Oct. 2, 1923. 1,469,230

J. MacKAYE

CENTRIFUGAL SEPARATING APPARATUS

Filed March 26, 1920 8 Sheets-Sheet 1

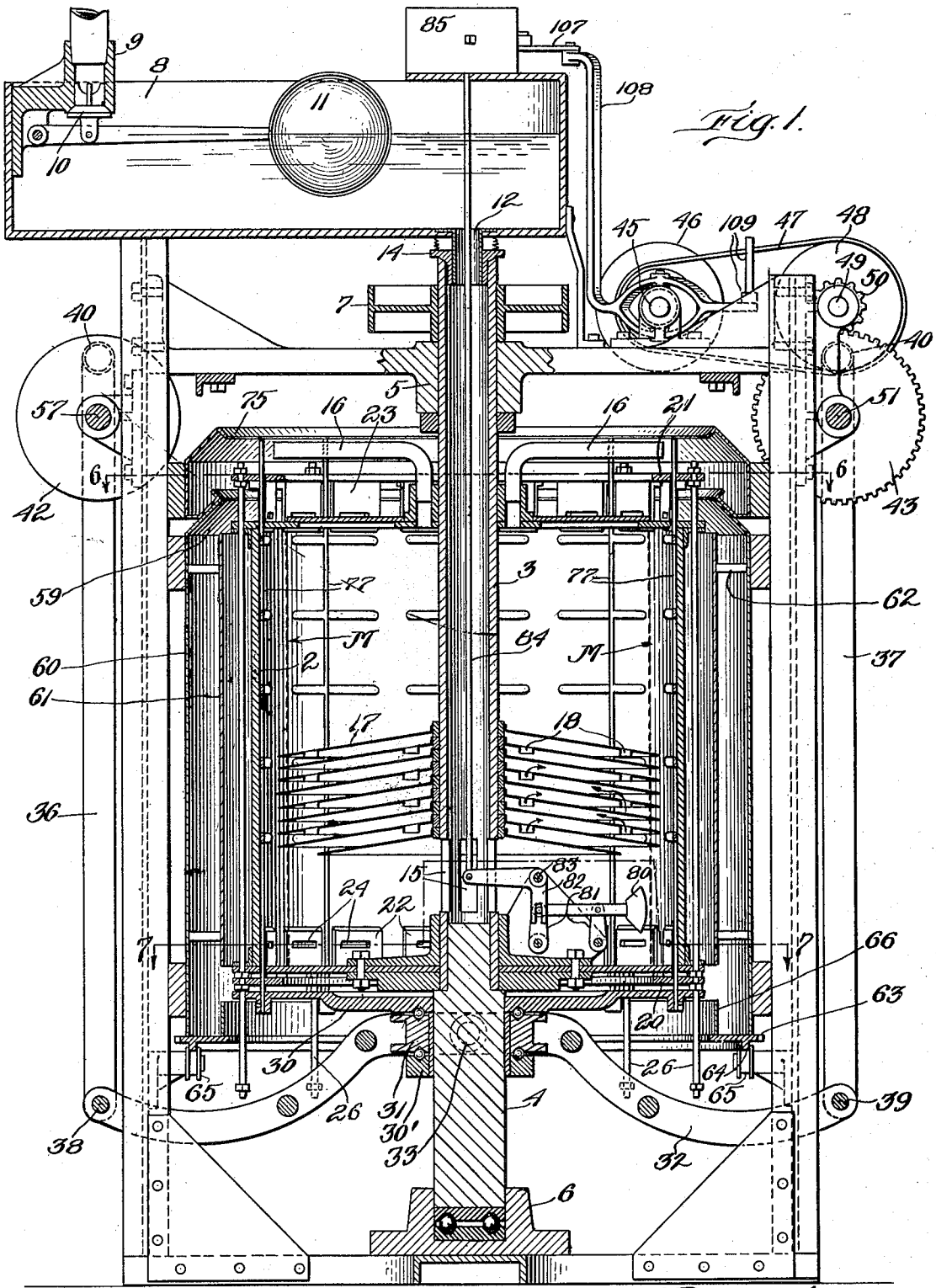


Fig. 1.

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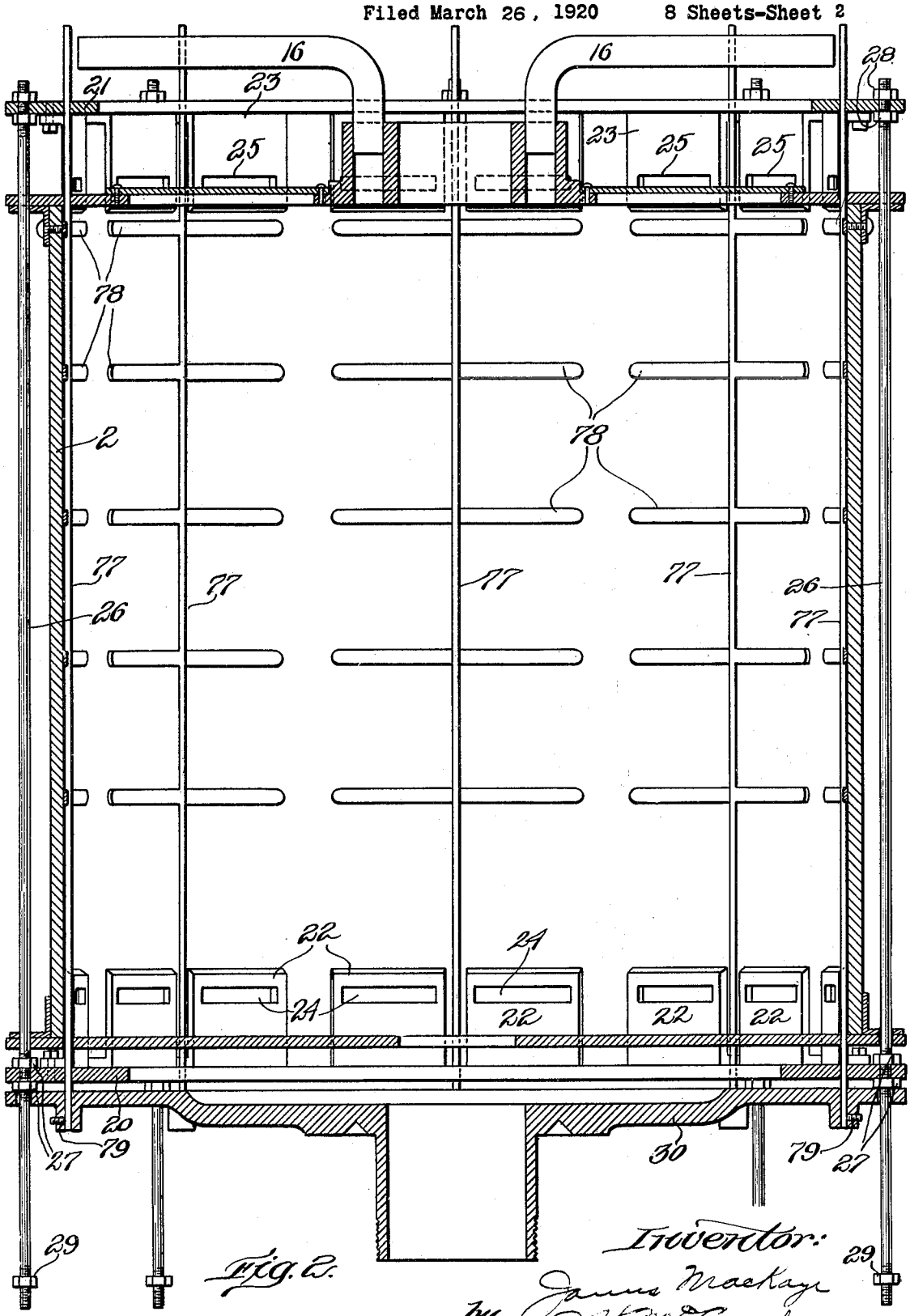


Fig. 2.

