindrical surface of the body of solid material within the rotor. Another feature is that a supply of liquid under pressure is maintained and it is fed alternately to opposite ends of one or more hydraulic cylinders. Another feature is that the admission of liquid to and the discharge of liquid from opposite ends of the hydraulic cylinders is controlled automatically by movement of the tool. Another feature is that the resulting reciprocation of the tool is controlled by a single control element. Another feature is that the single control element may consist of a by-pass leading from the pipe that carries liquid under pressure to one end of the cylinder, with the result that mere opening and closing of the by-pass will respectively cause or prevent continued reciprocation of the tool, and the tool may be brought to rest in a desired position, preferably a position in which it does not interfere with the separating operation.

In the drawings in which like reference characters indicate similar parts,

Fig. 1 is a view partly in section of a centrifugal machine embodying my invention;

Fig. 2 is a plan view of the tool operating mechanism shown in Fig. 1;

Figs. 3 and 4 are vertical sectional views of the apparatus shown in Fig. 2; with the parts in different positions;

Figs. 3a and 4a are partial sectional views on the line Y—Y of Fig. 2;

Fig. 5 is a sectional view on the line 5—5 of Fig. 4;

Fig. 6 is a partial sectional view on the line 6—6 of Fig. 3;

Fig. 7 is a partial sectional view on the line 7—7 of Fig. 1;

Fig. 8 is a longitudinal sectional view on the line 8—8 of Fig. 2; and

Fig. 9 shows diagrammatically the arrangement of piping for the operating liquid that is under the pressure.

While apparatus embodying my invention is subject to various modifications the following detailed description of the embodiment of my invention shown in the drawings will assist in an understanding of my invention and additional features of my invention will appear therefrom.

A centrifugal rotor 10 comprising a wall 11, which may be of cylindrical or other suitable form and which may be perforated or imperforate, and an end wall 12 provided with an opening 13 and an end wall 14, is mounted upon shaft 15 carried in bearings 16 and 17 that are supported by housing 18 that encloses the rotor. The shaft, and the attached rotor may be rotated in any suitable manner as by pulley 13. Liquid separated centrifugally from the solids is collected in the housing 18 and withdrawn therefrom through outlet 20. The mixture of liquids with solids, that is to be separated, is supplied in any suitable manner to the rotor 10 as by means of pipe 21 having a discharge slot 22. After a cake of solids, of suitable radial depth, is formed in the rotor by draining or by sedimentation or by both such operations, and after supply of mixture to the rotor is discontinued, and after any time interval that may be desirable to effect further separation of liquid from the solids, the solids are dislodged from the rotor as hereinafter described during the rotation of the rotor, and the dislodged solids fall into a hopper, the position of which is generally indicated by the lines 23, the hopper extending through a suitable opening in casing 18 and having an outlet 24 for the solids.

The means for supporting and moving the dislodging or cutting tool 25 may be mounted in any manner, in proper relation to rotor 11, as by bolting the flange or base plate 26 thereof in position over the opening 27 in the housing 18. Tool 25 is attached to and supported by the tool-operating bar or member 28 that is mounted for reciprocation and rotation in the bearings 29 and 30 that are carried by the frame 31 that is connected to the flange or base plate 26. Bearing 30 is provided at the end thereof adjacent the rotor with a stuffing box that prevents entrance into the bearing of foreign materials such as liquids and solids introduced into rotor 11, said stuffing box comprising packing 311 that is compressed by compression member 32 upon tightening of bolts 33, only one of which is shown. Between bearings 29 and 30 the frame 31 is spaced from bar 28 to provide a space 133 around bar 28 and is provided with openings 34 through which foreign material entering bearing 30 is discharged, to the end that it does not enter bearing 29. In the construction shown frame 31 is provided with a third bearing 35 for bar 28.

