Nov. 18, 1947. C. E. WOOD 2,431,007

PUMPING APPARATUS

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Fig. 1.

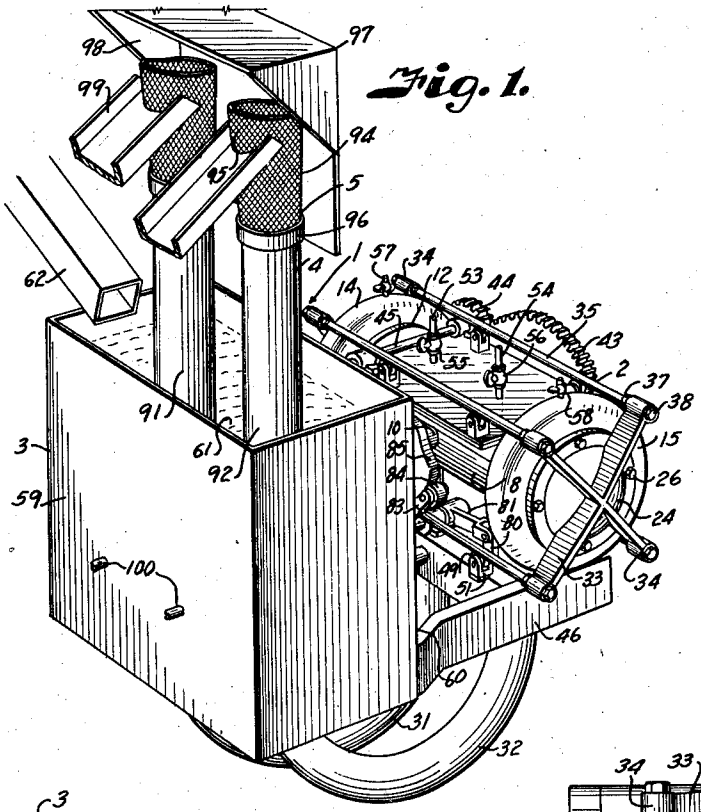

Fig. 2.

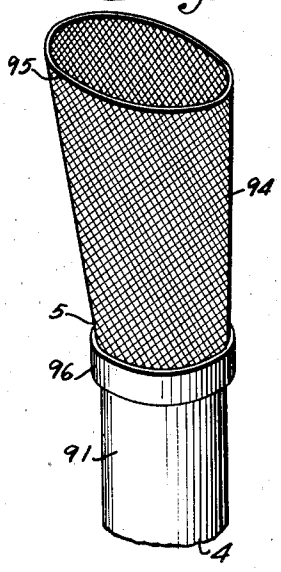

Fig. 3.

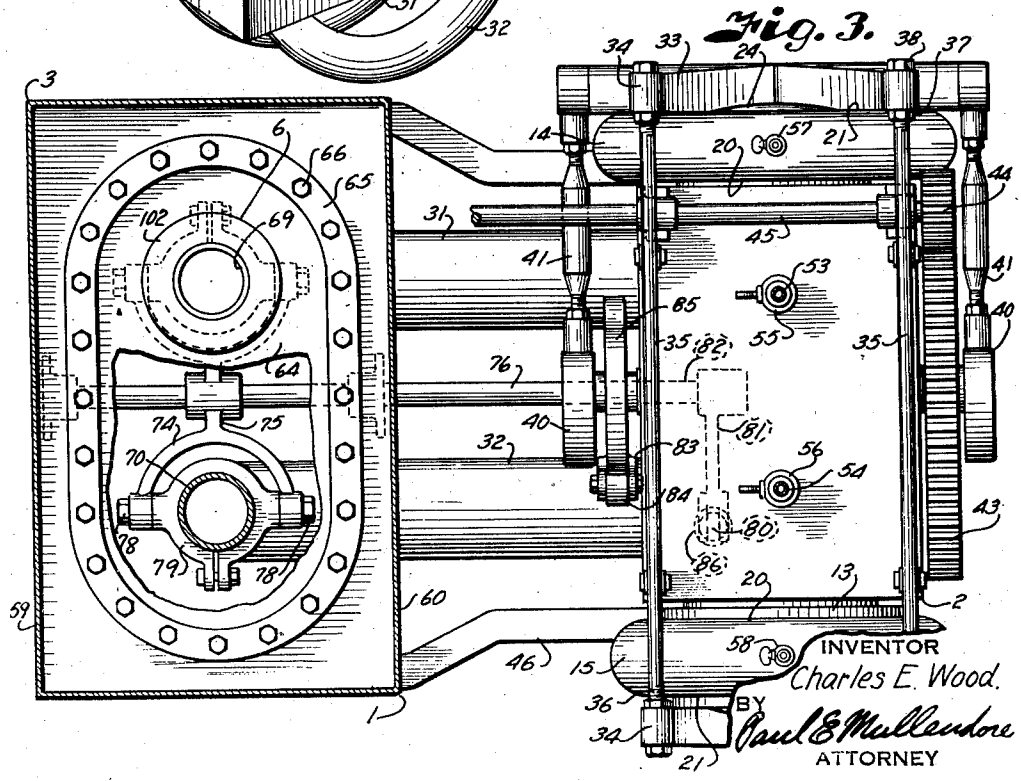

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Fig. 4.

