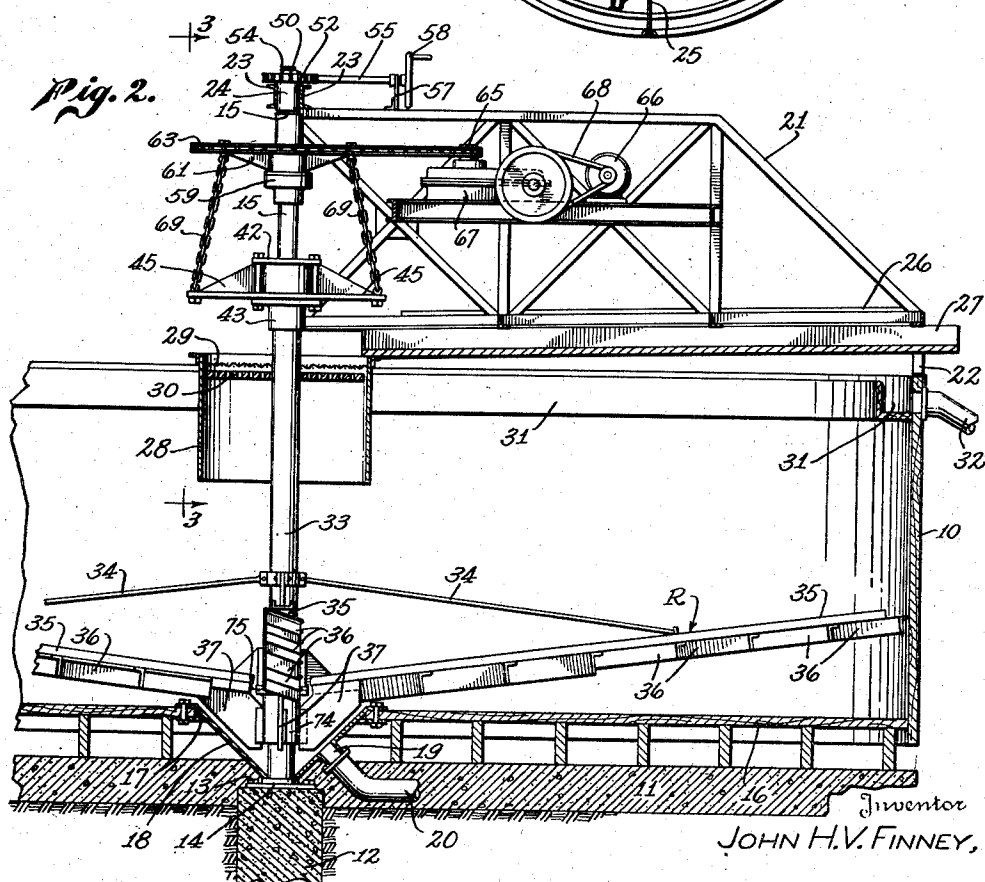
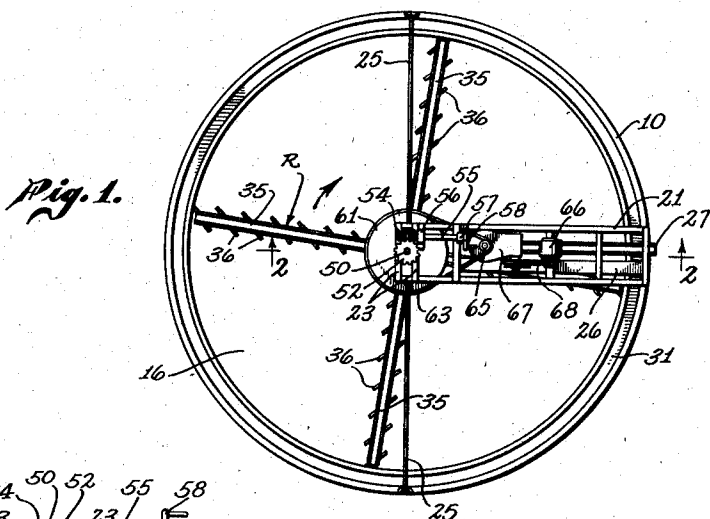