In the construction shown in the drawings the cutting edge of tool 25 is moved from and toward the inner surface of rotor 11 by rotation of bar 28. During the formation of a cake of solids in the rotor, the final approximate position of the inner surface of the cake being indicated by dotted circle 36 in Fig. 7, tool 25 is maintained, by

suitable rotation of bar 28, in a position in which it will not engage the surface of the cake, such a position being indicated by dotted lines in Fig. 7. After a cake of sufficient depth has been formed bar 28 is rotated, clockwise in Fig. 7, to carry the cutting edge of the tool into the cake and toward the inner surface of rotor 11. For this purpose bar 28 is provided with a keyway 37 in which fits key 38 carried by worm-wheel 39 housed in frame 31 between bearings 29 and 35. Shaft 40 is mounted in frame 31 for rotation and carries a worm 41 engaging worm-wheel 39. Shaft 40 is also provided with gear 42 which is engaged by gear 43 mounted on shaft 44 to which is secured gear 45 which in turn engages rack 46. Rack 46 slides within auxiliary housing 310 and the extent to which it may slide is limited at each end of its motion by means of stops 47 and 48, which in the construction shown are adjusted by being screwed into the ends of auxiliary housing 310 and locked in position by lock nuts 49. In the construction shown rod 50 is secured to rack 46 and passes through one end of auxiliary housing 310, as by passing through stop 47, and rod 50 carries on its end a piston 51 that is located within hydraulic cylinder 52. Liquid under pressure is supplied by pipe 53 to four-way valve 54 and, according to the setting of valve 54 liquid under pressure is carried to one end of cylinder 52 and from the other end thereof by pipes 55, liquid so discharged from cylinder 52 being returned to the source of liquid supply by pipe 56. Thus, when operating handle 57 of four-way valve 54 is in the position shown in Fig. 1, liquid under pressure will be passed to the right hand end of cylinder 52 to swing tool 25 from the position shown in dotted lines to the position shown in full lines in Fig. 7. When the operating handle 57 is swung into the position indicated in dotted lines in Fig. 1 the rotational movement of bar 28 will be in the opposite direction. The cutting adjustment of tool 25 may also be effected by hand-wheel 58 mounted on shaft 40.

In the construction described, for rotating rod 28 and thereby adjusting its cutting position, the limiting positions of cutting tool 25 are determined by the position of stops 47 and 48. Thus regardless of whether the position of tool 25 is adjusted by controlling the supply of liquid to cylinder 52 or by rotating hand-wheel 58 the limits of that adjustment are determined by the engagement of the ends of the sliding rack 46 with the stops 47 and 48 and no binding or wedging can occur, as would be the case if the stops acted upon some part (e. g. worm-wheel 39) that is moved through a worm and worm-wheel. Thus while rack 46 contributes to the adjustment of tool 25 when that adjustment is effected by hydraulic cylinder 52, and also contributes then to the limiting of that adjustment, it also constitutes a non-binding stop when adjustment is effected by movement of hand wheel 58.

For the purpose of carrying cutting tool 25 back and forth across the cake in rotor 11 in a direction parallel to the axis of the rotor, hydraulic means is provided. In the construction shown this means comprises hydraulic cylinders 59 and 60 within which are located pistons 61 provided with piston rods 62 that extend through stuffing boxes 63. In the construction shown, cylinders 59 and 60 are respectively provided with heads 64 that abut against flange or plate 26 of frame 31 and heads 65 that carry stuffing boxes 63. Heads 65 are provided with ears 66 and thereby bolted by means of bolts 67 to portions of frame 31.

31. To assist in holding cylinders 59 and 60 in position long bolts 68 pass through cylinder heads 65 and through cylinder heads 64 and are threaded into flange or base plate 26. Tool-operating bar 28 is formed with a portion 69 that is of reduced diameter and a bushing 70 fits thereon and rests against the resulting shoulder and is prevented from rotating on bar 28 by pin 71. Yoke 72 is provided with an opening within which bushing 70 rotates, and nut 73 acts to hold yoke 72 in place on bushing 70. A washer 74 lies between nut 73 and yoke 72 and has a tongue extending into slot 75 in bar 28 to the end that rotation of bar 28 within yoke 72 will not cause nut 73 to be unscrewed. The outer ends of piston rods 62 are secured in yoke 72 as shown in Fig. 2 and motion of piston 61 is thereby imparted to rod 28 to effect movement of the tool across the face of the cake in rotor 11. Plate 76, which is triangular in the construction shown in Fig. 5 is held in fixed position with respect to frame 31 by being bolted to the three rods 77 that are threaded into frame 31. As shown in Fig. 3 yoke 72 is provided with a downward extension 78 having an opening that accommodates the lowermost of rods 77, yoke 72 being thereby held against rotation in the event that rotation of bar 28 tends to cause rotation of yoke 72.

