July 7, 1953 D. RAGLAND 2,644,401

APPARATUS FOR PUMPING DRILLING FLUIDS

Filed March 15, 1951 4 Sheets-Sheet 1

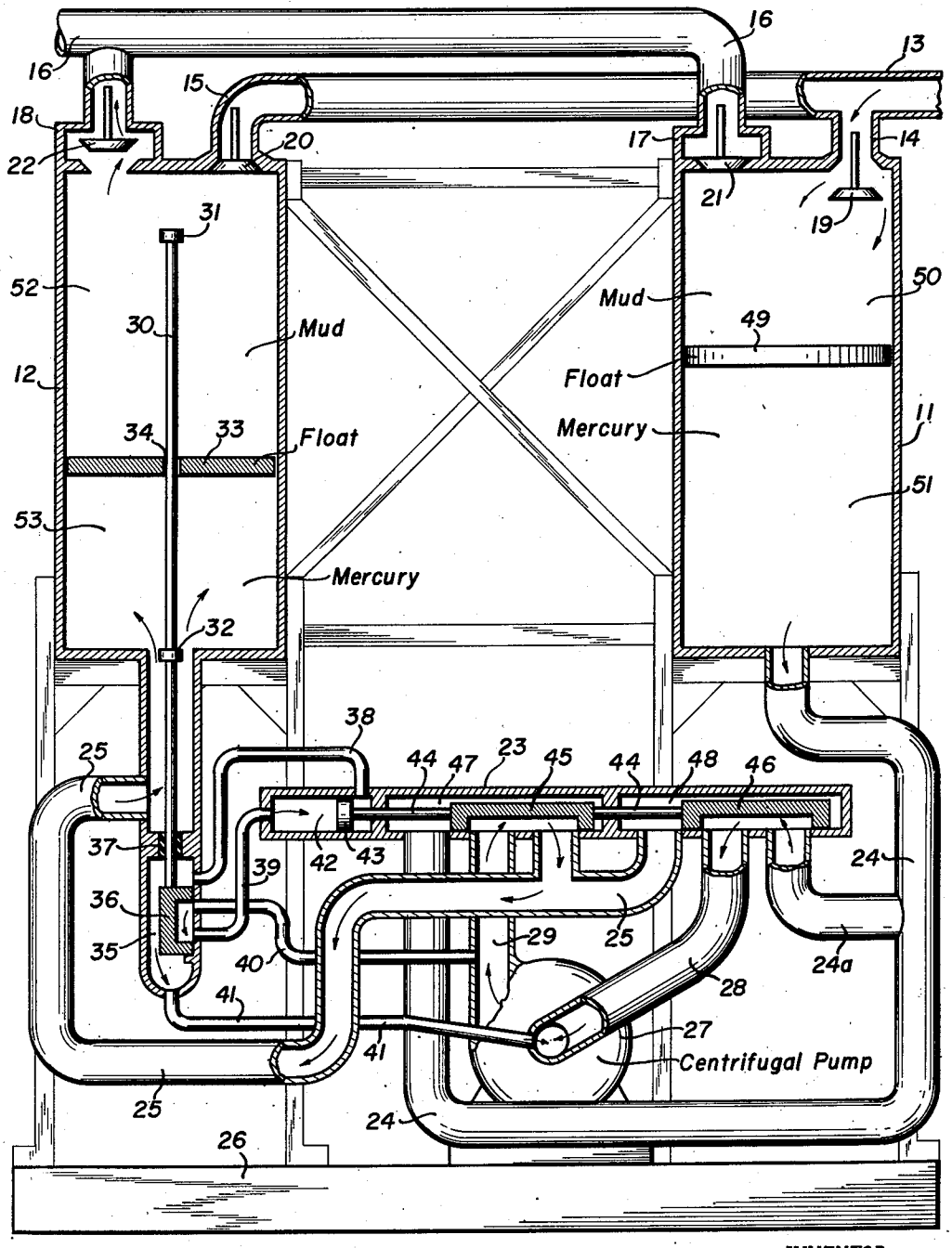

FIG. 1.