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4 Sheets-Sheet 1



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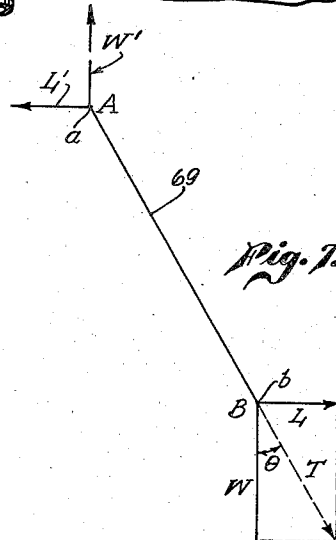
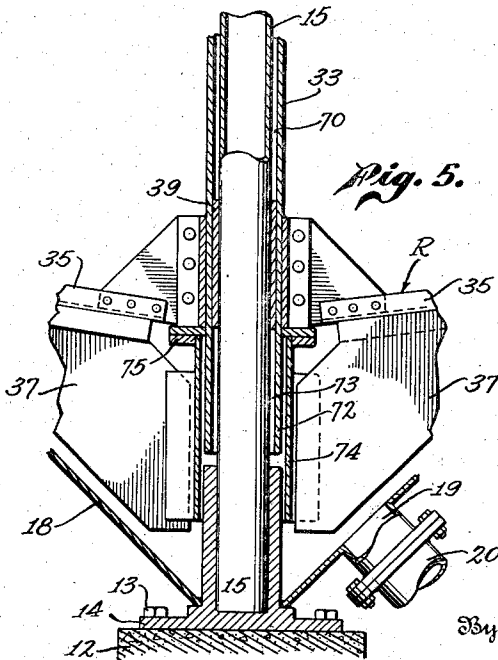
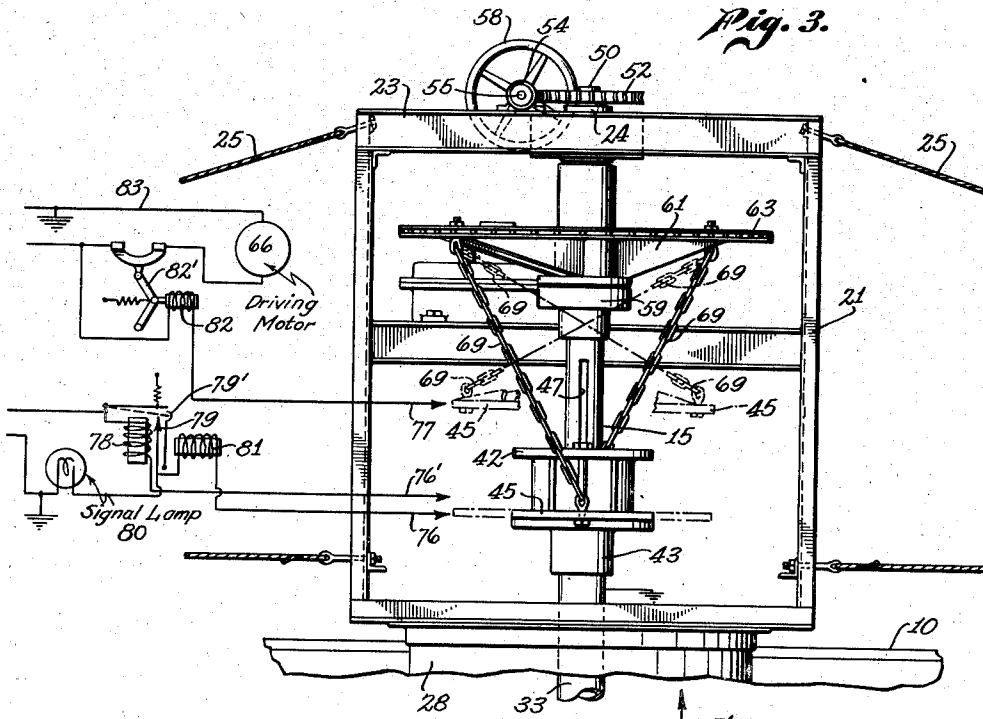
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4 Sheets-Sheet 2



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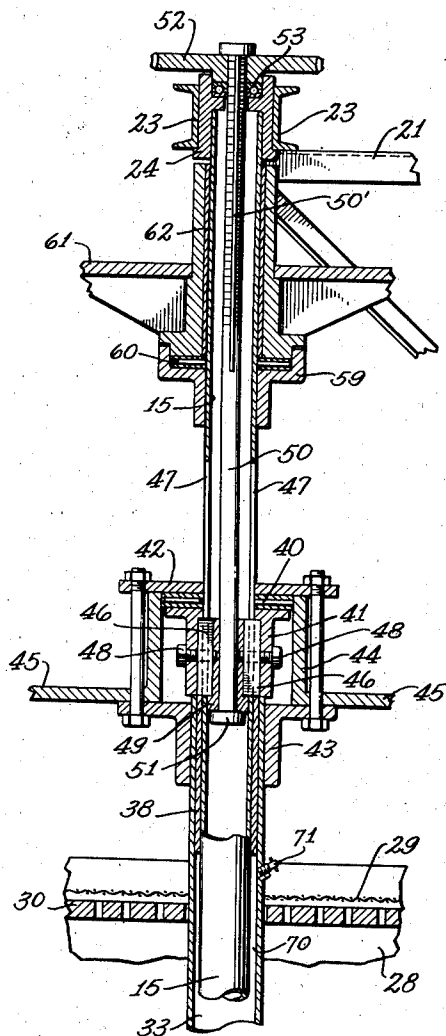


Fig. 4.

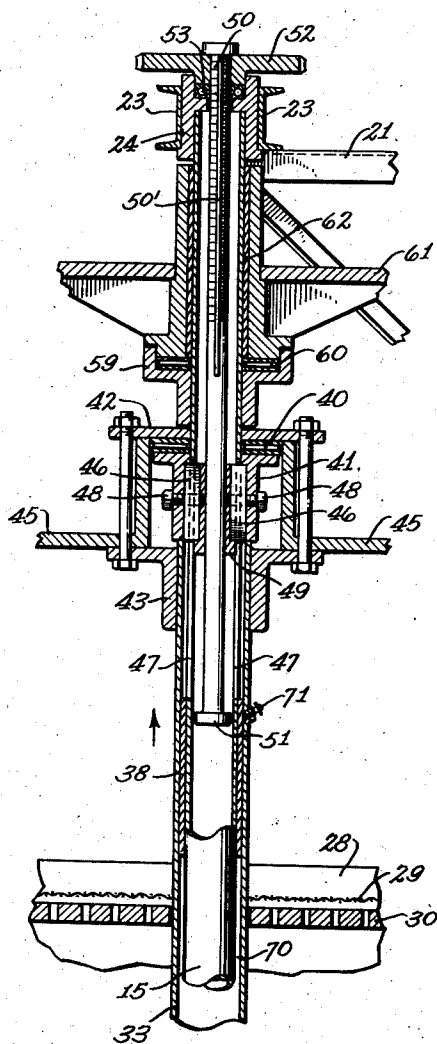


Fig. 6.