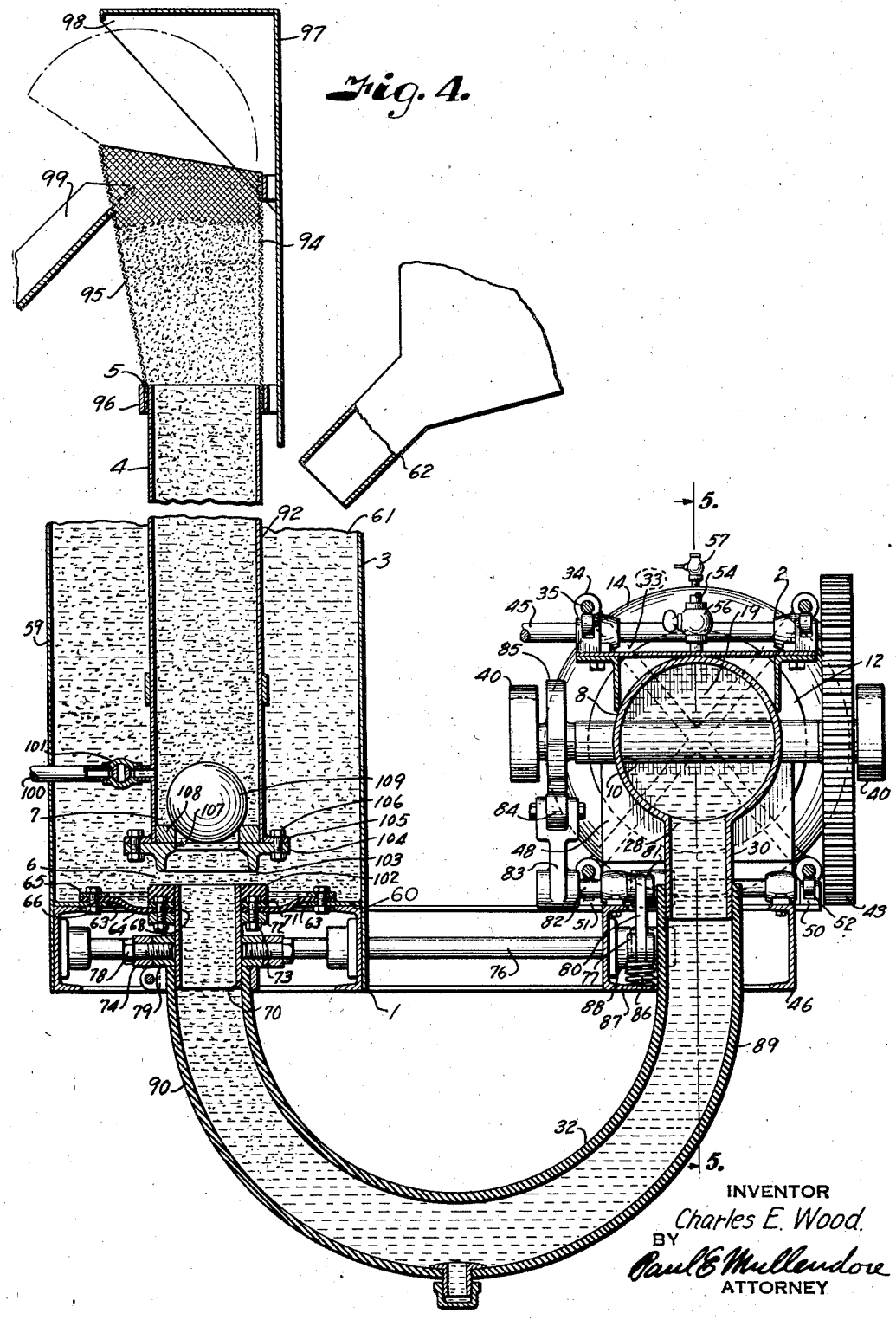


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Fig. 5.