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APPARATUS FOR PUMPING DRILLING FLUIDS

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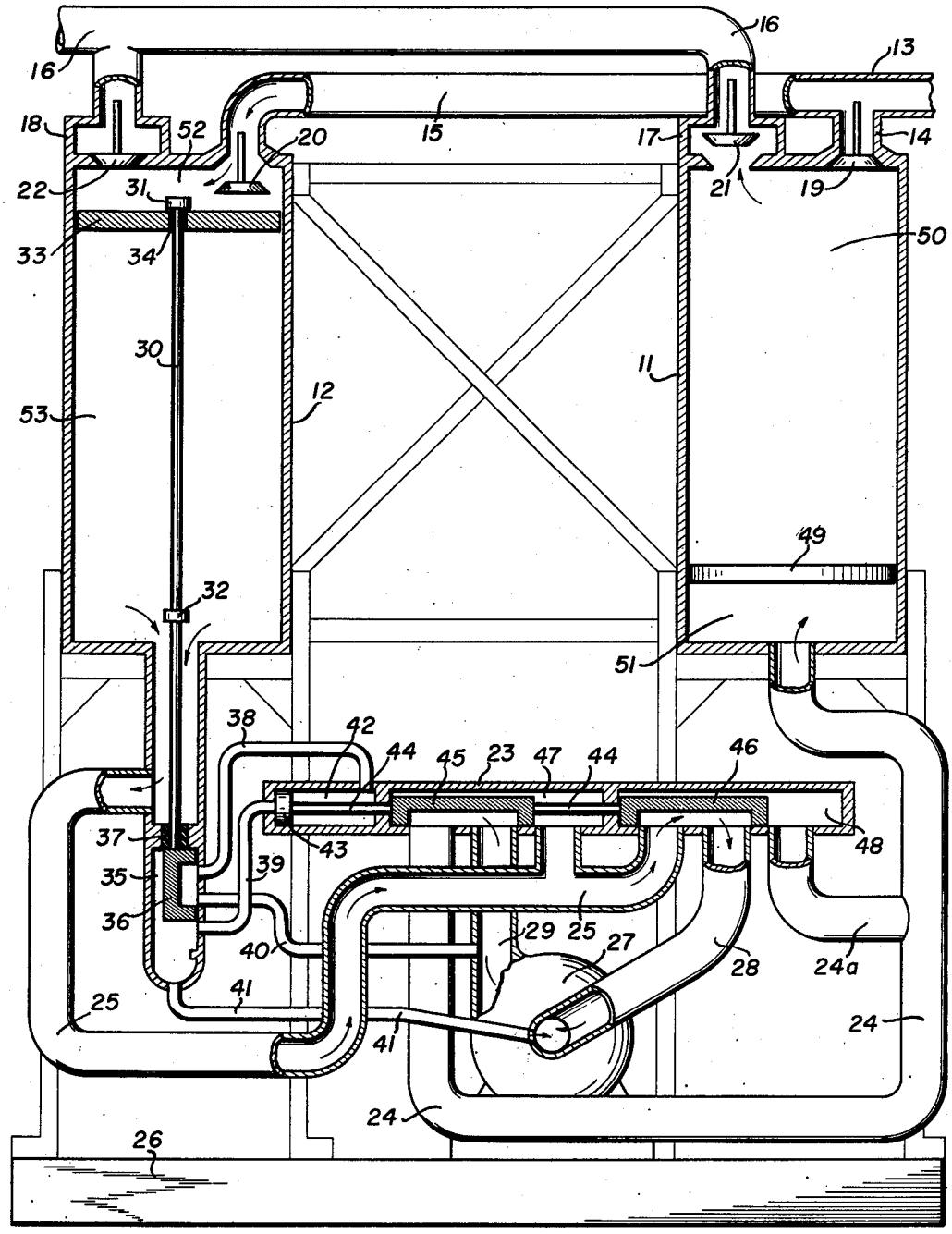

FIG. 2.