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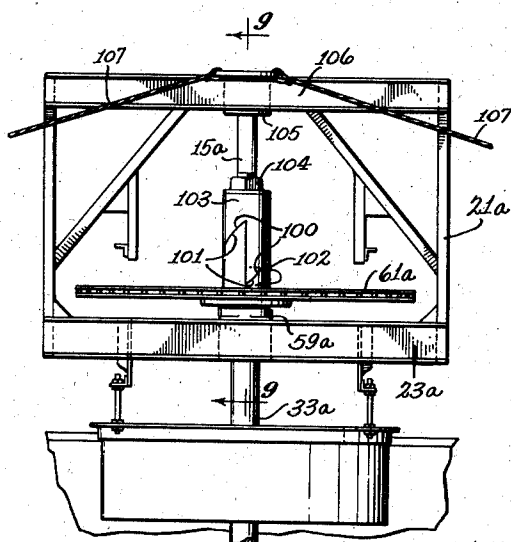


Fig. 8.

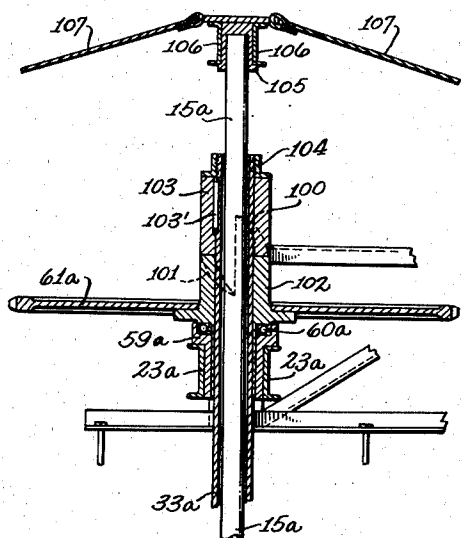


Fig. 9.

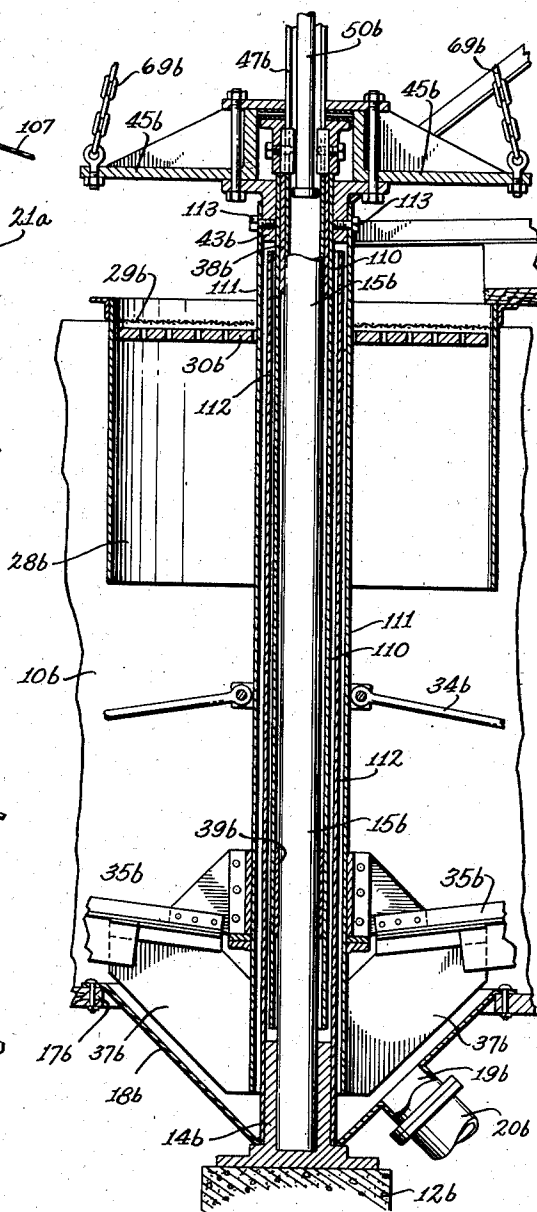


Fig. 10.

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UNITED STATES PATENT OFFICE

2,295,943

THICKENER

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Application August 2, 1937, Serial No. 156,840

18 Claims. (Cl. 210—55)

This invention relates generally to the art of removing solid matter which settles from suspended solid particles in various liquids, and more particularly to machines known as thickeners and clarifiers in use in the fields of metallurgy, water clarification, sewage disposal, and in various chemical and industrial processes, for the removal of the solids from liquids in a continuous or intermittent operation.

An object of the invention is to provide a thickener or clarifier which is structurally characterized by the provision of simple and highly efficient safety means operable to prevent damage to the sludge working or raking element and other mechanism of the machine should same become overloaded by excessive resistance offered to the movement of the element from any cause such as an obstruction in the tank, or settled solids accumulating therein beyond a predetermined quantity as a result of feeding solids in suspension to the tank at a higher rate than the sludge is discharged from the tank, all in such manner as to automatically elevate the raking element sufficiently to reduce the raking load to a safe maximum.

Another object is to provide a machine of the above described character wherein an accumulation of settled solids in the bottom of the tank following discontinuance of the operation of the machine will cause the raking element to be elevated when the machine is again placed in operation, to a level at which the raking load will not be excessive, and will then permit the raking element to remove solids from the top of the mass at a maximum rate until the excess amount of solids has been cleared from the tank and the raking element occupies its lowermost position.