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CENTRIFUGAL SEPARATING APPARATUS

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Fig. 4.

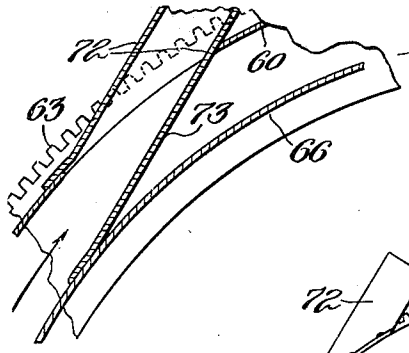


Fig. 3.

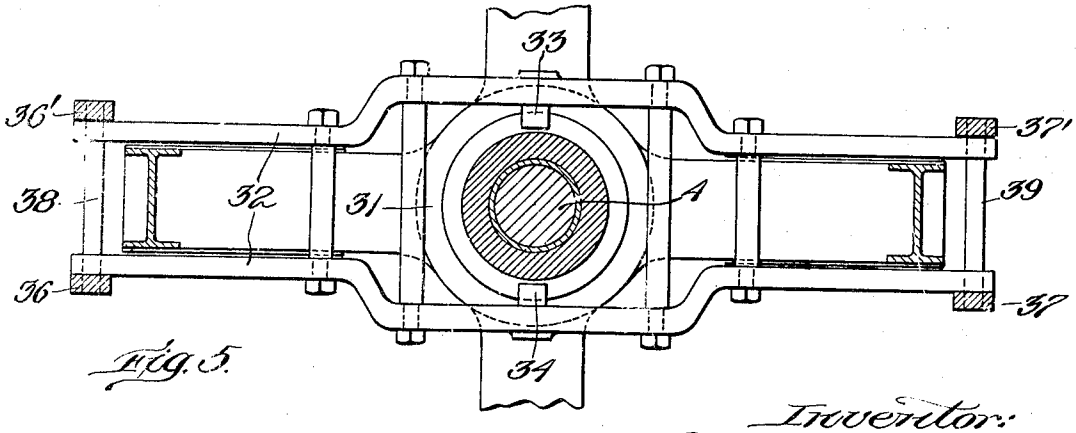


Fig. 5.

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CENTRIFUGAL SEPARATING APPARATUS

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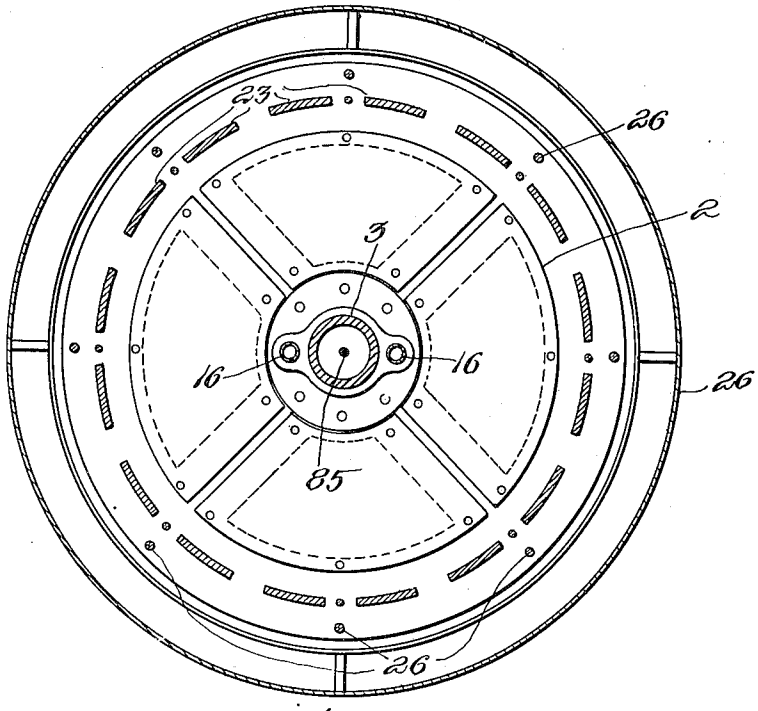
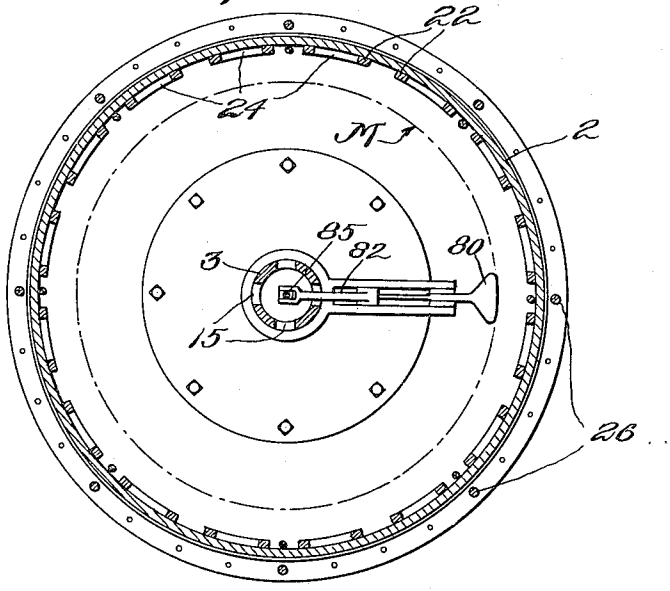


Fig. 6.

Fig. 7.



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CENTRIFUGAL SEPARATING APPARATUS

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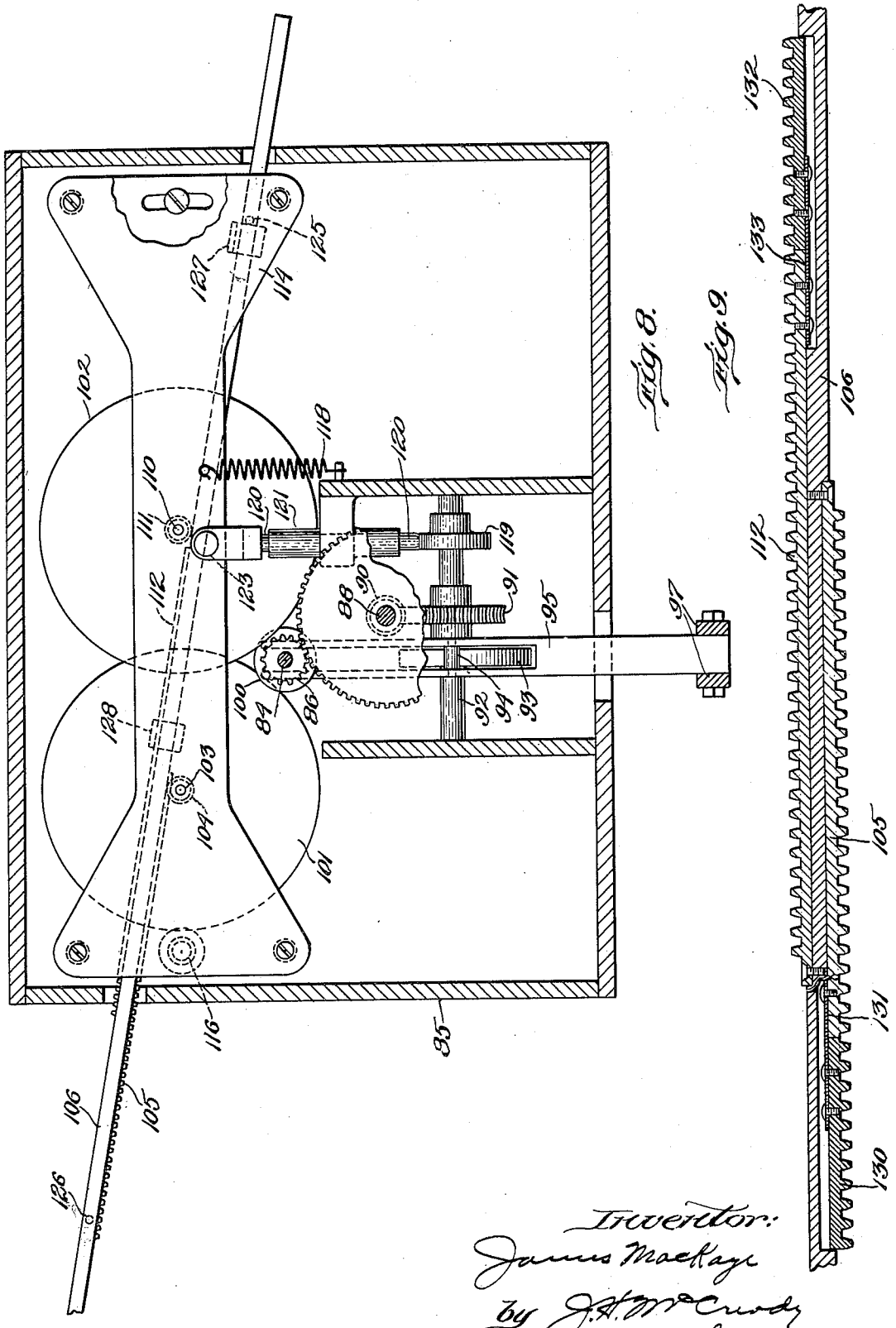