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APPARATUS FOR PUMPING DRILLING FLUIDS

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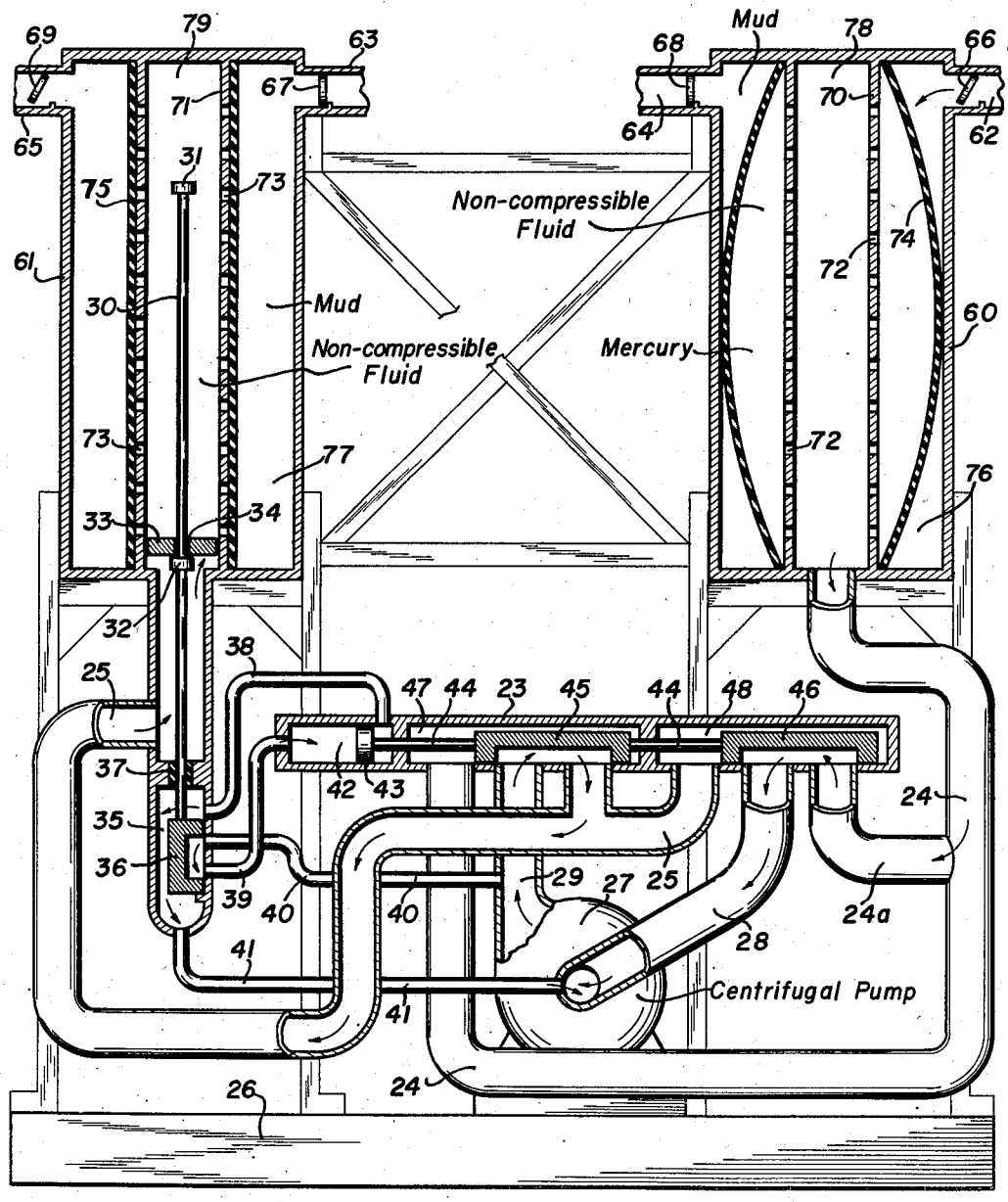

FIG. 3.