Another object is to provide a safety device of the above described character which also functions to proportionately raise the raking element should the rate of feed of suspended solids temporarily become excessive and the solids accumulate in excess of the predetermined safe raking capacity, yet permitting the raking element to lower proportionately when a normal feeding rate is resumed, so that at all times the raking element will operate at maximum raking capacity and without any possibility of becoming damaged by an excessive raking load.

A further object is to provide a warning signal which is activated at a predetermined point in the raising movement of the raking element, and which also embodies means for discontinuing operation of the raking element should the warn-

ing signal be disregarded and raising movement of the raking element continue.

Another object is to provide lubricating means for the bearings which mount the raking element to rotate, and which means is so associated with the bearings submerged in the liquid under treatment, as to prevent the liquid and solids therein from reaching the bearing and damaging same.

A further object is to provide means for rigidly supporting the raking element for rotation about a vertical axis in the settling tank, and to arrange the bearings for the raking element so as to eliminate bending stresses upon the supporting shaft of the element, and yet support the entire weight of the raking mechanism therefrom in a balanced condition so as to obviate the necessity for a superstructure across the tank to support the mechanism.

With these and other objects in view, the invention consists in the combinations and arrangements of elements as set forth in the following specification and particularly pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a plan view of the thickener embodying this invention;

Fig. 2 is an enlarged partial vertical sectional view taken on line 2—2 of Fig. 1 with certain parts shown in elevation;

Fig. 3 is a fragmentary vertical sectional view taken on line 3—3 of Fig. 2, with certain associated electrical circuit arrangements shown schematically;

Figs. 4 and 5 are enlarged detail sectional views of the upper and lower portions respectively of the rotary mounting, driving, and lifting assembly for the raking element;

Fig. 6 is a fragmentary sectional view similar to Fig. 4 but showing certain parts in the position they occupy when the raking element has been automatically raised to its upper extreme position;

Fig. 7 is a diagrammatic view illustrating the forces present in the automatic raising and lowering means for the raking element when the latter is in operation;

Fig. 8 is a fragmentary side view illustrating a modified form of safety means for raising the raking element;

Fig. 9 is a vertical sectional view taken on line 9—9 of Fig. 8; and

Fig. 10 is a fragmentary sectional view of a modified form of bearing protector.

Referring specifically to Figs. 1 to 7 of the drawings, the invention is shown for the purpose

of illustration, associated with a receptacle in the form of a circular, open-top tank 10 supported horizontally on a suitable foundation 11, a depressed portion 12 of which has rigidly secured thereon by anchor bolts 13 a socket 14 disposed co-axially of the tank.

Fixed at its lower end in the socket 14 and projecting perpendicularly upward through the center of the tank to a point considerably above the latter is a hollow stationary shaft or axle 15 upon which is rotatably mounted a sludge working means in the form of a raking element R to be later fully described in detail.

The floor 16 of the tank 10 is provided with a large central opening 17 from which depends a sludge discharge cone 18 welded to the socket 14 and having an outlet 19 to which is connected a suitable pipe line 20 with which a sludge pump (not shown) can be associated to draw off sludge from the tank.

A suitable framework 21 is rigidly secured at 22 to the upper peripheral portion of the tank 10, or to a suitable structure supported independently of the tank, and is rigidly connected by transverse channel members 23—23 to a collar 24 in which the upper portion of the shaft 15 is secured. The framework co-acts with suitable guy cables 25—25 connected to the framework 21 and to the periphery of the tank or to any suitable external anchoring means independent of the tank, to rigidly support the shaft in its vertical position.

The framework supports a walkway 26 and a feed launder 27 above the top of the tank, the latter being inclined towards the center of said tank to deliver liquid and solids in suspension to an inlet in the form of a feed well 28 supported by the framework 21 around the shaft 15 and including a screen 29 for removing chips and large particles from the liquid. A float 30 in the feed well is provided to reduce the velocity of the liquid and cause the liquid to be gently distributed over the entire area of the feed well to thus not disturb the quiet surface of the liquid in the tank. An overflow launder 31 at the rim of the tank receives clarified liquid therefrom and includes a suitable discharge pipe 32 for conducting such liquid away from the tank for storage or further treatment.

The raking element R, which is mounted for rotation and vertical movement on the shaft 15, comprises a driving sleeve 33 to which are rigidly secured at their inner ends and by tie-rods 34, arms 35 having raking blades 36 arranged at such angles as to rake settled solids on the tank floor 16 towards the discharge cone 18 during rotation of the element. In the present instance, four equally spaced arms are shown, although this number may vary in different size installations. Scraper blades 37 project from the arms 35 into the discharge cone 18 to maintain sludge therein in a fluid state so that it can be drawn out through the outlet 19.

The sleeve 33 is journaled on the shaft 15 by means of upper and lower bearings 38 and 39 respectively, and the weight of the raking element is supported by a thrust bearing 40 (Fig. 4). The bearing 40 is interposed between a collar 41 and the upper one of two end flanges 42 and 43 of the hub 44 of diametrically opposed torque arms 45—45. The lower flange 43 is welded or otherwise fixed to the upper end of the sleeve 33, and the collar 41 is confined against rotation by keys 46—46 working in longitudinal slots 47—47 in the shaft 15 and secured to the collar

by bolts 48—48 threaded into a connector 49 freely slidable in the shaft 15.