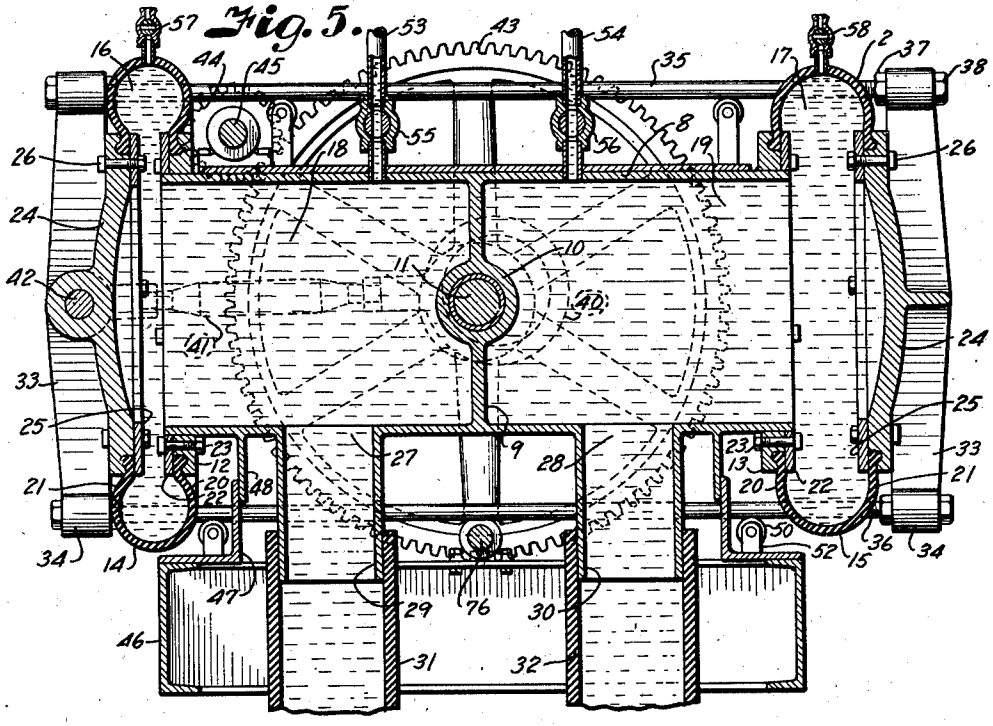

Fig. 6.

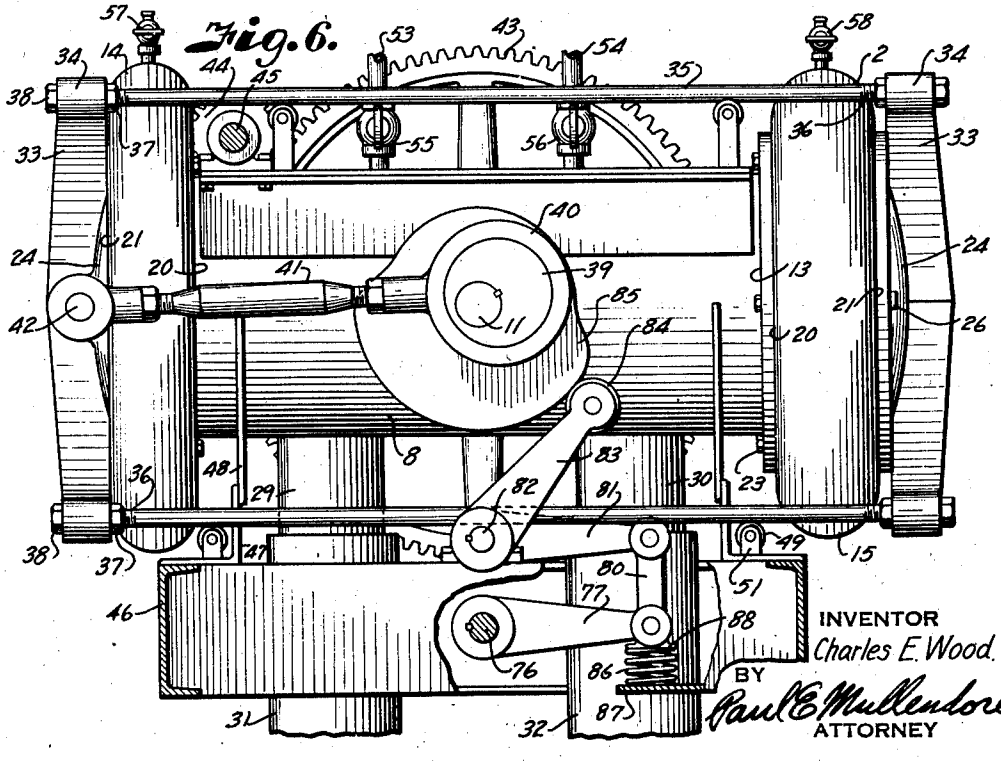

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Fig. 7.