Stop member 79 engages the end of bearing 35 to limit the movement of bar 28 into the rotor (to the right in Fig. 3) and is threaded upon bar 28 in order that its position thereon may be adjusted, and is held in adjusted position on bar 28 by set screw 80. Stop member 81 engages plate 76 and limits the outward movement of bar 28 (movement of bar 28 to the left in Fig. 4), being threaded upon bar 28 for adjustment and being held in adjusted position by set screw 82.

From the foregoing it will be apparent that by admitting liquid under pressure alternately to opposite ends of cylinders 59 and 60, tool 25 will be moved back and forth across the cake in rotor 11, and that the engagement of stop 79 with bearing 35 will adjustably limit the extent of such movement in one direction while engagement of stop 81 with plate 76 will adjustably limit that movement in the other direction, and that bar 28 may be rotated to adjust the distance of the tool from the inner surface of the rotor without imparting rotation to any part of the hydraulic tool-reciprocating mechanism. Worm-wheel 39, which rotates bar 28, is so located intermediate the ends of bar 28 that keyway 37 never passes within or through packing 311 or into a position in which material treated in the rotor might lodge within that keyway.

Mechanism is provided whereby predetermined reciprocation of tool-bar 28 in each direction will cause a discontinuance of supply of liquid under pressure to one end of cylinders 59 and 60 and an initiation of such supply to the other end of those cylinders, and cause a corresponding reversal of the discharge of liquid from the opposite ends of those cylinders. And, such mechanism effects a complete and rapid reversal, the supply to one end of the cylinders being suddenly and completely discontinued and the supply to the other end of the cylinders being suddenly and completely initiated. The circulating system for the operating liquid is shown in Fig. 9. A supply of liquid, preferably oil, is maintained in tank 83, and pump 84 driven by motor 85 delivers the liquid under pressure into supply pipe 86 and by means of throttle valve 87 the rate of flow of liquid under pressure to four-way-valve 88 is controlled.

From four-way-valve 88, pipes 89 communicate with one end of cylinders 59 and 60 and pipes 90 communicate with the other end of those cylinders and pipe 91 leads through relief valve 92 back to supply tank 83. Liquid supplied under pressure by pump 84 that is in excess of liquid permitted to pass throttle valve 87 is returned to tank 83 by pipe 186 in which pressure relief valve 187 is positioned. From the pipes 90 there leads to the return pipe 91, a by-pass 93 that is controlled by valve 94 and contains relief valve 194. The internal construction of valve 88 appears in Figs. 3a and 4a. When movable member 95 of valve 88 is in the position shown in Fig. 3a liquid under pressure will pass from pipe 86 through passage 96 into pipes 89 and to the right hand ends of cylinders 59 and 60 and liquid will pass from the left hand ends of those cylinders through pipes 90 and through passage 97 of movable member 95 into return pipe 91. Provided by-pass-valve 94 is closed, shifting of movable member 95 counterclockwise until passage 96 leads from pipes 89 to return 91 and passage 97 leads from supply pipe 86 to pipes 90 as shown in Fig. 4a, will cause liquid under pressure to be supplied to the left-hand ends of those cylinders and permit liquid to be discharged from the right-hand end of those cylinders into return pipe 91. Automatic mechanism is hereinafter described for effecting movement of movable member 95 back and forth from one of the adjustments above described to the other. If the tool is moving from right to left liquid under pressure will be entering the right hand end of the cylinders through pipes 89 and liquid discharged from the other ends of the cylinders will return to the supply either through pipe 93 or pipe 91, if valve 94 is open; and when the position of valve 88 is reversed and liquid under pressure is supplied to pipes 90 that liquid will return to tank 83 through pipe 93 when valve 94 is open instead of entering the left hand end of the cylinders. If then valve 94 is closed liquid under pressure will stop passing through pipe 93 and will enter the left hand end of the cylinders. If, however, by-pass-valve 94 is opened tool 25 will stop in the position shown in Fig. 1, if it is then in that position, or it will continue its motion to the left until it comes to that position if valve 94 is open as the tool is moving from right to left in Fig. 1. Inasmuch as the reversing mechanism reverses the position of valve 88 at each end of the stroke of tool 25, the mere closing of valve 94 will cause reciprocation of tool 25 to begin and the mere opening of valve 94 will cause reciprocation of tool 25 to discontinue. By opening valve 94 at the end of a cake dislodging operation when tool 25 is moving from right to left in Fig. 4, tool 25 will come to the position shown in Figs. 1 and 4 and stop in preparation for the next separating and cake-forming operation.