A manual lift screw 50 having a head 51 at its lower end, extends freely through the connector 49 and shaft 15, and is threaded through a worm wheel 52 constituting a nut and mounted on a thrust bearing 53 seating in the collar 24. The worm wheel constantly meshes with a worm 54 fixed to a shaft 55 journaled in bearings 56 and 57 (Fig. 1) on the framework 21 and having a handwheel 58 which, when rotated in one direction, causes the worm wheel to co-act with the screw 50 in lifting the raking element R through the medium of the connector 49 and head 51 of the screw. Thus a manually operable means is provided for lifting the raking element whenever it is desired to do so.

In order to prevent rotation of the screw 50 during rotation of the wheel 52, said screw may be provided with a longitudinal keyway 50' adapted to be engaged by a suitable key (not shown) in the collar 24.

Fixed to the shaft 15 beyond the upper end of the slots 47 is a collar 59 supporting a thrust bearing 60 for a driving member in the form of a sprocket wheel 61 rotatably mounted on the shaft 15 by means of a bushing 62. A sprocket chain 63 connects the sprocket wheel 61 with a sprocket 65 adapted to be driven by an electric motor 66 through a suitable speed reducing mechanism 67 and a belt and pulley connection 68 between the mechanism and motor, all of which is supported on the framework 21 as clearly shown in Fig. 2.

Chains 69—69 are connected to the torque arms 45—45 and to the sprocket wheel 61 at the same radial distance from the axis of the shaft 15, and broadly constitute an operative connection between the raking element R and the driving mechanism therefor, by which the raking element is caused to be rotated and to be raised or lowered bodily according as the resistance to the raking movement of the element increases or decreases, all of which will be fully described in the operation of the invention.

The bearings 38 and 39 co-act with the shaft 15 and sleeve 33 to define therebetween an annular lubricant reservoir 70 communicating with the upper ends of the bearings and adapted to be supplied with grease through a suitable fitting 71 (Fig. 4). As the level of the grease is normally above the level of liquid in the tank 10, the hydrostatic head of the grease will be in excess of that of the liquid so that the grease tends to flow downward past the bearing 39 which is submerged in the liquid and is thus protected against the upward flow of liquid and suspended solids, which, if abrasive or corrosive, would damage the bearing.

As shown in Fig. 5, the lower end of the sleeve 33 projects below the bearing 39 as indicated at 72 for coaction with the shaft 15 in providing an annular pocket 73 in which grease which has worked past the bearing 39 will float so as to form a mechanical seal to prevent liquid and suspended solids from rising to the bearing. The lower end of the bearing 39 is in substantially unobstructed communication with the interior of the tank below the liquid level in view of the fact that the sleeve 33 is spaced from and free from engagement with the shaft 15 below the lower end of the bearing. Thus liquid will flow upwardly through the space between the shaft and sleeve to the lower end of the bearing from the open lower end of the sleeve in the absence of

the hydrostatic head of the lubricant. A skirt 74 fixed to the scraper blades 37 and to a flange 75 on the sleeve 33, protects the exposed lower portion of the shaft 15 against abrasion by sludge in the discharge cone 18.

As shown in Fig. 3, an alarm means may be provided so that the operator will be advised of an overloaded condition of the apparatus, and provision may also be made for interrupting the driving power to the raking means in the event that the safe operating load is exceeded. Such alarm means may comprise a plurality of electrical contact members 76, 76', and 77, the contact 76 being positioned to be engaged by the outer end of one of the arms 45 upon rotation thereof when the raking assembly is in its lowermost or normal operating position, the contact 76' being positioned to be engaged by such arm when the device has been overloaded to the extent that the raking assembly is raised any predetermined amount, and the contact 77 being positioned to be engaged by said arm when the upper limit of safe operating overload has been reached.

As the arms 45 and the associated raking assembly are raised into position to engage the contact 76', an electrical circuit is completed through a relay 78, closing the contact 79 and energizing a signal lamp 80. A suitable latch member 79' is preferably employed in position to engage the armature of the relay 78, holding the same in contacting position, in view of the fact that the electrical contact 76' will be but momentary. The lamp 80 will remain lighted as long as the device is being subjected to an overload, but should the device return to its lowered position (due to a change in the operating conditions within the thickener), so that the contact 76 is engaged, the latch-releasing relay 81 will be energized, retracting latch member 79' to release the armature of the relay 78, and extinguishing the lamp 80. Should the raking assembly be considerably overloaded, so that the arms 45 and the associated mechanism are raised to a point such that the contact 77 will be engaged, a circuit will be completed through relay 82 and the circuit breaker 82' will be actuated, breaking the current supply circuit 83 associated with the actuating motor 66, and the operation of the thickener thus stopped. The alarm controlling contact 76' may be placed at any desired position between the lowermost position of the arms 45 and the position of said arms for maximum safe overload.

The operation of the invention is as follows:

Let it be assumed that a liquid with solid particles in suspension is being delivered by the feed launder 27 to the feed well 28, and that the raking element R is being driven in the direction of the arrow in Fig. 1. As the solid particles settle out of the liquid to the floor 16 of the tank 10, the blades 36 slowly rake the solids towards the discharge cone 18, from which the solids are drawn out through the outlet 19 in the form of a thick pulp. It will be understood that in a thickener the object is to obtain pulp of a certain density, whereas in a clarifier the object is to obtain an overflow liquid in the overflow launder 31 which is free of the suspended solid particles. The device of the present invention is intended for operation as either a thickener or clarifier, but for purposes of simplicity the device will be termed a "thickener" hereinafter and in the subjoined claims.