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APPARATUS FOR PUMPING DRILLING FLUIDS

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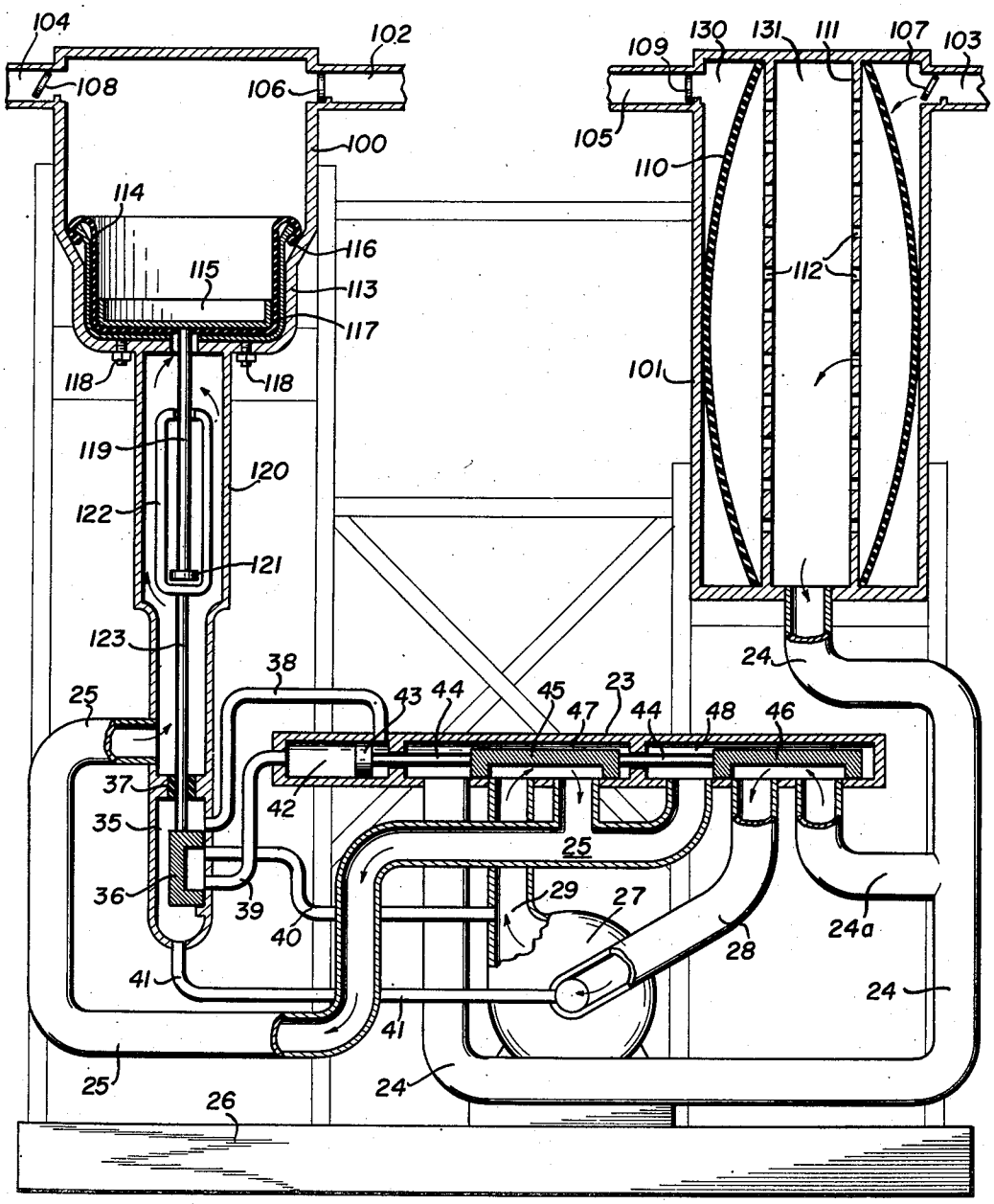

FIG. 4.