Fig. 8.

Fig. 9.

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CENTRIFUGAL SEPARATING APPARATUS

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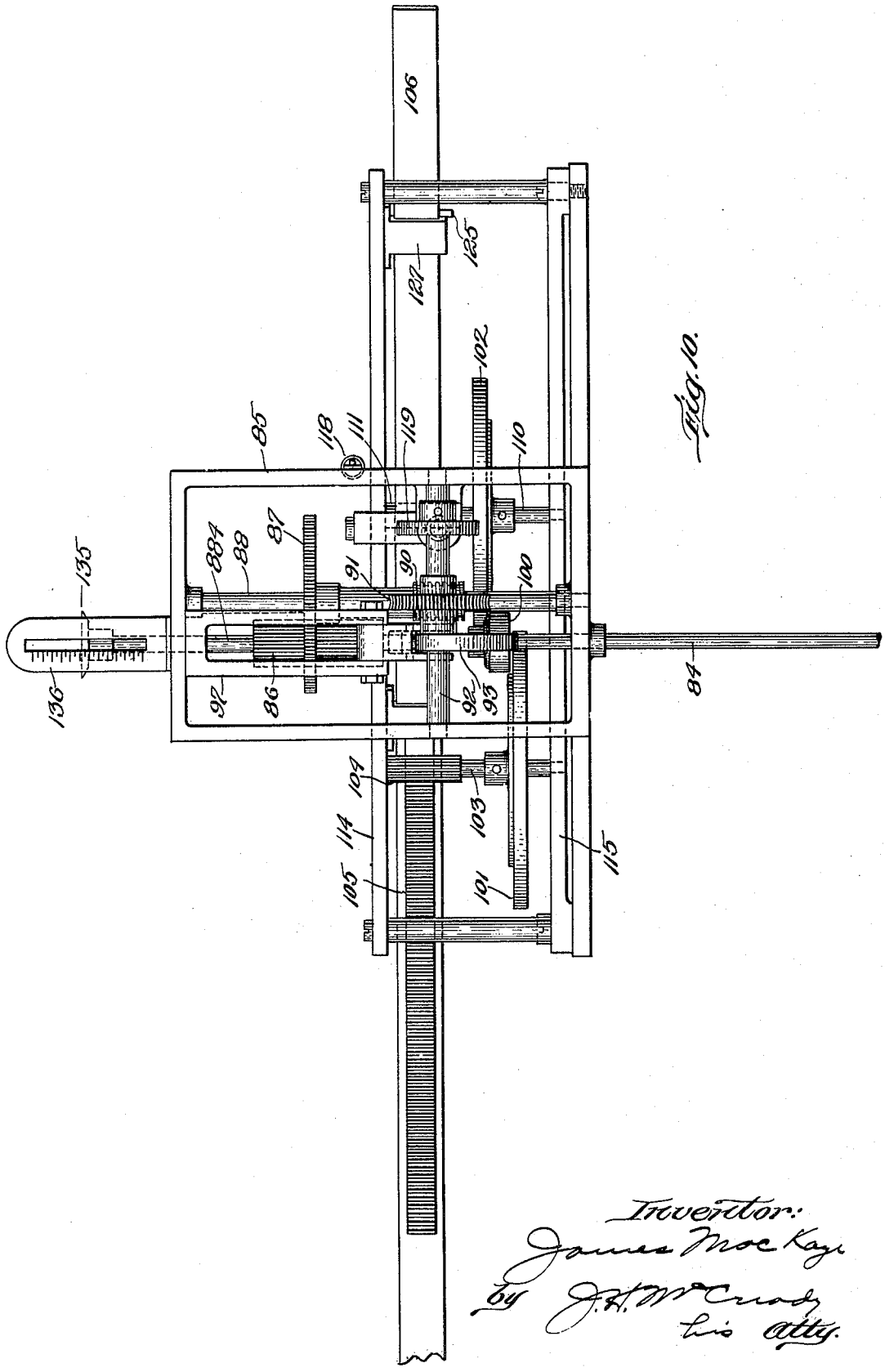


Fig. 10.

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CENTRIFUGAL SEPARATING APPARATUS

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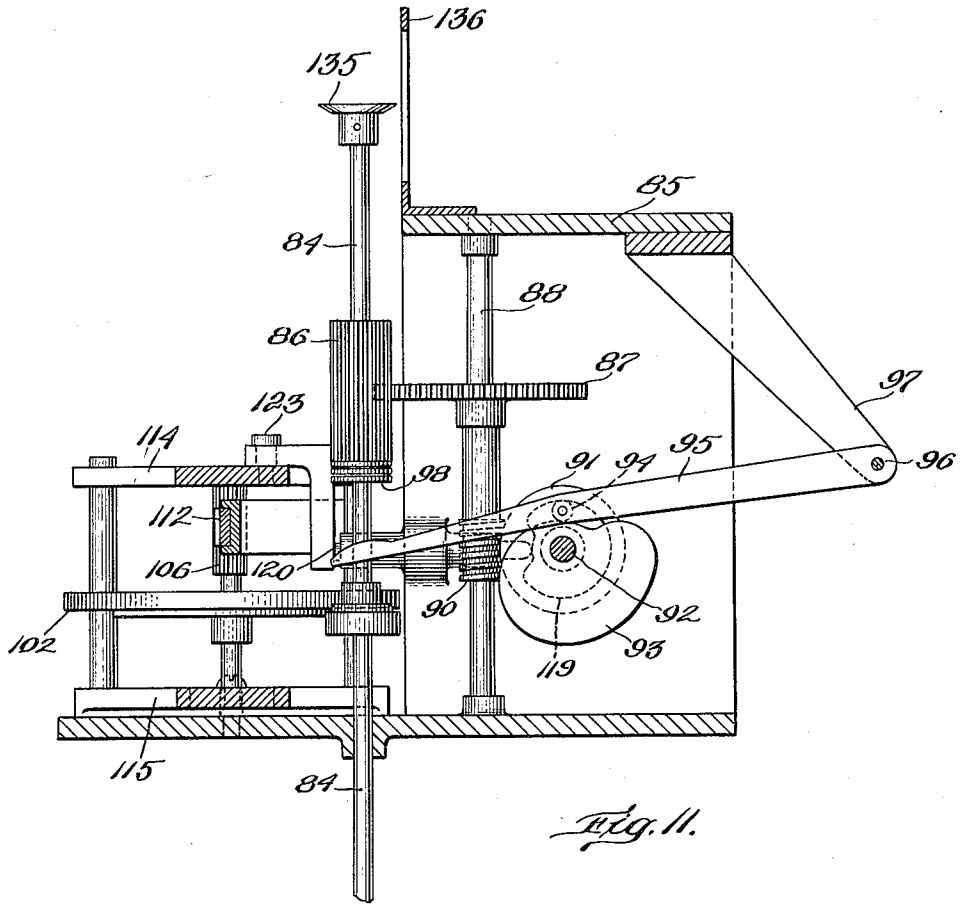


Fig. 11.