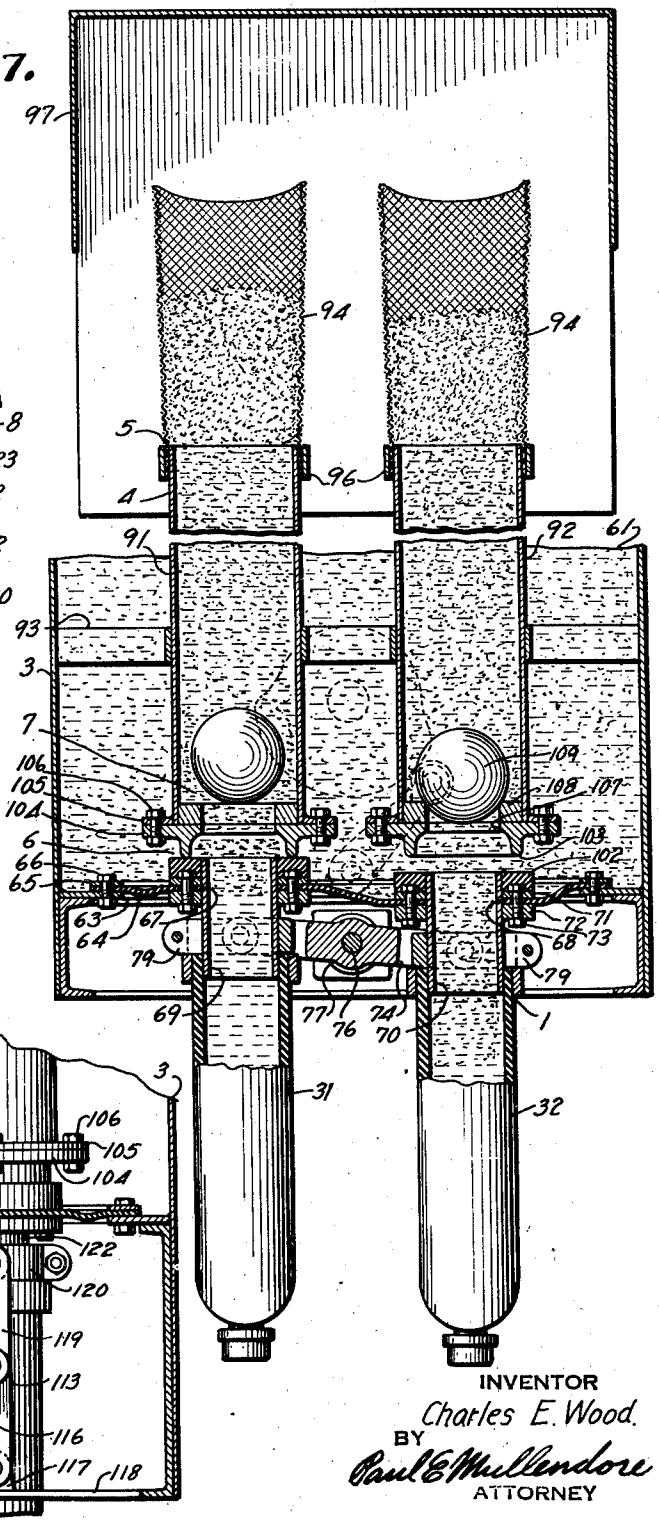



Fig. 8.

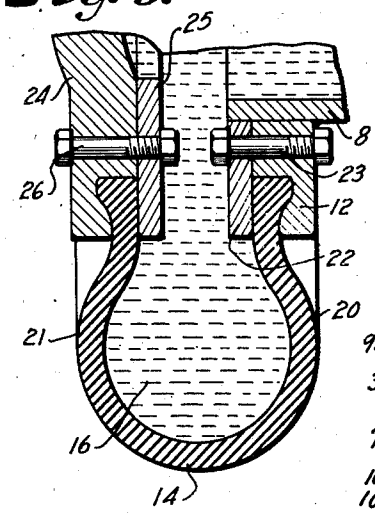
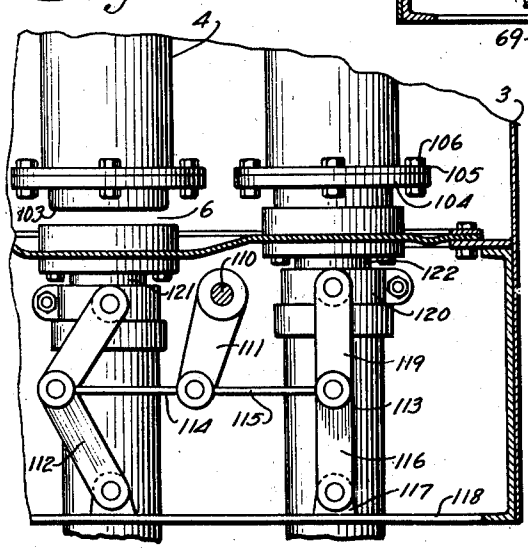



Fig. 9.

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Patented Nov. 18, 1947

2,431,007

# UNITED STATES PATENT OFFICE

2,431,007

## PUMPING APPARATUS

Charles E. Wood, Milwaukee, Wis.

Application December 17, 1943, Serial No. 514,599

15 Claims. (Cl. 302—15)

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This invention relates to an apparatus for pumping granular or abrasive materials, for example sand or gravel, from the bottom of a settling tank and delivering the material at any desired height.

The principal object of the invention is to provide a pumping apparatus of this character wherein the pump proper handles a clean fluid acting as a hydraulic piston to move the material being pumped.

Other objects of the invention are to provide a pumping apparatus wherein the materials are carried in a liquid vehicle in the form of a pulp; to provide the pumping apparatus with mechanism for separating the material from the liquid vehicle; to provide a pump equipped with means for controlling density of the pulp; and to provide for discharge of the liquid vehicle in one direction and the pumped material in another direction.

It is a further object of the invention to provide the pumping apparatus with a positive action valve mechanism which serves as an agitator in breaking up the material tending to compact at the inlet thereof.

In accomplishing these and other objects of the invention, I have provided improved structure, the preferred forms of which are illustrated in the accompanying drawings, wherein:

Fig. 1 is a perspective view of a pumping apparatus constructed in accordance with the present invention.

Fig. 2 is a perspective view of the separator for separating the material from its liquid vehicle.

Fig. 3 is a horizontal section through the apparatus showing the pump in plan.

Fig. 4 is an enlarged vertical section through the pumping apparatus.

Fig. 5 is a vertical section through the pump on the line 5—5, Fig. 4.

Fig. 6 is a side elevational view of the pump.

Fig. 7 is an enlarged vertical section through the riser and valve mechanism of the pumping apparatus.

Fig. 8 is an enlarged section through one of the pump diaphragms.

Fig. 9 is a side elevational view, partly in section, of a modified form of valve actuating mechanism.