It will be clear that as the sprocket wheel 61 is being driven in the direction of the arrow in

Fig. 1, each of the chains 69—69 exert a pull on the end of the respective torque arms 45—45, tending to rotate the raking element in the same direction and concurrently tending to lift the raking element bodily due to the resistance to rotation of the raking element which is offered by settled solids on the floor of the tank. As shown in Fig. 3, the chains act upon the torque arms at an angle to the perpendicular in vertical planes tangentially related to a circle having the axis of the shaft 15 as its center, so that the horizontal component of the tension to which the chains are subjected tends to rotate the raking element, whereas the vertical component of such tension tends to lift the raking element bodily.

To more fully explain the loads and stresses to which each chain is subjected, as well as the reaction thereof upon the raking element, reference will be had particularly to Figs. 3 and 7, particularly the latter figure in which AB represents one of the chains 69 extending from its connection *a* on the sprocket wheel 61 to *b*, its connection to one of the torque arms 45, it being understood that *a* and *b* are situated at the same radial distance from the axis of the shaft 15.

At B there will be a horizontal force L tangential to the circle of motion of the point B resulting from the torque in the raking element created by the resistance offered to its rotation by the scraping load. The weight of the raking assembly and solids which have settled thereon creates a downward force W so that the resultant of these forces is the tension T in the chain, the direction of which resultant is the inclination of the chain. In order to overcome these forces and rotate the raking assembly, the sprocket wheel 61 must exert identical but directly opposite forces L' and W' at the point A.

The weight W may be considered substantially constant, whereas the force L varies in accordance with the resistance of the scraping load in the tank. When L is zero the resultant T will be equal in value and direction to W so that the chain will hang vertically, whereas when L equals W the resultant T will incline downwardly and rearwardly relative to the direction of rotation, at an angle of 45°. Thus from zero load to a load in which L equals W, the chain changes its direction from the vertical to an inclination of 45°. As the chain AB is of constant length it will be evident that point B must be elevated sufficiently to permit the chain to assume the angle of 45°, thus raising the point B (and the associated raking structure) by an amount equal to $d - d \cos 45^\circ$, where *d* designates the length AB of a chain.

In one practical embodiment of the invention, the proportioning of the chain and associated parts is such that the chain will operate between the angles of 30° and 60°, as shown in Fig. 3, wherefrom it will be seen that the operating "lift" of the machine will be $d \cos 30^\circ - d \cos 60^\circ$. The minimum angle of 30° is fixed by the thrust bearing 40 which supports the raking element in a predetermined extreme lowered position.

Thus as $L = w \tan \theta$, it will be clear that if $\theta = 30^\circ$, then L will equal .577W. Therefore for all loads from zero until a load is reached in which $L = .577$ of W (the weight of the raking element and solids carried thereby), the raking element will not rise but will operate with its weight supported by the thrust bearing 40.

When L exceeds .577W, the inclination of the chains will exceed 30° and the raking element will be lifted to cause the connector 49 to rise off of the head 51 of the bolt 50, and the weight

of the raking element is then caused to be borne by the chains. Should the load increase sufficiently to force the chains to assume an angle of 60°, the force *L* will be 1.73*W*, the maximum load that the machine is intended to carry safely.

Prior to reaching this extreme raised position, the signal lamp 80 will be actuated, indicating a partial overloading of the device. Should its warning be disregarded, the circuit to the motor 66 will be disrupted to discontinue operation of the machine when the extreme raised position of the raking element is reached, as above described, thus positively preventing damage to the mechanism.

It will be manifest from the foregoing description that the thickener is fully automatic in its operation to maintain a predetermined definite lowered position from zero load to a predetermined proportion of full load, and to then rise upon a further increase in load until the full load position is reached at which position the operation of the driving mechanism is discontinued before any damage can be done.

Should there be a power failure during operation of the machine, and an accumulation of settled solids during the period in which the power is off, the raking element will automatically rise to a level at which the raking load is not excessive, when power is restored, upon which the raking element will remove solids from the top of the bed at a maximum rate until the accumulation is removed and the raking element reaches its extreme lowered position. Thus it will be apparent that should the rate of feed of suspended solids to the tank become excessive, the raking element will rise automatically and then gradually lower as the accumulation of settled solids is discharged from the tank and a normal feed is resumed. Should a solid object fall into the tank and obstruct rotation of the raking element, the latter will rise so as to either pass over the obstruction or cause the signal 80 to be activated or the motor 66 to be stopped.

Due to the fact that the raking element is caused to rise bodily by the raking load, and is thus moved uniformly throughout the lengths of the blade-carrying arms 35, it will be clear that all of the blades 36 will be equally relieved of the raking load. Furthermore, due to the submerged position of the lower bearing 39 directly opposite the arms, the shaft 15 will be relieved of bending stresses resulting from variations in the raking load.

When it is desired to lift the raking element manually, as, for example, when periodically operating the machine, the handwheel 58 will be suitably rotated for this purpose.

Referring now to Figs. 8 and 9, there is herein shown a second form of automatic safety means for effecting the raising and lowering movements of the raking element in accordance with the resistance to raking movement offered thereto.

This means comprises complementary helicoidal cams 100 and 101, the former of which is constructed on the upper end of the hub 102 of the driving sprocket wheel 61*a* supported by a ball thrust bearing 60*a* seating in a collar 59*a* fixed to the transverse channel members 23*a*—23*a* of the framework 21*a*.

The cam 101 is formed on the lower end of a collar 103 keyed at 103' to the driving sleeve 33*a* of the raking element and confined against upward axial displacement relative to the sleeve by

a nut 104 threaded on the latter. The sleeve 33*a* may be journaled on the stationary shaft 15*a* in the same manner as the sleeve 33 is journaled on the shaft 15 of the first described form of the invention. The shaft 15*a* extends to a point above the nut 104, and its upper end is fixed in a collar 105 secured to other transverse members 106—106 of the framework 21*a*. To these members guy cables 107 may be secured, and connected to the tank to coact with the framework 21*a* in rigidly supporting the shaft 15*a*.