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CENTRIFUGAL SEPARATING APPARATUS

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Fig. 13.

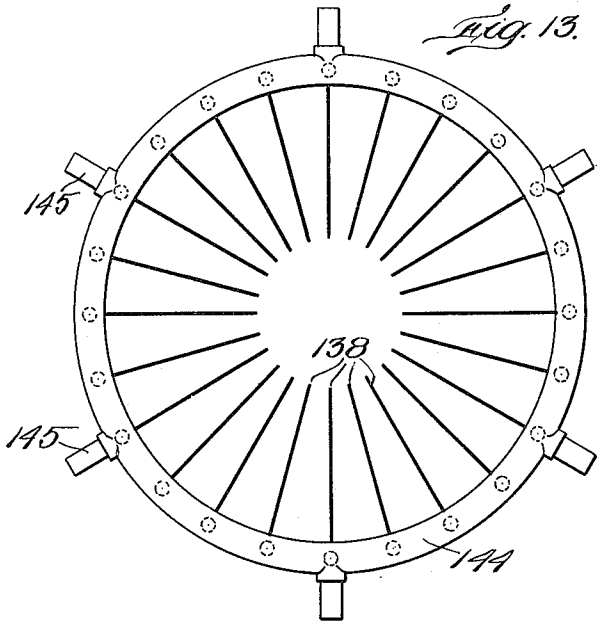


Fig. 14.

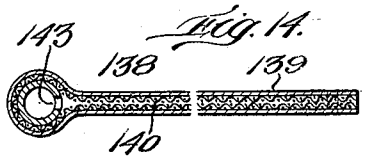
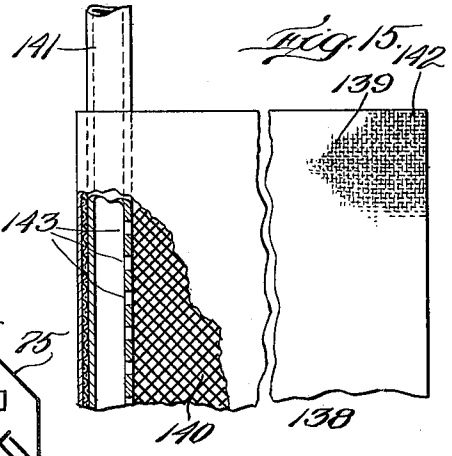


Fig. 15.



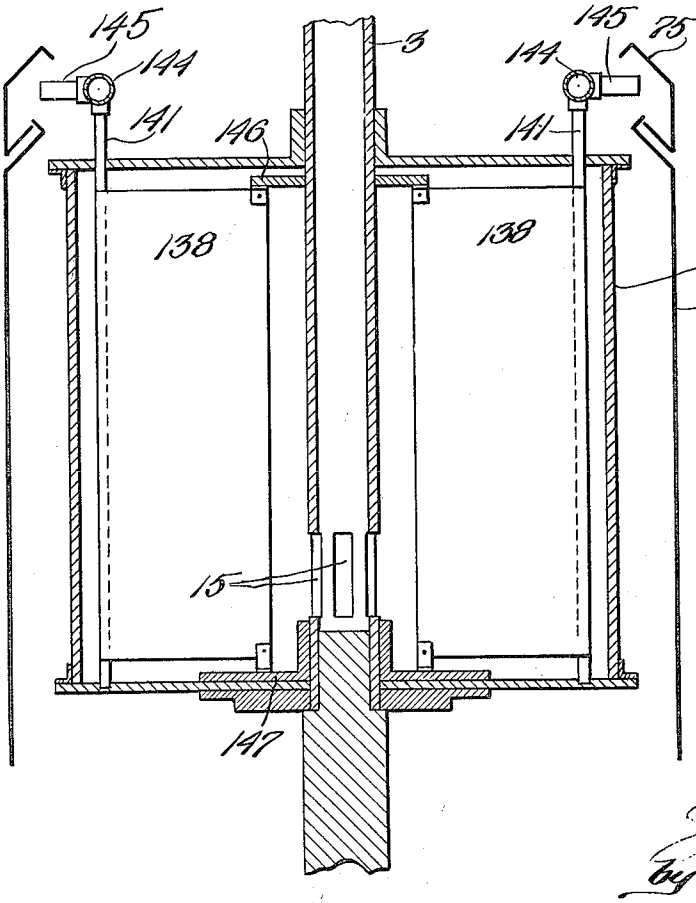


Fig. 12.

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UNITED STATES PATENT OFFICE.

JAMES MACKAYE, OF CAMBRIDGE, MASSACHUSETTS.

CENTRIFUGAL SEPARATING APPARATUS.

Application filed March 26, 1920. Serial No. 368,927.

To all whom it may concern:

Be it known that I, JAMES MACKAYE, a citizen of the United States, residing at Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Centrifugal Separating Apparatus, of which the following description, in connection with the accompanying drawings, is a specification, like reference characters on the drawings indicating like parts in the several figures.

This invention relates to centrifugal separators and is especially concerned with the separation of solids from liquids. It is one of the chief objects of the invention to devise a centrifugal separator which will successfully separate the solid and liquid materials that make up the slimes which are formed in certain processes involved in mining and ore reduction. It is a further object of the invention to devise an apparatus of this character in which the separation of the solid and liquids can be carried on continuously.

It has been proposed heretofore to separate solids from liquid materials through the uses of centrifugal action, but the various forms of apparatus for accomplishing this object, of which I am aware, have not been adapted to continuous operation. That is, it has been necessary to treat the material in batches, the solid matter separated in each batch being removed from the apparatus before the treatment of another batch could be begun. It is obvious that such an apparatus is not suited to the treatment of slimes or other mixtures of liquid and solid materials in which both a relatively large quantity of liquid and also a relatively large quantity of solid matter must be handled. The present invention aims to devise an apparatus which will successfully handle mixtures of this character.

It is obvious that in a centrifugal apparatus designed to continuously separate liquid and solid material where the volumes of both materials are relatively great, some provision must be made for releasing either continuously, or at intervals, quantities of both the liquid and the solid which have been separated in order to make room for the introduction of more material to be separated. The present invention makes provision of this character and it also includes a novel form of governing mechanism for controlling the rate at which the separated material will be ejected from the apparatus.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings and the novel features will be particularly pointed out in the appended claims.