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UNITED STATES PATENT OFFICE

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APPARATUS FOR PUMPING DRILLING FLUIDS

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Application March 15, 1951, Serial No. 215,782

9 Claims. (Cl. 103—45)

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The present invention is directed to apparatus for pumping fluids. More particularly, the invention is directed to improved apparatus for pumping drilling fluid comprising a suspension of finely divided solids in a fluid medium.

The apparatus of the present invention may be described briefly as involving a plurality of interconnected vessels defining chambers adapted to contain a body of mercury which serves as a liquid piston and which reciprocates between the chambers. Each of the chambers is provided with an inlet and an outlet which has means to resist the flow of fluid in a direction opposite to normal flow through said inlet and outlet. A housing defining passageways communicates with each of said chambers through conduits connected thereto and a pump is connected to the passageways in said housing by conduits defining an inlet and an outlet thereto. An actuating member is arranged in a first of the chambers which is adapted to rise and fall with the rise and fall of mercury in a first of the chambers. A pilot valve is connected to the actuating member; the pilot valve has passageways communicating with the first chamber and with the housing. The housing defines a piston cylinder having a piston carrying a piston rod attached to first and second valves which are adapted to open and close the pump inlet and outlet, the rise and fall of said actuating member opening and closing the pilot valve and causing movement of the piston rod and flow of mercury from the first chamber to the second chamber and vice versa on actuation of the pump.

The invention will be described further by reference to the drawing in which

Fig. 1 is a cross-sectional view of one embodiment of my invention showing the valves arranged in one position;

Fig. 2 is a similar cross-sectional view with the valves in a second position;

Fig. 3 is a sectional view of a modification of the apparatus of Figs. 1 and 2 showing a diaphragm arrangement in the first and second vessels; and

Fig. 4 is a sectional view of a further modification of the apparatus wherein the float arrangement is replaced by a diaphragm.

In the several figures of the drawing corresponding parts will be designated by identical numerals.

Referring now to Figs. 1 and 2, numerals 11 and 12 designate, respectively, a pair of vertical vessels defining chambers adapted to receive drilling fluid. A conduit 13 connects to vessel 11 by inlet 14 and to vessel 12 by inlet 15. A second conduit 16 is adapted to discharge fluid from vessel 11 by outlet 17 and from vessel 12 by outlet 18. Inlet 14 is provided with a valve 19 and inlet 15 is provided with a similar valve 20. Outlet 17 is provided with a valve 21 while outlet 18 is similarly provided with a valve 22. A housing 23 is connected to vessels 11 and 12, respectively, by conduits 24 and 25. The housing 23 defines a series of interconnected passageways and valves which will be described in more detail. Arranged on base member 26 which suitably may be a skid for easy movement of the structure is a centrifugal pump 27 which is connected to conduit 24 and housing 23 by an inlet line 28 and to housing 23 and conduit 25 by a discharge line 29.

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Arranged in the chamber defined by the vessel 12 is an elongated vertical rod 30 which defines with first and second ends thereof shoulders 31 and 32. Slidably arranged on the elongated rod or member 30 is a float 33 having a central opening 34 which allows the float to rise and fall in a manner which will be described further. The float shall be of such a density that it will float on the mercury but will sink in the drilling fluid. Connecting into the vessel 12 is a pilot valve 35 which has a slide member 36 which is connected to the elongated member 30 which protrudes into the valve 35 through a stuffing box 37. The valve 35 is connected to the housing 23 by conduits 38 and 39. Valve 35 is also connected to the discharge 29 of pump 27 by conduit 40. A fourth conduit 41 connects the valve 35 with the suction 28 of pump 27.

It will be seen that the housing 23 defines a piston cylinder 42 in which is arranged a piston 43. Connecting to piston 43 is a piston rod 44 which carries first and second valve members 45 and 46, the valve members 45 and 46 being adapted to open and close the discharge 29 and suction 28 of pump 27 in a manner which will be described further. It will be seen that the housing 23 defines chambers 47 and 48 in which the valves 45 and 46 are slidably arranged.

Arranged in the vessel 11 is a plate 49 which serves to prevent contamination between the drilling fluid and the liquid piston or body of mercury therein.