As the operation of this form of automatic safety means is similar to the form first described, it will suffice to state that normally the raking element will be suspended in its lowermost position shown in Figs. 8 and 9 by the collar 103 and will maintain this position until a predetermined safe maximum raking load is being carried. Should the raking load increase above this maximum the cams 100 and 101 will coact in response to relative rotation between the driving sprocket wheel 61*a* and the collar 103 caused by the increased resistance offered to the raking movement of the raking element, to raise the latter until the excessive raking load is sufficiently reduced, following which the sprocket wheel and collar will reversely rotate relatively and the cams will reversely coact to lower the raking element.

It will thus be manifest that the cams 100 and 101 and the chains 69—69 constitute radically different means for accomplishing the same result, and clearly illustrate the broad scope of this feature of the invention.

Reference will now be had to Fig. 10 in which is illustrated a modified form of rotary mounting for the raking element which differs from the first described form of rotary mounting in the provision of inner and outer sleeves 110 and 111 between which is freely received a protector sleeve 112 fixed to the socket 14*b*. The inner sleeve 110 is fixed at its upper end to the collar 43*b* of the torque arm 45*b*, and is journaled on the stationary shaft or axle 15*b* by the upper and lower bearings 38*b* and 39*b*. The outer sleeve 111 is secured at its upper end by bolts 113 to the collar 43*b* and has the arms 35*b* of the raking element secured thereto.

As the upper end of the protector sleeve 112 is above the level of liquid in the tank, it will be clear that the bearings 38*b* and 39*b*, and the shaft 15*b* will be fully protected against corrosive and abrasive actions of various liquids and suspended or settled solids. The protector sleeve 112 provides a mechanical barrier around the inner sleeve 110 from the base of the discharge cone 18*b* and insures that none of the contents can reach the bearings and shaft. This feature, in addition to the functioning of the lubricant reservoir between the bearings, assures proper lubrication thereof under all working conditions.

It will be understood that the sprocket wheel structure shown at 61 or 61*b* may be replaced by a worm wheel, gear or other suitable type of drive. Furthermore, it will be understood that the several novel features of the invention herein disclosed may be independently employed in connection with any suitable type of rotary thickening or clarifying apparatus. In particular, the lifting mechanism herein described may be employed independently of the preferred form of shaft and bearing structure which I have shown. For example, the center column such as 15 or 15*b* may be omitted and the driving sprocket 61 or 61*b* or other equivalent drive member may be

supported by thrust bearing means and journaled in suitable radial bearing means, said bearing means being carried by a bridge truss over the tank structure as in the conventional Dorr thickener, and the raking assembly may be carried by and operatively associated with the drive means through the agency of lifting mechanism of one of the types herein described.

I claim:

1. In a thickener, a receptacle having an inlet for liquid and an outlet for sludge; means for moving settled solids in the liquid towards the outlet; means for driving the first means; means coacting with the driving means and first means to raise the latter bodily in the receptacle in response to resistance to the movement of the first means; and means by which operation of the driving means is caused to be discontinued when the first means has been raised to a predetermined extreme elevated position.

2. In a thickener, a receptacle having an inlet for liquid and an outlet for sludge; rotary and vertically adjustable means in the receptacle for moving settled solids towards the outlet; means for rotating the first means; and engaging helicoidal cams of constant slope coaxially arranged relative to the first and second means and operatively connecting them to raise the first means in response to resistance offered to rotation thereof.

3. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including means to automatically vary the vertical position of the sleeve and raking mechanism in response to the resistance offered to rotational raking movement; means transmitting to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

4. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including a pair of engaging cams to automatically vary the vertical position of the sleeve and raking mechanism in response to the resistance offered to rotational raking movement; means transmitting to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

5. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including a driving member provided with an inclined surface engaging a driven member rigidly secured to the sleeve and adapted to automatically vary the vertical position of the

sleeve and raking mechanism in response to the resistance offered to rotational raking movement; means transmitting to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

6. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism; means supporting the sleeve and transmitting to the shaft throughout the range of vertical movement of the sleeve with respect to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

7. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including a driving member, and a driven member rigidly secured to the sleeve and provided with an inclined surface drivingly engaged by the driving member, said drive means being adapted to automatically vary the vertical position of the sleeve and raking mechanism in response to the resistance offered to rotational raking movement; means transmitting to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

8. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including a driving member, and a driven member rigidly secured to the sleeve, one of said two members being provided with an inclined surface engaged by the other member, said drive means being adapted to automatically vary the vertical position of the sleeve and raking mechanism in response to the resistance offered to rotational raking movement; means transmitting to the shaft vertical loads imposed by the sleeve and raking mechanism; and means at the lower end of the shaft adapted to support the shaft and its loads independently of the tank.

9. In a thickener, a tank having an inlet for liquid-solids mixture and an outlet for settled solids; a centrally located vertical stationary shaft; a sleeve mounted on the shaft for rotational and vertical movement; a rotary raking mechanism attached to the sleeve and rotatable within the tank to move settled solids to said outlet; drive means for rotating the sleeve and raking mechanism including means to vary automatically the vertical position of the sleeve and raking mechanism in response to the resistance offered to rotational raking movement; and means supporting the sleeve and transmitting to

the shaft throughout the range of vertical movement of the sleeve with respect to the shaft vertical loads imposed by the sleeve and raking mechanism.

10. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: means rotatably mounting the raking element in the receptacle including a lower bearing adapted to be submerged in the liquid; and means defining a lubricant reservoir extending above the liquid level and in communication with the upper end of said bearing to feed lubricant thereto under the greater hydrostatic head of the lubricant, whereby to prevent upward flow of liquid to the bearing, the lower end of said bearing being in substantially unobstructed communication with the interior of the receptacle below the liquid level, whereby liquid will flow into said bearing in the absence of said greater hydrostatic head.

11. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: means rotatably mounting the raking element in the receptacle including a lower bearing adapted to be submerged in the liquid; means defining a lubricant reservoir extending above the liquid level and in communication with the upper end of said bearing to feed lubricant thereto under the greater hydrostatic head of the lubricant, whereby to prevent upward flow of liquid to the bearing; and means defining a space below said bearing in which lubricant working past the bearing can collect to aid in preventing liquid and suspended solids from rising to the bearing, said space communicating with the lower end of said bearing and being in communication below the lower end of said bearing with the interior of the receptacle below the liquid level, whereby liquid will flow into said bearing in the absence of said greater hydrostatic head.

12. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: a vertical shaft in the receptacle; a raking element having inner and outer mounting sleeves; means mounting said inner sleeve for rotation on said shaft; and means interposed between said sleeves for isolating the inner sleeve, mounting means, and shaft from the contents of the receptacle.

13. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: a vertical shaft in the receptacle; a raking element having inner and outer mounting sleeves; means mounting said inner sleeve for rotation on said shaft; a protector sleeve interposed freely between said inner and outer sleeves and extending from a point below the inner sleeve to a point above the level of liquid in the receptacle; and means for supporting the protector sleeve to seal off the interior thereof from the contents of the tank.

14. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: a vertical shaft in the receptacle; a raking element having inner and outer mounting sleeves; 75

means mounting said inner sleeve for rotation on said shaft; and means surrounding said inner sleeve to protect the latter, mounting means, and shaft from contact with the contents of the tank.

15. In a thickener of the type in which a raking element is rotated in a liquid receptacle having inlet and outlet means for liquid and outlet means for sludge, the combination comprising: a raking element having a driving sleeve; means coacting with said sleeve to mount the raking element for rotation in the receptacle; and means coacting with the receptacle and sleeve to isolate the latter from the contents of the receptacle.

16. Rake mounting mechanism for a thickener of the type comprising a tank containing a body of liquid and having inlet and outlet means for liquid and outlet means for sludge and in which a rake is submerged and rotated in said body of liquid, said mechanism comprising: a sleeve with an open lower end extending from above the liquid level to a point below the liquid level and attached to the rake; a stationary shaft extending upwardly from the bottom of the tank within the sleeve; a bearing within the sleeve at a point lower than the tank liquid level rotatably mounting the sleeve on the shaft, said bearing substantially filling the space between the shaft and sleeve so as to form a lubricant reservoir above the bearing; and a body of fluid lubricant contained within the reservoir and extending upwardly from the bearing to a point above the liquid level in the tank so as to cause lubricant to flow past the bearing and thereby prevent access of tank liquid to the bearing through the open end of the sleeve, the lower end of said bearing being in substantially unobstructed communication with the liquid through the open lower end of the sleeve, whereby liquid will flow into said bearing in the absence of said body of lubricant.

17. Rake mounting mechanism for a thickener of the type comprising a tank containing a body of liquid and having inlet and outlet means for liquid and outlet means for sludge and in which a rake is submerged and rotated in said body of liquid, said mechanism comprising: a sleeve with an open lower end extending from above the liquid level to a point below the liquid level and attached to the rake; a stationary shaft extending upwardly from the bottom of the tank within the sleeve; and spaced upper and lower bearings within the sleeve rotatably mounting the sleeve on the shaft, the lower bearing being beneath the tank liquid level and substantially filling the space between the shaft and sleeve so as to form a lubricant reservoir above the bearing, and providing within the reservoir a lubricant containing space in which the hydrostatic head of the lubricant is greater than the hydrostatic head of the tank liquid, whereby to prevent upward flow of liquid to the bearing, said sleeve being spaced from and free from engagement with the shaft below the bearing and communicating freely through its open lower end with the liquid, whereby the liquid will flow upwardly between the shaft and sleeve to the bearing in the absence of the hydrostatic head of the lubricant.

18. Rake mounting mechanism for a thickener of the type comprising a tank containing a body of liquid and having inlet and outlet means for liquid and outlet means for sludge and in which a rake is submerged and rotated in said body of liquid, said mechanism comprising: a sleeve with

an open lower end extending from above the liquid level to a point below the liquid level and attached to the rake; a stationary shaft extending upwardly from the bottom of the tank within the sleeve; a bearing within the sleeve at a point lower than the tank liquid level rotatably mounting the sleeve on the shaft, said bearing substantially filling the space between the shaft and sleeve so as to form a lubricant reservoir above the bearing; and a body of fluid lubricant contained within the reservoir above the bearing and extending upwardly from the bearing to a point above the liquid level in the tank so as to cause lubricant to flow past the bearing and

thereby prevent access of tank liquid to the bearing through the open end of the sleeve, the sleeve projecting below the bearing to provide a pocket in which lubricant passing the bearing collects to aid in preventing access of tank liquid to the bearing, said sleeve being spaced from and free from engagement with the shaft below the bearing and communicating freely through its open lower end with the liquid, whereby the liquid will flow upwardly between the shaft and sleeve to the bearing in the absence of the hydrostatic head of the lubricant.

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