Referring more in detail to the drawings:

1 designates a pumping apparatus constructed in accordance with the present invention and which includes a pump 2 providing the motive force for hydraulic pistons pulsated to and from

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a feed hopper or tank 3 from which material is discharged through risers 4 to a separating head 5 under control of a diaphragm inlet valve mechanism 6 and check valves 7, as later described. In the illustrated instance, the pumping apparatus is particularly designed for elevating sand or gravel, and therefore the feed hopper 3 may be a settling tank or classifier wherefrom a mixture of sand and water is discharged to the separating head to effect dewatering of the sand and discharge of the sand at desired height above the water level carried in the hopper 3. Since sand, gravel and similar materials are of abrasive character and tend to pack in the cylinders and around the valves of a pump, I have provided a pump which handles only fluid which constitutes the hydraulic pistons.

The pump includes a cylinder 8, divided intermediate its ends by a partition 9 having a tubular boss 10 extending through a diameter thereof for mounting a shaft 11 therein, as later described. The ends of the cylinder have flanges 12 and 13 for attaching diaphragms 14 and 15. The diaphragms are substantially the shape of an automobile casing to form annular expansible and contractible chambers 16 and 17 communicating with ends of the cylinder chambers 18 and 19 between the side walls 20 and 21 of the diaphragms. The side walls 20 of the respective diaphragms are clamped to the flanges 12 and 13 by rings 22 encircling the cylinder and secured by bolts 23. The other side walls 21 of the diaphragms are clamped to heads 24 by rings 25 secured by bolts 26 extending through the rings and marginal edges of the heads as shown in Fig. 5. The heads thus cooperate with the diaphragms in closing the ends of the cylinder chambers 18 and 19 and are adapted to be moved to and from the respective ends of the cylinders for expanding and contracting the diaphragms to effect pulsation of a fluid through open ports 27 and 28 communicating with the chambers formed in the cylinder on the respective sides of the partition 9.

The ports 27 and 28 connect with nipples 29 and 30 for attaching the ends of flexible ducts 31 and 32. The diaphragm heads have transverse arms 33 terminating in sleeve-like bosses 34. Extending through the bosses are tie rods 35 having threaded ends 36 for mounting nuts 37 and 38 engaging the respective ends of the sleeve-like bosses on the arms so that the diaphragm heads are connected together and operated in alternate relation, that is, when one of the diaphragms is contracted to force liquid from

that end of the cylinder, the other is expanded to draw liquid therein.

In order to actuate the diaphragms, the shaft 11 is provided on the respective ends thereof with eccentrics 39 carrying eccentric straps 40 of connecting rods 41. The opposite ends of the connecting rods are secured to wrist pins 42 extending from one of the heads 24. The shaft is rotated by a gear 43, fixed on one end thereof and meshing with a driving pinion 44 on a countershaft 45 rotatably mounted on the upper portion of the cylinder.

The pump thus described is mounted on a base frame 46 having upwardly extending flanges 47 fixed to flanges 48 adjacent the ends of the cylinder as best shown in Fig. 5. In order to support the diaphragm heads in coaxial relation with the cylinder, the lower rods are guidingly supported on rollers 49 and 50 supported in brackets 51 and 52 fixed to the base frame in line with the connecting rods. Liquid supply is maintained to the respective cylinder compartments through supply pipes 53 and 54 under control of valves 55 and 56. In order to assure complete filling of the respective chambers with liquid, the upper portions of the respective diaphragms are provided with vent valves 57 and 58 so that the valves may be opened to allow escape of air as the pump chambers are filled through the pipes 53 and 54.

The feed hopper 3 may comprise a tank having side walls 59 and a bottom 60. The top of the tank is open, as at 61, to admit the water separated from the sand and the supply of sand which is admitted through a spout 62. The tank is supported upon the base frame 46 which carries the pump 2 and the bottom thereof is provided with an elongated opening 63. Covering the opening 63 is a flexible diaphragm 64 which is secured in sealed relation with the marginal edge of the opening by a clamping plate 65 retained by bolts 66 or similar fastening devices.

Formed in the diaphragm, substantially in accordance with the spacing of the ports 27 and 28, are openings 67 and 68 and extending through these openings are valve tubes 69 and 70, the valve tubes being anchored to the diaphragm by clamping rings 71 and 72, one of which is secured to the tubes and the other being movable thereon and adapted to be drawn in clamping engagement with the diaphragm by fastening devices such as bolts 73. The valve tubes are supported on the yoke ends 74 of a lever 75 which is fixed on a shaft 76 having its ends journalled in the base frame and provided with a rocker arm 77. The end yokes 74 are connected with the valve tubes by trunnion screws 78 threaded into rings 79 fixed to the valve tubes.

The rocker arm 77 is connected by a link 80 with a rocker arm 81 on a shaft 82, which in turn carries an arm 83 having a cam roller 84 engageable with the periphery of a cam 85 mounted on the shaft 11. The roller 84 is retained in yielding contact with the periphery of the cam by a spring 86 having one end engaging a bracket-like plate 87 on the sub-frame and its opposite end against a foot 88 on the link 80. With this arrangement the shaft is rocked alternately in opposite directions in timed relation with movement of the respective pump diaphragms so that the valve tube associated with one pump cylinder is lifted when the diaphragm for that pump cylinder is contracted and the other tube is lowered when the diaphragm for its corresponding pump chamber is expanded. The valve tubes are connected with the ends of the flexible ducts 31 and 32 so that the ducts hang in a U shape and form downwardly extending legs 89 connected with the pump and upwardly extending legs 90 connected with the valve tubes.