Referring now to the drawings,—

Figure 1 is a vertical, central, cross sectional view of a centrifugal separator constructed in accordance with the present invention;

Fig. 2 is a vertical cross sectional view of a cylinder showing the valve and scraper mechanism;

Fig. 3 is a plan view of the apparatus shown in Fig. 1;

Fig. 4 is a cross sectional view showing a detail of the arrangement for ejecting the solid material separated from the mixture that is treated;

Fig. 5 is a horizontal cross sectional view showing the part of the mechanism for operating the valves and scrapers;

Fig. 6 is a horizontal cross sectional view substantially on the line 6—6, Fig. 1;

Fig. 7 is a view similar to Fig. 6 on the line 7—7, Fig. 1;

Fig. 8 is a plan view, partly in cross section, of the governor mechanism;

Fig. 9 is a cross sectional view of a rack used in the governor mechanism;

Fig. 10 is a side elevation of the governor mechanism;

Fig. 11 is a view at right angles to the view shown in Fig. 10 of the governor mechanism, certain of the parts in Fig. 11 being shown in cross section;

Fig. 12 is a cross sectional view, partly in elevation, illustrating a modified construction;

Fig. 13 is a plan view of the modified construction illustrated in Fig. 12;

Fig. 14 is a horizontal cross sectional view through one of the filters used in the modified construction; and

Fig. 15 is a view partly in side elevation and partly in cross section of a portion of the filter shown in Fig. 14.

The apparatus shown comprises a cylinder 2 mounted on a vertical shaft consisting of an upper hollow portion 3, Fig. 1, and a lower solid portion 4, the two parts of the shaft being secured fast together. This shaft rotates in upper and lower bearings

5 and 6, respectively, and is driven by a belt connection with a pulley 7 fixed to the upper end of the shaft 3. The cylinder 2 is secured fast to the two-part shaft 3—4 and rotates therewith.

The fluid mixture to be treated is led into a tank 8 through a pipe 9, the flow of liquid into this tank being regulated by a valve 10 controlled by a ball float 11. An outlet pipe 12 set into the bottom of the tank and supported in a collar 14, Fig. 1, having a running fit with the upper end of the hollow shaft 3, allows the liquid to flow by gravity into the shaft 3. From this shaft the liquid flows through holes 15 into the lower part of the cylinder 2. It is obvious that due to the rapid rotation of the cylinder the solid parts of material carried by the liquid will be thrown against the peripheral wall of the cylinder and after a time will build up a layer of mud, as indicated at M. The liquid, being lighter than the solid material, will occupy the central portion of the cylinder and, due to the hydraulic head upon it, will flow to the upper part of the cylinder where it will be discharged through pipes 16.

In order to render substantially uniform the flow of the liquid through all parts of the cylinder and thus subject all parts of the body of liquid to the centrifugal action for substantially the same length of time, a series of settling pans 17, or disks, are interposed at an intermediate point in the cylinder. Only a few of these pans are shown in Fig. 1. The peripheral edges of these pans or disks lie in the layer of mud M and each pan is provided with a series of short depending outlet tubes 18, these tubes on alternate pans being located close to the shaft 3, while those in the other pans are located at a considerably greater radial distance from the shaft. The result of this arrangement is to cause the liquid to flow in a zigzag path as it travels upwardly toward the outlet of the cylinder. It will be noted that the pans 17 have the shape of a cone with a very broad base and a very short axis so that as the fluid mixture flows from a discharge opening adjacent to the shaft 3 to another opening near the peripheral edge of the next pan, it must flow downwardly in opposition to the general direction of flow through the cylinder, and it flows upwardly in travelling from one pan to another only as it moves inwardly toward the center of rotation, and consequently travels in opposition to the direction in which it is urged by centrifugal force. This arrangement has been adopted chiefly for the purpose of so distributing the flow through the cylinder that all parts of the fluid mixture will be subjected to substantially the same centrifugal action as it flows through the cylinder. Consequently, any tendency for a part of the fluid mixture to take a short cut through the cylinder is effectually prevented. This arrangement, therefore, not only operates to produce a more uniform distribution of the solid material separated from the liquid content of the mixture, but it also produces a more uniform treatment of all parts of the fluid mixture. If the mixture flowing into the cylinder contains a relatively large proportion of solid matter it is evident that the layer of mud M will build up very rapidly and in order to enable the apparatus to operate continuously a reciprocating valve mechanism is provided to discharge the mud from the cylinder. This valve mechanism comprises a flat ring 20, Figs. 1 and 2, at the bottom of the cylinder 2 and a similar ring 21 at the top of the cylinder. The ring 20 carries a series of upstanding plates 22, best shown in Fig. 2, that project through slots formed in the lower end of the cylinder close to the peripheral wall of the cylinder and each of these plates has a pocket or slot 24 formed therein. The upper ring 21 carries a similar set of plates 23 likewise provided with pockets or slots which are indicated at 25. These plates and their slots constitute the valves. It is obvious that when the lower set of valves are raised, as shown in Figs. 1 and 2, so that the slots 24 are in communication with the interior of the cylinder, they will fill in a very short time with mud. If they are now moved downwardly to a point below the bottom of the cylinder this mud will be thrown out of the valves through the action of centrifugal force. Similarly, when the upper set of valves 23 is moved downwardly in the cylinder they receive a charge of mud which they deliver when they are again moved upwardly far enough to carry the pockets 25 above the upper end of the cylinder.

For the purpose of operating these valves, the rings 20 and 21 are connected together by a series of rods 26 which surround the cylinder 2 and are guided in peripheral flanges formed by extending the upper and lower ends of the cylinder beyond its peripheral wall. The lower valve ring 20 is adjustably secured to the rods 26 by nuts 27 while the other valve ring 21 is similarly secured by nuts 28. Each ring, therefore, can be vertically adjusted independently of the other. The rods 26 project below the ring 20 for a considerable distance and each has a nut 29 threaded thereon near its lower end. This entire set of rods extends through a circular plate 30, Figs. 1 and 2, which rotates with the shaft 4. A collar 30′ also rotates with this shaft and between the parts 30 and 30′ is mounted a collar 31 spaced from the parts 30 and 30′ by ball bearings. The part 31 is straddled by a

yoke 32, Fig. 5, which receives two pins 33 and 34 projecting from opposite sides of the collar 31. This arrangement thus enables the plate 30 to rotate relatively to the yoke 32 but compels the two members to move vertically in unison.

For the purpose of reciprocating the yoke 32, two pairs of connecting rods 36—36′ and 37—37′, Fig. 5, are secured at their lower ends by pivots 38 and 39 to the opposite ends of the yoke. The upper ends of the two connecting rods 36—36′ run on crank pins 40 and 40′ carried, respectively, by a bevel gear 56 and a disk 42, Fig. 3. The upper ends of the opposite links 37 and 37′ are mounted, respectively, on crank pins 41 and 41′ carried by the respective parts 52 and 43, Fig. 3. The chain of connections for driving these parts is best shown in Fig. 3. These connections comprise a pulley 44, which may be belted to any convenient source of power, mounted fast in a shaft 45 to which also is fixed a cone pulley 46 that is connected by a belt 47 to another cone pulley 48 fast on the shaft 49. A pinion 50 also fast on this shaft meshes with the gear wheel 43 and drives this gear and with it the shaft 51 on which it is fixed. A mitre gear 52 fast on the shaft 51 meshes with another mitre gear 53 fast on the shaft 54 and operates through similar gears 55 and 56 to drive the shaft 57 on which the disk 42 is secured.

It will now be evident that when the machine is in operation the circular plate 30 will be reciprocated longitudinally of the shaft 4 by the connections just described, and that as it nears the upper limit of its stroke it will engage the lower set of nuts 27 and thus lift the valve rings 20 and 21, and, consequently, raise the valves carried by said rings. This imparts the up stroke to the valves. As the plate 30 is lowered it will not produce any movement of the valves until it reaches a point near the lower limit of its stroke where it engages the set of nuts 29 on the lower ends of the rods 26, the remainder of the down stroke of the plate 30 being operative to lower both sets of valves. These operations are repeated as long as the machine continues in operation.