The automatic reversing mechanism comprises rod 96, one end of which is supported for sliding in plate 76 and the other end of which is supported by a pivot on rocker arm 97 which is pivoted to bracket 98, carried by frame 31. Contact members 99 are threaded upon rod 96 in order that their position thereon may be so adjusted that they will be suitably engaged by lug 101 on yoke 72 at predetermined points in the stroke of tool 25. This lug may be carried by any of the reciprocating parts. Pivoted to the opposite end of rocker arm 97 is link 102 that is pivotally connected to one end of valve-operating bar 103 supported for sliding in auxiliary frame 104 that is mounted upon frame 31. Movable member 95

of four-way-valve 88 is attached to shaft 105 to which is secured arm 106 carrying roller 107. Rod 103 is provided with arms 108 and 109 for cooperating with roller 107 to swing arm 106 and rotate movable member 95 of valve 88. Rod 103 is provided with a projection 110 which cooperates with a projection 111 on lever 112 that is pivoted at 113 and pressed upwardly by spring 114. These parts are shown in Figs. 1 and 4 in the position in which they lie when tool 25 is moving to the right and valve 88 is in the setting shown in Fig. 4a. As tool 25 approaches the limit of its movement to the right, lug 101 will engage stop 99 at the right-hand end of bar 96 and cause bar 103 to move to the left until the apex of projection 110 snaps over the apex of projection 111 and then a quick and complete movement of rod 103 to the left will occur as projection 110 rides down the left-hand slope of projection 111, due to the action of spring 114, and the parts will be brought to the position shown in Fig. 3; and the engagement of arm 109 with roller 107 will have caused valve member 95 to be given a quick and complete clockwise movement to the position shown in Fig. 3a. Thereupon tool 25 will be moved to the left in Fig. 3 until lug 101 strikes contact member 99 at the left hand end of rod 96 and causes bar 103 to move to the right until the apex of projection 110 snaps over the apex of projection 111 into the position shown in Figs. 1 and 4. The resulting action of arm 108 on roller 107, swings valve operating arm 106 to the position shown in Figs. 1 and 4, and arm 106 rotates shaft 105 counter-clockwise and reverses the position of valve member 95 to the position shown in Fig. 4a and causes liquid under pressure to be admitted again to the left-hand end of cylinders 59 and 60 and tool 25 will move to the right. Arm 106 is provided with an extension 116 that engages cushioning stops at the limiting positions of arm 106 when the parts of valve 88 are in register in the settings shown in Figs. 3a and 4a. These stops may be of any suitable construction but are shown in the drawings simply as lugs 117 in which are adjustably threaded the screws 118 that engage extension 116.

This hydraulic reciprocation of the tool with automatic reversing at each end of its stroke will continue until by-pass valve 94 is opened and oil under pressure is returned to tank 83 through pipe 93 instead of passing through pipes 90 to the left hand ends of cylinders 59 and 60. During such reciprocation tool 25 is swung more and more toward the inner wall of rotor 11 and farther and farther into the cake thereon, by admitting liquid under pressure to the right-hand end of cylinder 52, through proper adjustment of valve 57, or by rotating hand-wheel 58 counter-clockwise. When the removal of the cake is completed, liquid under pressure is admitted to the left-hand end of cylinder 52 or hand-wheel 58 is rotated clockwise until tool 25 is brought to the position shown in dotted lines in Fig. 7. Stops 47 and 48 prevent rotation of tool 25 to a point at which it engages the inner surface of rotor 11; and stops 79 and 81 positively prevent, without binding or wedging, reciprocation of tool 25 from bringing tool 25 into engagement with the side walls of rotor 11. The force transmitted when any of these stops come into operation is transmitted by contact of a flat face with another flat face and no force is applied through a worm-wheel or any other construction that might cause a binding or wedging to occur when the stops come into action.