Located in the feed hopper above the valve tubes are riser pipes 91 and 92. These risers are supported in fixed position on bracket arms 93 fixed to the feed hopper as shown in Figs. 4 and 7. The risers extend a sufficient distance above the valve tubes to conduct the sand and water mixture and discharge it at the desired height. The upper ends of the risers carry the separator head 5, now to be described.

Mounted on the upper end of each riser pipe is a dewatering cone 94 formed of screen material and having one side 95 pitched in a forward and upward direction relatively to the extended walls of the risers. The dewatering cones are connected with the tops of the risers by clamping bands 96. Carried by the clamping bands 96 and spaced away from the vertical sides of the dewatering cones is a hood-like housing 97, having an open front 98 on the side of the pitched portions 95 of the cones so as to discharge dewatered material onto a chute 99. The lower end of each riser pipe has a duct 100 provided with a control valve 101 wherethrough fresh water is admitted to the lower end of each riser. Carried above the valve diaphragm, on the end of each valve tube, is a gasket ring 102 adapted to engage a downwardly facing valve seat 103 on valve seating rings 104 which are secured to laterally extending flanges 105 of the riser tubes by bolts 106. The rings 104 are provided with openings 107 coaxial with the valve tubes and carry valve seats 108 for seating check valves 109 in the form of balls, as shown in Fig. 4, to prevent back flow of the sand and water mixture or pulp from the respective riser pipes.

In operating a pumping apparatus constructed as described, each of the pump chambers is completely filled with water through the pipes 53 and 54 upon opening of the valves 55 and 56, the air being released from the respective chambers through the vent valves 57 and 58. When the diaphragms are completely filled with liquid and the liquid begins to discharge through the vents, the valves 57 and 58 are closed. When the cylinders are filled with water a corresponding water level is maintained in the lower portion of the feed hopper so that the flexible ducts 31 and 32 are completely filled with liquid. The sand is admitted to the feed hopper from a feed spout or the like 62 so that it collects on the bottom of the hopper 3 in surrounding relation with the lower ends of the riser pipes.

When the pump is started, the shaft 11 is rotated to cause the connecting rods 41 to move the diaphragms responsive to throw of the eccentrics 39, contracting one of the diaphragms to discharge liquid from that chamber, and expanding the other diaphragm, causing flow of liquid thereinto. On the next cycle, the operation is reversed so that the liquid is alternately moved through one of the ducts 31 or 32 toward its riser pipe, while the liquid in the other tube is being drawn into the other pump chamber. The columns of liquid in the respective tubes thus form hydraulic pistons and are equivalent to a double acting pump.

Simultaneously with pulsation of the liquid in the flexible ducts 31 and 32, the cam 85 rocks the arm 83 to effect rocking of the valve control shaft 76 through the arm 81 and link 80 against action of the spring 86 whenever the high lobe

portion of the cam engages the roller 84 so that the shaft 76 is rocked in a clockwise direction, Figs. 6 and 7, to raise the valve tube 69 and lower the other valve tube 70, the timing being such that when the valve tube 69 is lifted to engage the gasket 102 with the seat 103, the diaphragm having connection with that tube is being contracted so that the liquid is discharged from the pump chamber through the flexible duct and upwardly through the seat of the check valve. The other valve tube, however, is moved away from its seat and the water is receding in the upper leg of that tube so that sand in the feed hopper flows into the open upper end of the tube to follow the receding water. As the high portion of the cam 85 moves out of contact with the roller 84, the spring 86 comes into play to rock the shaft 76 in an anticlockwise direction, reversing movement of the valve tubes so that the valve 70 is brought into engagement with its seat and the valve tube 69 is moved away from its seat to allow filling of that tube with sand from the feed hopper to follow the receding liquid in the tube since the pump chamber associated with that tube is on its expansion stroke. The other diaphragm, however, is on its contraction stroke and is causing discharge of the water through the valve tube connected therewith, forcing the sand collected in the discharge end of the flexible tube past the check valve and into the riser.

As the pumping apparatus continues in operation, the heads in the riser pipes approach the dewatering cones and the sand and water are discharged through dewatering cones, the water falling back through the screen into the feed hopper and the sand discharging through the open top of the cones. A very small stream of fresh water may be introduced into the cylinder chambers under pressure or through a check valve (not shown) on the suction or expansion strokes of the diaphragms so that a constant stream of fresh water is being discharged through the sand on the pressure stroke and thereby prevent the sand from falling back into the flexible ducts to the cylinder. This water insures proper fluidity of the pulp in the riser pipes so that it is moved with the same ease as a heavy fluid. The mixture of sand and water in the flexible ducts and riser pipes is preferably maintained at about seventy (70%) per cent solids. At this density the pulp has the characteristics of a heavy fluid and offers little more pipe friction than water. If the solid content rises to as much as seventy-five (75%) per cent or eighty (80%) per cent, the pulp may immediately assume the characteristics of a solid and the pipe friction makes pumping almost an impossibility with reasonable pressures, but where the water feed is maintained so that the pulp is approximately seventy (70%) per cent solids, a pump as described will lift a column of pulp approximately thirty-two (32') feet high with a pressure of approximately twenty-five (25) pounds per square inch.