The mud discharged by the upper set of valves is thrown against the upper inclined wall 59 of a casing or curb 60 which encircles the cylinder 2, this mud dropping down between the casing 60 and an inner casing member 61 spaced from the part 60 by suitable stays or braces 62. The mud drops on the upper surface of a ring 63 having a depending flange 64 that runs in a circular series of grooved pulleys or idlers 65. In a like manner, the mud discharged by the lower valves is directed between the outer curb or casing 60 and an inner curb 66, Fig. 1, and falls on the surface of the ring 63. For the purpose of driving the ring 63 its outer edge is toothed, as clearly shown in Figs. 3 and 4, to mesh with a pinion 67 fast on the lower end of a shaft 68 which is driven through a bevel gear connection 69 with a horizontal shaft 70 driven by a sprocket and chain connection 71 from the shaft 54, previously referred to. This ring 63 delivers the mud to a tangential discharge chute 72, Figs. 3 and 4, one wall of this chute being extended across the upper surface of the ring and closely adjacent thereto, as indicated at 73, Fig. 4, to form a scraper which deflects the mud into the chute 72.

The liquid ejected from the cylinder 2 through the pipes 16 is caught in an upper stationary curb or casing 75, Fig. 1, which is drained by one or more discharge conduits.

From the foregoing it will now be understood that when the separator is in operation the fluid mixture to be treated will flow continuously into the cylinder, the solid constituent of this mixture being separated from the liquid constituent by centrifugal action, and the mud thus extracted from the mixture will be discharged substantially continuously through the opposite ends of the cylinder by the valve mechanism. The valves take the mud from points near the ends of the cylinder and there is a tendency, therefore, to reduce the thickness of the wall of mud at these points more rapidly than elsewhere. Unless this tendency is counteracted or compensation is made for it, the result will be to form holes in the layer of mud near the opposite ends of the cylinder and the valves then would begin to discharge liquid. For the purpose, therefore, of preventing such action a series of mud distributors are provided on the interior of the cylinder. These distributors are best shown in Fig. 2, from which it will be seen that they each comprise a rod 77 lying close to the inner wall of the cylinder, each rod being provided with a series of flat arms 78 extending at opposite sides thereof and lying against the cylinder wall. The rods 77 project through the opposite ends of the cylinder and are secured by set screws 79 at their lower ends to the plate 30 which, as above described, operates the valves 22 and 23. It will be recalled that this plate has a considerable amount of lost motion with reference to the valve operating rods 26, only a relatively short part of each stroke near its extremities serving to move the valves. Since, however, the distributors are connected directly to the plate 30 they have a stroke equal to that of the plate, and this stroke is made slightly greater than the distance between adjacent arms 78 so that practically the entire body of mud is subjected to their distributing or levelling action. The

discharge pipe 16 delivers between the rods 77.

The presence of the distributing pans or cones 17, as above described, assists in producting a uniform distribution of the mud over the wall of the cylinder, and this action, combined with that of the distributors and with the natural tendency of the mud to flow to the most remote point radially of the cylinder, maintains the layer of mud substantially level notwithstanding the fact that the valves remove the mud only from the opposite ends of this cylindrical layer.

It is desirable to so control the operation of the separator that the mud will be discharged substantially as rapidly as it is deposited. This object may be obtained either by varying the rate of deposit or the rate of discharge. I consider it far more feasible, however, to control the rate of discharge and for that reason I have provided a governing mechanism for the mud discharging means and made this mechanism responsive automatically to variations in the thickness of the layer of mud, so that when this thickness increases beyond a predetermined limit the discharging means will be operated to carry the mud away more rapidly, and conversely, if the thickness of the mud layer becomes too thin the rate of its discharge will be reduced. In other words, the governing mechanism tends to so regulate the rate of discharge of the mud that the thickness of the layer will be maintained within substantially predetermind limits.

As above pointed out, the mud discharging valves are driven by a variable speed mechanism comprising the cone pulleys 46 and 48 and the belt 47 which connects these pulley. By referring to Fig. 3 it will seen that when the belt is in the position there shown, the shaft 49 will be driven at a low speed, while if the belt is shifted to the opposite ends of the pulleys the shaft 49 will be driven at a greatly increased speed, it being assumed, of course, that the shaft 45 is being driven at a contant speed. The valve mechanism is positively connected with the shaft 49 so that the rate of operation of the valves varies directly with the speed of the shaft 49. The governing mechanism is arranged to shift this belt backward or forward, as may be desired, to effect the required change in speed of the mud discharging mechanism.

The governing mechanism comprises a float or feeler 80, Fig. 1, pivoted on the upper end of an arm 81 so that it can move backward or forward in a substantially horizontal plane toward or from the surface of the layer or mud M. One arm of a bell crank lever 82, fulcrumed at 83, has a pin and slot connection with the rearward end of an extension or arm projecting from the feeler 80 while the other arm of said bell crank lever projects through one of the slots 15 in the hollow shaft 3 and is pivoted to the lower end of a rod 84 that extends axially through this shaft and into the casing 85, Fig. 1, in which the governing mechanism is housed. It will be seen that the bell crank lever 82 and the rod 84 are so arranged that the rod rotates with the cylinder and this fact is utilized by making the rod 44 the driving shaft for the governing mechanism.

The float, as shown in Figs. 1 and 7, has a large mud engaging face so that it will not sink appreciably into the mud, and it is normally held against the surface of the mud by the weight of the parts connected to it and by the action of centrifugal force on the feeler itself. If the rate of discharge of the mud happened to be greater than the rate of deposit, the feeler would move toward the cylinder wall as fast as it is allowed to by the decrease in the thickness of mud; but if the reverse of these condition obtains, the feeler would, in a short time, become buried in mud and thus would not respond to variations in thickness in the mud layer. For this reason mechanism has been provided to move the feeler intermittently away from the mud and then release the feeler whereupon it will return to a position determined by the depth of the mud at that particular instant.

This mechanism will best be understood by referring to Figs. 10 and 11, from which it will be seen that the rod 84 has fixed thereon, near its upper end, a barrel pinion 86 meshing with a spur gear 87 fast on a shaft 88 which is journaled in the walls of the casing 85. Also mounted on the shaft 88 is a worm 90 driving a worm wheel 91 fast on a transverse shaft 92. This shaft carries a cam 93, Fig. 11, the surface of which engages a roll 94 which is mounted on a lever 95 fulcrumed at 96 on a bracket 97. The forward end of this lever is forked to straddle the rod 84, and when it is swung upwardly by the cam 93, this forked end engages a coller 98 mounted immediately under the barrel pinion 86 and spaced therefrom by anti-friction bearings. The further upward movement of this lever raises the rod 84 and consequently moves the float 80 backwardly away from the surface of the mud. When the lever 95 is next lowered the weight of the rod 84, and the parts carried thereby, combined with the centrifugal action of the float 80, moves the float forward again into contact with the surface of the mud. The float thus is moved at intervals away from the mud and is enabled to reposition itself in accordance with any changes that have occured in the depth of mud.

Referring to Figs. 8 and 10 it will be seen

that the rod 84 carries a friction roll or disk 100 which may engage with the peripheral edge either of another friction disk 101 or of a similar disk 102, the former mounted immediately below, and the latter immediately above, the usual level of the disk 100 so that normally it does not engage either of these disks. When the lower disk is engaged and driven by the disk 100, the result is to rotate the shaft 103, to which the disk 101 is fixed, and with it the pinion 104, also fast on said shaft. The pinion 104 meshes with a rack 105 fast on a bar or slide 106, and its rotation slides the bar in one direction through the casing 85. As shown in Figs. 1 and 3, this bar is connected by a link 107 with a lever 108 which operates the shipper 109 for the belt 47. When the disk 102 is driven by the disk 100, this motion is transmitted through a shaft 110, pinion 111 and rack 112 also fast on the bar 106 and slides this bar in the opposite direction.