Arranged in the vessel 11 is a body of drilling fluid 50 above the plate 49 while below it is a body of mercury 51. In vessel 12 the drilling fluid is indicated by numeral 52 above the float 33 which rests on the body of mercury 53 therein.

It will be noted that the conduits 24 and 24a are interconnected and connect to vessel 11 by the conduit 24. The conduit 24a connects to the

housing 23 and allows communication with the inlet 28. The conduit 24 connects to the housing 23 and provides communication with the outlet 29. The conduit 25 is connected to the housing 23 at two points, a first point adjacent the inlet 28 and a second point adjacent the outlet 29. Thus the conduit 25 may communicate, on actuation of valve 46, with the inlet 28 and communication may be had between the outlet 29 and conduit 25. This flow may be readily understood by reference to Figs. 1 and 2.

Referring now to Fig. 3 which is a further embodiment of my invention, a plurality or pair of vessels 60 and 61 are provided, respectively, with inlets 62 and 63 and outlets 64 and 65. Inlets 62 and 63 are provided with check valves 66 and 67 to resist flow therethrough in a direction opposite from that of normal flow while outlets 64 and 65 are similarly provided with check valves 68 and 69 to resist flow back into the vessels 60 and 61. Arranged concentrically in vessels 60 and 61 are cylindrical sleeves 70 and 71 which define a plurality of ports 72 and 73 to allow flow therethrough. Cylindrical sleeves 70 and 71 serve as seats for diaphragms 74 and 75 which are also concentrically arranged in vessels 60 and 61 and define therewith outer chambers 76 and 77 and inner chambers 78 and 79. Inner chamber 79 of vessel 61 is provided with an elongated vertical member 30. Arranged slidably on elongated member 30 is a float 33 provided with a central opening 34. Float 33 in Fig. 3 is similar to but of different dimensions than float 33 to conform to the diameter of sleeve 71 by virtue of being arranged in the inner chamber 79 of vessel 61. In the embodiment of Fig. 3, the elongated member 30 is about ⅔ the length of member 30 of Figs. 1 and 2 but is otherwise identical thereto. In this embodiment of my invention, each of the chambers 78 and 79 contains an amount of a non-compressible fluid equal to the volume of the perforated cylinders of sleeves 70 and 71 and the interface thereof with the mercury is at least below the bottom shoulder 32 of the member 30 when the respective vessel is beginning to be filled with mercury at the start of a cycle when drilling fluid is being discharged from either the chamber 76 or 77. The remaining parts of the embodiment of Fig. 3 are identical to the embodiments of Figs. 1 and 2 and further detailed description is not believed necessary.

Referring now to Fig. 4 which is a still further embodiment of my invention, a plurality of vessels 100 and 101 are provided, respectively, with inlets 102 and 103 and outlets 104 and 105. Inlets 102 and 103 are provided with check valves 106 and 107 to resist flow therethrough in a direction opposite from that of normal flow while outlets 104 and 105 are similarly provided with check valves 108 and 109 to resist flow back into the vessels 100 and 101. Arranged in vessel 101 is a diaphragm member 110 which is arranged concentrically therein which has a cylindrical sleeve 111 as a seating member defining a plurality of ports 112 to allow flow therethrough.

Vessel 100 has a reduced portion 113 in which is arranged a diaphragm member 114 carrying a plate 115. Diaphragm member 114 is attached annularly at ring 116 to the reduced portion 113 of vessel 100. A cup-shaped member 117 is bolted to the vessel 100 by bolt 118 to affix the diaphragm to the vessel 100. The plate 115 is attached to a rod member 119 which is arranged in a housing 120 which is fluidly connected to conduit 25 and to valve 35. Rod member 119 is provided with a shoulder 121 at its lower end and the rod member 119 is arranged in a yoke 122. The rod member 119 is slidably seated in the yoke 122 so that it may move vertically therein. The yoke 122 is connected by a second rod member 123 to the slide member 36 of pilot valve 35, the rod member 123 protruding into valve 35 through a stuffing box 37. The vessel 101 has been illustrated as being similar to vessel 60 of Fig. 3. It is to be understood that it may be constructed similar to vessel 100 with elimination of rod member 119, yoke 122, and rod member 123 which will eliminate the necessity of employing a non-compressible fluid in the chamber 131. As shown, however, vessel 101 is provided with a diaphragm 110 which divides the vessel 101 into chambers 130 and 131 with the diaphragm 110 in a distended condition by virtue of the chamber 131 being filled with mercury and non-compressible fluid. The remaining parts of the embodiment of Fig. 4 are identical to the embodiments of Figs. 1 to 3 and further detailed description will not be given.