The dewatering at the discharge of the riser pipe is purely a matter of allowing sufficient drainage time for the water to escape through the screens. The conical screen section, that is, the inclined portion at the open front of the housing, allows the sand to lift slightly away from the screen surface on the upstroke. The center of gravity of the moving pulp rises above the top of the screen and falls outwardly toward the side having the pitch so that the sand is discharged onto the chute entirely on that side of the screen. Inclination or pitch of the cone should not be too great or a stationary bed of sand will accumulate on the screen and prevent free discharge of the liquid. The liquid and small amount of fine sand that filter through the screen flow back into the feed hopper and are reused for maintaining the desired fluidity of the pulp. If desired, the vertical side of the screen may be cut slightly lower than the pitched side. With this arrangement, when the pump exhausts the settled sand in the feed hopper and takes an excess of water into the riser pipes, the water will be discharged over the lower vertical sides of the screens. This water then returns to the hopper opposite the sand discharge side, making an automatic by-pass for the excess water and permitting the pump to be operated at a speed and displacement that will handle a maximum load and discharge only when enough tonnage is accumulated to cover the valve.

While I have particularly illustrated and described the invention as being adapted for pumping sand and gravel, it is obvious that it is adapted for pumping any materials which are ordinarily not capable of being handled in ordinary piston actuated pumps. By use of the hydraulic pistons to move the sand, the diaphragms and other pump parts are relieved from abrasive wear of the solids. This arrangement also permits use of diaphragms of U-shaped section with a resulting large displacement and long life. The valves and diaphragm being positioned in the bottom of the hopper, act as agitators to break up any compact mass of sand when the pump is idle. The control of the density of the pulp in the riser pipe is also a most desirable feature as the mixture of sand and water permits free motion between the grains of sand, giving the pulp the characteristics of a fluid.

It is obvious that the difference in pitch and height of the sides of the dewatering screen section insure movement of the sand on the screen surface on the upstroke to keep the screen clean. This has the triple advantage of keeping the screen clean, discharging the dewatered sand entirely over one side of the dewatering cone, and discharging the excess water over the opposite side where it can be returned to the feed hopper.

In the form of valve actuating mechanism shown in Fig. 9, the actuating shaft 110 has an arm 111 connected with toggles 112 and 113 by links 114 and 115. The toggles are of the same construction and have one link 116 thereof pivotally connected with a fixed bracket 117 attached to a cross-bar 118 of the sub-frame at a point in alignment with the vertical plane extending through the axes of the respective valve tubes. The other links 119 of the toggles are pivotally connected with collars 120 clamped to the valve tubes 121 and 122. It is thus obvious that when the arm 111 moves one of the toggles to dead center position, the valve tube connected therewith is moved into seating engagement with the riser and the other toggle is hinged to move the valve tube away from its riser as shown in the drawing. Otherwise the construction is the same as in the preferred form.

What I claim and desire to secure by Letters Patent is:

1. A pumping apparatus including, a tubular riser member, a duct member having a discharge end in coaxial alignment with the riser member, means supporting one of said members for movement out of abutting engagement with the other member to allow inflow of material to be pumped and into abutting engagement with the other

member, means for reciprocating the movable member to and from said abutting engagement, pulsating means for pulsating a fluid medium in the member receiving said material to expel the material through the other member, means for actuating the reciprocating means in time with the pulsating means and a check in said other member to prevent back flow of said material when the members are out of abutting engagement.

2. A pumping apparatus including, a tank, a flexible diaphragm in the bottom of the tank, a valve tube carried by the flexible diaphragm, a riser tube supported in coaxial alignment with the valve tube, means for moving the valve tube into and out of valving engagement with the riser tube, a duct connected with the valve tube, and means for pulsating a fluid medium in said duct, said pulsating means acting in timed relation with movement of the valve tube.

3. A pumping apparatus including, a tank, a plurality of riser tubes in the tank, a valve tube for each riser tube, means supporting the valve tubes for movement to and from abutting engagement with the riser tubes, means connected with the valve tubes for effecting alternate pulsations through the valve tubes, and means for actuating the valve tubes in synchronism with said alternating pulsations.

4. A pumping apparatus including, a container for a pulp material, a riser tube having a lower end opening within the container for admitting a pulp to be pumped into the lower end of the riser tube, means for effecting elevation of the pulp through said riser tube, a foraminated head forming an upward continuation of said riser tube for returning the liquid component of said pulp to the container and having an open top for discharging the solid components of said pulp, and a receiver for the solid components, said foraminated head having one side pitched relatively to the vertical axis of said riser tube for effecting directional discharge of the solid components of the pulp into said receiver.

5. A pumping apparatus including, a pair of cylinder chambers, expansible and contractable diaphragm means at the ends of said cylinder chambers, means for alternately actuating said diaphragm means, flexible U-shaped ducts having inlet ends connected with said chambers, valve tubes connected with the outlet ends of said ducts, material discharge pipes having inlets supported in fixed coaxial alignment with said valve tubes, material delivering means surrounding the inlets of said discharge pipes, and means for alternately moving the valve tubes into and out of engagement with the riser pipes, said means operating in synchronism with the diaphragm actuating means.