Since the disk 102 slightly overlies the disk 100, it is necessary to move the former disk out of the path of movement of the latter disk when the lever 95 raises the disk 100 to permit the readjustment of the feeler. For this purpose the two disks 101 and 102 and the shafts and pinions fixed thereto are supported in a frame comprising upper and lower plates 114 and 115, respectively, spaced apart by suitable studs, and this frame is pivoted at 116, Fig. 8, so that the entire frame and the disks 101 and 102 carried thereby can be swung toward or from the axis of the driving disk 100. Normally the frame is held in its position closest to said disk by a spring 118, Fig. 8. The frame is swung away from this disk at the proper time by a cam 119 fast on the shaft 92 and engaging one end of a rod 120 which slides through a bearing 121 and is pivoted at 123 to the upper plate 114 of the swinging frame. The spring 118 always holds the end of the rod 120 in contact with the surface of the cam 119 and the cam 119 is so designed that it permits the disks 101 and 102 to swing forward into position to engage the disk 100 only at the proper point in the cycle of operations of the governing mechanism.

Assuming now that the feeler has just been moved out of contact with the layer of mud by the lever 95 and the cam 93, and that an increase has taken place in the thickness of this layer, it will be seen that when the cam 119 again allows the disks 101 and 102 to swing forward, the upper disk 102 will be engaged by the driving disk 100 due to the fact that the feeler now is in engagement with a thicker layer of mud and consequently does not permit the driving disk 100 to drop down to its normal level. The rotation of the pinion 111 thus produced will move the rod 106 toward the left, Fig. 8, into the position in which it is shown in said figures; that is, until the pinion 111 runs off the end of the rack 112 thus shifting the belt 47, Fig. 3, on to the large end of the driving pulley and the small end of the driven pulley, and consequently increasing the speed of the latter pulley and therefore of the mud discharging mechanism.

If, however, upon a readjusting movement of the feeler 80 the driving disk 100 drops low enough to engage the disk 101 the result will be to move the slide 106 in the opposite direction and thus shift the belt 47 back into the position in which it is shown in Fig. 3 and thereby reduce the rate of discharge of the mud.

The limits of movement of the bar or slide 106 are determined by stops 125 and 126, Fig. 8, these stops engaging brackets 127 and 128, respectively, in which the bar is supported and which, in turn, are supported by the plate 114. The racks 105 and 112 are made of such relative lengths that either the pinion 104 or 111 is always in engagement with its respective rack. Furthermore, in order to enable the pinions better to come in mesh with their respective racks after having run out of engagement therewith, the rack 105, Fig. 9, has an end section 130 secured thereto by a leaf spring 131, and the rack 112 has similar parts designated at 132 and 133, respectively. By referring to Fig. 8 it will be seen that the next shifting movement of the slide 106 from the position there shown will be toward the right this motion being produced by the pinion 104. At this time the pinion 111 is out of engagement with its rack, but immediately after the bar starts to slide, the yieldingly supported rack section 132 will engage the pinion 111. The disk 102 and the pinion 111 at this time are free to rotate and they may have become turned in such a position that the teeth of the pinion will not mesh with the teeth of the rack. Consequently, if a tooth of the rack should strike on top of a tooth of the pinion, the rack section 132 will yield and, as the bar continues to slide toward the right, the teeth of the rack will soon slip into mesh with the pinion. Any danger of breaking the parts thus is avoided.

For the purpose of affording the attendant a visual indication of the thickness of the mud in the cylinder, the rod 84 is extended, as shown in Figs. 10 and 11, to a point above the pinion 86 and is provided with a sharp edged disk 135 which moves over a scale on a plate 136 fastened to the frame, the scale being properly graduated to indicate the thickness of the layer of mud in the cylinder.

The construction above described is particularly adapted for those conditions in which it is not essential that the liquid be discharged from the centrifugal apparatus in a clear condition, or where the apparatus is to be used in conjunction with settling

beds or filtering apparatus for clearing up the liquid discharged from the centrifugal cylinder, the greater part of this solid material, however, being extracted in the centrifugal apparatus. For some classes of service in which it is desirable to secure a more complete extraction of the solid matter, and therefore to discharge from the apparatus a clear liquid, it is advisable to use a filtering apparatus. The construction designed to meet these requirements is illustrated in Figs. 12 to 15, inclusive. In this arrangement the settling pans, or cones, are eliminated and a series of filter units 138 are supported radially in the cylinder 2. Each of these units preferably consists of an envelope 139 of filtering material, such as cloth, secured on a woven wire frame 140, both the wire and the cloth being folded around a pipe or tube 141. This construction is clearly shown in Figs. 14 and 15. It will be evident that with this construction the liquid constituent of the mixture is afforded in a very large filtering surface. The wire fabric frame or body 140 serves to hold apart the opposite layers of filtering material 139 of each unit and thus prevent them from collapsing or being squeezed together by the external pressure. A series of holes 143 controlled in one side of the tube 141 open toward the main part of the filter unit and allow the liquid that penetrates the filtering material to flow into the tube 141. These tubes are connected to a header 144 which may be either continuous, as shown in Fig. 13, or in sections, and a series of discharge pipes 145 lead from the header at intervals and discharge the liquid against the casing 175. By making these pipes of suitable length and diameter they can be kept filled with liquid at all times and the centrifugal action exerted on the liquid contained in them creates a suction in the apparatus which materially aids in forcing the liquid through the filters. The filter units may be supported in the cylinder in any convenient manner, as, for instance, by upper and lower rings 146 and 147, respectively, provided with suitable spaces or slots to receive the upper and lower ends, respectively, of the units.

While I have herein shown and described the best embodiment of the invention of which I am at present aware, this embodiment may be modified in many respects without departing from the spirit or scope of this invention. For instance, the member 2 has been herein shown as a cylinder since this is the usual form given this member, but it is obvious that this member might be made of prismatic or other shape without departing from the invention. It will also be understood that in referring herein to the material to be separated as a fluid mixture, this term is intended to designate a mixture of a liquid and a solid, or a material which when mixed with a liquid, acts like a solid and can be handled the same way in an apparatus of the character here described.

What is claimed as new is:

1. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valve mechanism for discharging said mud from the cylinder, and means for continuously driving said valve mechanism independently of the motion of said cylinder.

2. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, and a plurality of reciprocating valves, said valves being operative to transfer mud from within the cylinder to a point outside the cylinder.

3. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, a set of valves spaced around the periphery of said cylinder at each end thereof, and means common to both sets of valves for reciprocating them in a direction parallel to the axis of rotation of the cylinder whereby said valves are operative to discharge mud from the cylinder.

4. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valves projecting through the opposite ends of said cylinder close to the cylinder wall, and means for reciprocating said valves in a direction parallel to the axis of rotation of the cylinder to cause them to discharge mud from the cylinder.

5. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting

the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, an annular valve mechanism comprising a circular series of plates projecting through one end of the cylinder closely adjacent to the cylinder wall, said plates being provided with mud receiving pockets, and means for reciprocating said plates to move said pockets into and out of said cylinder.

6. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, said outlet leading from said cylinder adjacent to its axis of rotation, and means for acting on the materials treated while they are in the cylinder to produce a substantially uniform distribution of the mud over the inner wall of the cylinder.

7. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, said outlet leading from said cylinder adjacent to its axis of rotation, and means for acting on the mud to effect a substantially uniform distribution of it over the inner wall of the cylinder.

8. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, a series of distributors spaced apart around the inner surface of the cylinder wall, and means for reciprocating said distributors in paths substantially parallel to the axis of the cylinder.

9. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, a series of rods spaced apart around the inner surface of the cylinder wall, each of said rods having a plurality of arms projecting therefrom, whereby said rods and their arms serve as distributors for the mud, and means for longitudinally reciprocating said rods.

10. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, means for discharging mud from the cylinder while the process of separation continues uninterruptedly, and reciprocating means operative between the normal surface of the mud and the inner wall of said cylinder for exerting a levelling action on the mud.

11. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valve mechanism for discharging mud from the cylinder substantially continuously, and means for maintaining a substantially uniform distribution of the mud over the inner surface of the cylinder notwithstanding the action of said valve mechanism.

12. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, reciprocating valves movable into and out of said cylinder to discharge mud from the cylinder, reciprocating distributors operating on the mud within the cylinder, and a common operating mechanism for said valves and distributors.

13. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valve mechanism for discharging said mud through the end of the cylinder while the process of separation continues uninterruptedly, and means for driving said valve

mechanism independently of the motion of said cylinder.

14. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, recprocating valve mechanism operative to transfer mud from within the cylinder through the end of the cylinder to a point outside the cylinder, and means for driving said valve mechanism independently of the motion of the cylinder.

15. A centrfugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid materal to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, a plurality of distributors spaced apart around the inner surface of the cylinder, substantially in contact therewith, and means for moving said distributors substantially parallel to said inner surface to cause them to exert a levelling action on said layer of mud.

16. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, and a series of superposed settling pans in said cylinder, the peripheral edges of said pans projecting into said layer of mud, and said pans being provided with apertures which cause the fluid mixture to flow from points adjacent to said layer of mud to points adjacent to the axis of rotation of the cylinder, and vice versa, in passing from one pan to the next.

17. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, and a series of conical settling pans mounted to rotate with said cylinder and arranged in superposed relationship said pans having their peripheral edges projecting into said layer of mud, and the alternate pans having apertures therethrough close to the axis of rotation of the cylinder while the other pans are provided with apertures located close to the layer of mud, whereby the fluid mixture in flowing through the cylinder is compelled to follow a tortuous path.

18. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, and automatic means for giving a visual indication of the thickness of said layer of mud.

19. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, and automatic means operative through contact with the surface of said layer of mud for indicating the thickness of said layer of mud at substantially any instant.

20. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner while the process of separation continues uninterruptedly, a discharge outlet for the liquid, a feeler mounted to engage the surface of said layer of mud within the cylinder and controlled as to position by the thickness of said layer of mud, and means responsive to variations in the position of said feeler for controlling the operation of the separator to maintain the thickness of said layer of mud substantially within predetermined limits.

21. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner, a discharge outlet for the liquid, variable speed mechanism for driving said discharging means, a feeler within said cylinder operative to engage the surface of said layer

of mud and controlled as to position by variations in the thickness of said layer, and connections between said mechanism and said feeler whereby predetermined variations in the position of the feeler effect changes in the operation of said discharging mechanism designed to maintain the thickness of said layer of mud within substantially predetermined limits.

22. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner, a discharge outlet for the liquid, variable speed mechanism for driving said discharging means, a feeler within said cylinder operative to engage the surface of said layer of mud and controlled as to position by variations in the thickness of said layer, and means for controlling said variable speed mechanism including a member whose position is adjusted by said feeler and which is operative to initiate the changes in speed at which said mechanism drives said discharging means.

23. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner while the process of separation continues uninterruptedly, a discharge outlet for the liquid, and a governing mechanism controlling the operation of said discharging means, said governing mechanism comprising a feeler within the cylinder normally in engagement with the surface of said layer of mud, and means for moving said feeler intermittently out of contact with said layer of mud.

24. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner while the process of separation continues uninterruptedly, a discharge outlet for the liquid, means for acting on said layer of mud to distribute it over the inner surface of the cylinder, a common operating mechanism for said discharging and distributing means, and a governing mechanism controlling the operation of said discharging and distributing means and comprising a feeler mounted within the cylinder and controlled as to position by variations in the thickness of said layer of mud.

25. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging from the cylinder mud separated in this manner while the process of separation continues uninterruptedly, a discharge outlet for the liquid, and automatic governing mechanism for controlling the operation of said discharging means to increase the rate of discharge of the mud when the thickness of the layer of mud increases beyond a predetermined point and for reducing the rate of discharge when the thickness of said layer decreases beyond a predetermined point.

26. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, a feeler mounted to engage the surface of said layer of mud within the cylinder and controlled as to position by variations in the thickness of said layer of mud, and an indicating device operated by said feeler to give visual indications of the thickness of said layer of mud.

27. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, reciprocating valve mechanism for discharging said mud from the cylinder, a discharge outlet for the liquid, variable speed mechanism for driving said valve mechanism, and an automatic governing mechanism controlling said variable speed mechanism to maintain the rate of discharge of said solid material substantially equal to its rate of deposit.

28. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into

said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valves projecting through the opposite ends of said cylinder close to the cylinder wall, means for reciprocating said valves in a direction parallel to the axis of rotation of the cylinder to cause them to discharge mud from the cylinder, reciprocating distributors for exerting a levelling action on said layer of mud, and an automatic governing mechanism controlling the operation of said valves and comprising a feeler mounted within the cylinder to engage the surface of said layer of mud and controlled as to position by variations in the thickness of said layer.

29. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, means for discharging said mud from the cylinder while the process of separation continues uninterruptedly, a discharge outlet for the liquid, mechanism operative independently of the rotation of the cylinder for driving said mud discharging means, and means responsive automatically to variations in the thickness of said layer of mud for controlling the operation of said mud discharging means to maintain the thickness of said layer of mud substantially within predetermined limits.

30. A centrifugal separator comprising, in combination, a cylinder, means for supplying a fluid mixture to be separated to said cylinder at a substantially constant rate, mechanism for rotating said cylinder whereby the action of centrifugal force on said mixture will cause the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, valve mechanism for discharging said solid material from the cylinder while the process of separation continues uninterruptedly, mechanism operative independently of the rotation of the cylinder for driving said valve mechanism, and governing means operative automatically to control the rate of discharge of said solid material by said valve mechanism and thereby to maintain the thickness of said layer of mud substantially within predetermined limits.

31. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, valve mechanism for discharging said solid material from the cylinder while the process of separation continues uninterruptedly, a discharge outlet for the liquid, means for driving said valve mechanism, and a governing mechanism controlling the operation of said valve mechanism and comprising oppositely driven parts operative to effect a change in the rate of said mud discharging operation, and means controlled by a feeler contacting with said layer of mud for bringing one or the other of said parts into operation when predetermined changes in the position of the feeler take place.

32. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, valve mechanism for discharging said solid material from the cylinder while the process of separation continues uninterruptedly, a discharge outlet for the liquid, means for driving said valve mechanism, a governing mechanism controlling the operation of said valve mechanism and comprising a rack, a belt shipper operated by said rack, power driven mechanism for moving said rack in opposite directions, and means operated by a feeler mounted within said cylinder and engaging the surface of said layer of mud for controlling the operative connection between said power driven mechanism and said rack.

33. A centrifugal separator comprising, in combination, a cylinder, mechanism for rotating said cylinder, means for conducting the fluid mixture to be separated into said cylinder whereby the action of centrifugal force on the mixture in the cylinder causes the solid material to separate and form a layer of mud on the inner surface of the cylinder, a discharge outlet for the liquid, means for discharging mud from the cylinder while the process of separation continues uninterruptedly, and means for acting on the mud between the inner wall of said cylinder and the normal surface of the mud to exert a levelling action on the mud.

In testimony whereof I have signed my name to this specification.

JAMES MacKAYE.