The apparatus of the present invention functions in the following manner with respect to Figs. 1 and 2. Assuming for the purpose of this description that conduit 13 is connected to a mud or slush pit, the valve 19 is in the open position and drilling fluid or mud indicated as 50, referring particularly to Fig. 1, is being drawn into vessel 11. It will be seen that mercury indicated as 51 is contained in vessel 11 to slightly above the mid-point thereof and is separated from the drilling fluid by a plate 49. The centrifugal pump 27 is in operation and is withdrawing mercury from vessel 11 through conduit 24 which communicates with suction 28 by conduit 24a. Thus the mercury is forced to travel through conduit 24 and conduit 24a and thence to suction 28 of pump 27 since valves 45 and 46 are in a position to close the conduit 24 from communicating with the discharge 29. The mercury then discharges from the pump 27 into discharge 29 which communicates with conduit or passageway 25. Thus the mercury flows from conduit 24 into suction 28 and thence through discharge 29 into conduit 25 and thence into vessel 12 where the mercury level is indicated generally by numeral 53. The float 33 rises with the rise of the mercury until the float hits the shoulder 31 in the upper portion of vessel 12. Meanwhile the valve 22 in outlet 18 is open and the mud or drilling fluid 52 is forced out of vessel 12 into conduit 16 which communicates with the circulating system in the drilling operation as is well-known to the art. The pilot valve 35 is connected by line 40 to the discharge 29 which allows flow of mercury into the piston cylinder and against the piston 43, holding the valves 45 and 46 into the position shown to allow the mercury to fill completely the vessel 12 and to displace substantially all the mud therefrom.

Referring now to Fig. 2, it will be seen that the drilling fluid 52 has been substantially displaced from the vessel 12 and that the plate 33 has raised the shoulder 31 to its highest position. Referring to vessel 11 it will be seen that the vessel is substantially full of drilling fluid and mercury as represented by the portion beneath the plate 49 has been substantially exhausted. The cycle is then reversed and drilling fluid is drawn into vessel 12 from the conduit 13 and inlet 15, valve 20 being in the open position and valve 22 of outlet 18 being in the closed position. Since the elongated member or rod 30

has been raised, the valve 35 containing the slide member 36 is now pushed up to a position so that the conduits 38 and 40 are communicating with each other and the conduit 39 allows the mercury in chamber 42 ahead of piston 43 to be discharged through valve 35 into conduit 41 and thence into the suction 28 of pump 27, the mercury from vessel 12 being discharged by conduit 25 into the suction 28 and thence into centrifugal pump 27 and outward therefrom through discharge 29 and conduit 24 into chamber 11. With the positions of valves 45 and 46 as shown in Fig. 2 the passageway 24a is blocked and the mercury moves, following the flow indicated generally by the arrows, allowing it to be pumped from vessel 12 into vessel 11 causing the mud 50 therein to flow through outlet 17 by opening valve 21 into conduit 16, inlet line 14 containing valve 19 being blocked thereby.