6. A pumping apparatus including, a pair of tubular riser members, a pair of duct members having discharge ends in coaxial alignment with the riser members, means supporting the members of one pair for movement into and out of abutting engagement with the members of the other pair, means for supporting a material to be pumped for inflow into one of the members when said members are out of abutting engagement, means for pulsating a fluid medium in the members receiving said material to expel the material through the other members, checks in said other members to prevent back flow of said material when the members are out of abutting engagement, and means for alternately actuating the movably supported members.



7. A pumping apparatus including, a pair of tubular riser members, a pair of duct members having discharge ends in coaxial alignment with the riser members, means supporting members of one pair for movement into and out of abutting engagement with the members of the other pair, means for supporting pulp material to be pumped for inflow into the members of one pair when the members of the other pair are out of abutting engagement, means for pulsating a fluid medium in the members receiving the pulp to expel the material into the other members when said members are in abutting engagement, means for alternately actuating the movably supported members, and means in the top of said riser members for separating solid components of the pulp from the liquid component.

8. A pumping apparatus including, a riser tube, a container for admitting a pulp to be pumped into the lower end of the riser tube, means for effecting elevation of the pulp through said riser tube, a foraminated head forming an upward continuation of said riser tube and located over the container for returning the liquid component of said pulp to the container, a receiver for solid components of said pulp, said head having an open top for discharging the solid components of said pulp into the pulp receiver, said foraminated head having one side pitched relatively to the vertical axis of said riser tube for effecting directional discharge of the solid components of the pulp, and a hood over said head to direct flow of the separated components.

9. A pumping apparatus including, a pump chamber for a liquid, an expansible and contractable diaphragm means connected with said pump chamber, means for actuating said diaphragm means to pulsate said liquid, a flexible U-shaped duct having an inlet end connected with said chamber to transmit said pulsations, a valve tube connected with the outer ends of said duct, a riser pipe supported in fixed coaxial alignment with said valve tube, a container for supporting a material to be pumped for inlet into the valve tube and means for moving the valve tube into and out of engagement with the riser pipe and operating in synchronism with the diaphragm actuating means whereby the pulsating liquid moves the material through the riser pipe.

10. A pumping apparatus including, a pump chamber for a liquid, an expansible and contractable diaphragm means connected with said chamber, means for actuating said diaphragm means to pulsate said liquid, a flexible U-shaped duct having an inlet end connected with said chamber to transmit said pulsations, a valve tube connected with the outer ends of said duct, a riser pipe supported in fixed coaxial alignment with said valve tube, a container for supporting a material to be pumped for inlet into the valve tube means for moving the valve tube into and out of engagement with the riser pipe, said means operating in synchronism with the diaphragm actuating means, and means for effecting flow of fluid into said chamber.

11. A pumping apparatus including, a pair of liquid receiving chambers, expansible and contractable diaphragm means at the ends of said liquid receiving chambers, means for alternately actuating said diaphragm means to alternately expel and draw liquid into the chambers, flexible U-shaped ducts having inlet ends connected with said chambers to conduct said pulsated liquid, valve tubes connected with the outer ends of said ducts, riser pipes supported in fixed coaxial align-

ment with said valve tubes, means supporting material to be pumped through the risers for inlet into the valve tubes, means for alternately moving the valve tubes into and out of engagement with the riser pipes in synchronism with the diaphragm actuating means whereby the material entering the valve tubes is lifted in the riser pipes by said pulsated liquid, and means for effecting flow of liquid into said chambers.

12. A pumping apparatus including, a tank, a plurality of riser tubes in the tank, a valve tube for each riser tube, means supporting the valve tubes for movement to and from abutting engagement with the riser tubes, check valves in said riser tubes, means connected with the valve tubes for effecting alternate pulsations through the valve tubes, and means for actuating the valve tubes in synchronism with said alternating pulsations.

13. A pumping apparatus including a container for a pump material, a riser tube having an imperforate wall and a lower end opening within the container for admitting the pulp to be pumped into the riser tube, means for effecting elevation of the pulp through the riser tube, a foraminated head forming a continuation of said tube and located over the container through which liquid component of the pulp is returned to the container while the solid components of the pulp move upwardly through said foraminated head, said foraminated head having an open top, and offtake means for receiving said solid components from the open top of said head for discharging the solid components of said pulp.

14. A pumping apparatus including a tubular riser member, a duct member having a discharge end in coaxial alignment with the riser member, means supporting one of said members for movement into and out of abutting engagement with the other member, a container for supporting material to be pumped for inflow into the duct member, means for introducing liquid into the riser member, means for reciprocating the movable member, means for pulsating a fluid medium in the duct member receiving said material to expel the material through the tubular riser member, and a check in the tubular riser member to prevent backflow of said material when the members are out of abutting engagement.

15. A pumping apparatus including a tubular riser member, a duct member having a discharge end in coaxial alignment with the riser member, a container for pulp-like material surrounding the discharge end of the duct member and the inlet of the riser member, means supporting one of said members for movement out of engagement with the other member to allow inflow of pulp-like material and into abutting engagement with said other member, means for moving the movable member, means for introducing a liquid into the riser member to maintain desired fluidity of the pulp-like material, means for pulsating a fluid medium in said members to expel the material through the tubular riser member when said members are in abutting engagement, and means for effecting flow of liquid into the duct member.

CHARLES E. WOOD.

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