While I have described certain embodiments of

my invention in great detail in order to assist in a full understanding thereof, I do not intend that my invention shall be limited to such details but that it shall include such modifications and variations as fall within the appended claims.

I claim:

1. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, hydraulic means for moving said tool in opposite directions, a pipe for supplying liquid under pressure to said means, a throttle valve for controlling the rate of flow of liquid in said pipe toward said means, and a valved by-pass leading from said pipe between said throttle valve and said means.

2. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a hydraulic cylinder having a piston connected to said tool for the movement thereof, a valve adjustable to settings respectively causing liquid under pressure to enter opposite ends of said cylinder, a by-pass for diverting liquid passed by said valve to one end of said cylinder, and a valve controlling the flow of fluid through said by-pass to control the movement of said piston.

3. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool-moving member carrying said tool, a hydraulic cylinder, a piston in said cylinder and having a piston rod, and a part connected to said rod and swiveled to said member for transmitting movement of said rod to said member.

4. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool moving member carrying said tool, a hydraulic cylinder, a piston in said cylinder and having a piston rod, a part mounted on said member for relative rotation and fixed against longitudinal movement with respect thereto and connected to said rod, and means for effecting a relative rotation between said part and said member.

5. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a member supporting said tool and mounted for reciprocation and rotation, means for rotating said member, a reciprocating rod, means connecting said rod and said member for relative rotation, and means preventing rotation of said member from rotating said connecting means.

6. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a member supporting said tool and mounted for reciprocation and rotation, means for rotating said member, a reciprocating rod, means connecting said rod and said member, for relative rotation, and a guide constraining said connecting means to reciprocating motion.

7. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, hydraulic means for operating said tool, a source of supply of liquid under pressure for said hydraulic means, a pipe leading from said source to said hydraulic means, a throttle valve in said pipe, and a relief by-pass leading

from said pipe at a point between said throttle valve and said source of supply.

8. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool holder, and a bearing adjacent said rotor and supporting said tool holder and having an opening intermediate its ends for the discharge of foreign matter entering one end of the bearing.

9. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a bar supporting said tool and having a longitudinal key slot extending away from said tool beginning at a point spaced from said tool and extending away from said tool, a bearing engaging said holder between said key slot and said tool, means for reciprocating said tool holder in said bearing, a stuffing box at the end of the bearing adjacent said tool, and a stop limiting reciprocation of said holder to prevent movement of said key slot into said stuffing box.

10. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool holder mounted for rotation to carry said tool toward and from the cake of solids in the rotor, irreversible means including a driving member and a driven member for rotating said holder, and stops limiting the extent of movement of said driving member.

11. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool holder mounted for rotation to carry said tool toward and from the cake of solids in the rotor, means for rotating said holder, comprising a worm and worm-wheel, a rack and

pinion operatively connected to said worm, and non-binding stops for limiting the movement of said rack.

12. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool for movement along the inner wall of the rotor, a tool holder mounted for rotation to carry said tool toward and from the cake of solids in the rotor, a worm-wheel keyed to said holder, a worm engaging said worm-wheel, and non-binding means for limiting rotation of said worm while permitting more than a full rotation thereof.

13. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool, a hydraulic cylinder for reciprocating said tool, conduits respectively conducting fluid to opposite ends of said cylinder and a by-pass leading from one of said conduits.

14. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool, a hydraulic cylinder for reciprocating said tool, conduits respectively conducting fluid to opposite ends of said cylinder, means controlled by movement of said tool for directing fluid alternately into said conduits, and a by-pass leading from one of said conduits.

15. In a device for the removal of solids from the rotor of a centrifugal machine, a solid-dislodging tool, a hydraulic cylinder for reciprocating said tool, conduits respectively conducting fluid to opposite ends of said cylinder, means controlled by movement of said tool for directing fluid alternately into said conduits, and a by-pass leading from that one of said conduits through which fluid is flowing into said cylinder during movement of the tool into the rotor.

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