The embodiment of Fig. 3 works in a manner similar to that of Figs. 1 and 2 with the difference that the mercury is excluded from contact with the drilling fluid. In this embodiment of my invention, Fig. 3 represents the valve 35 in a position similar to the arrangement of Fig. 1. In this embodiment, however, the outer chamber 77 of vessel 61 is completely full of drilling fluid while the inner chamber 78 of vessel 60 contains substantially its maximum amount of mercury and has arranged above it a non-compressible liquid such as water, and the like. The outer chamber 76 contains its minimum amount of drilling fluid. Mercury is, therefore, being pumped from inner chamber 78 by conduits 24 and 24a into suction 28 and thence into pump 27 and outward therefrom by discharge 29 which communicates with conduit 25 allowing mercury to be delivered into inner chamber 79 which also contains a non-compressible liquid such as water, and the like. Since the float 33 is at its lowest point and has shoved elongated member 30 downward by bearing against shoulder 32, the discharge 29 communicates by conduits 40 and 39 with chamber 42 ahead of piston member 43 causing the piston member to move to the right as far as possible and causing mercury to be discharged from the back of piston 43 to conduit 38 into valve 35 and thence to the conduit 41 into suction 28 of pump 27. As inner chamber 79 of vessel 61 becomes filled to its greatest extent with mercury, the diaphragm 75 is distended by it and the non-compressible liquid, and the drilling fluid in outer chamber 77 will be discharged through discharge 65 by opening valve 69. The outer chamber 76 of the vessel 60 will become filled with mud while the mercury in inner vessel 78 thereof will be at its lowest point; thereafter the cycle will reverse as has been described with respect to Figs. 1 and 2.

The apparatus of Fig. 4 works in a manner similar to that of Figs. 1 to 3 with the difference that a non-compressible fluid is not required in the vessel 100. In this embodiment of my invention, however, a diaphragm 114 carries a plate 115 which is connected through members 119 and 123 to slide member 36 contained in pilot valve 35. In vessel 101 the diaphragm 110 is distended by mercury and a non-compressible fluid arranged above the body of mercury. The valve 107 is shown in the open position and drilling mud is being drawn into the outer chamber 130 defined by the diaphragm 110 and the vessel 101 while the inner chamber 131 defined by the diaphragm is being exhausted of mercury in a direction of flow shown by the arrows. Mercury

is being drawn via conduits 24 and 24a into suction 28 of pump 27 and thence into outlet 29 and conduit 25 and thence by housing 120 to the underside of diaphragm 114. The slide member 36 causes mercury to pump by discharge 29 into conduit 40 and thence by conduit 39 into chamber 42 and against the piston 43 arranged in cylinder causing the piston to move to the right and causing the valve members 45 and 46 carried by piston rod 44 to also move to the right to the farthest extent. Mercury is discharged from cylinder 42 by conduit 38 and thence into valve 35 and back into the pump suction 28 by conduit 41. As the mercury rises under the diaphragm 114 it is moved upwardly forcing drilling mud contained in vessel 100 outwardly by outlet 104, check valve 103 being opened. As the mercury substantially fills chamber 100 under diaphragm 114 the cycle is reversed when the shoulder 121 reaches the limit of its upward travel and causes a vertical movement of yoke 122 and connecting rod 123 and corresponding upward movement of slide member 36 of valve 35 which allows the pilot valve to assume the position shown in Fig. 2 which causes the slide members 45 and 46 carried by piston rod 44 to move to the left causing mercury to flow into inner chamber 131 of vessel 101. Thereafter the cycle will reverse as has been previously described. It will be understood, of course, that, when vessel 101 is constructed like vessel 100, it will be unnecessary to use a non-compressible fluid therein.

It will be seen from the foregoing description taken with the drawing that substantial advantages inure to the present invention. All of the moving parts except the motivating means (not shown) for pump 27 are enclosed eliminating the possibility of leaks around or in packing glands and permitting the use of a high density fluid, such as mercury, for the fluid piston, which will produce a discharge pressure approximately 13.6 times greater than the pressure of the same pump pumping water. Furthermore, other advantages inure to the present invention in that a pump is provided for pumping drilling fluid, such as drilling mud, which eliminates substantially pistons, liners, and piston rods in contact with the drilling mud. It is well known that on mud pumps where such pistons, liners and rods are subjected to abrasive action of solids in the drilling fluid it is necessary to replace these various elements at frequent intervals due to scoring and erosion.

While water is mentioned as the non-compressible liquid employed in the inner chambers of Figs. 3 and 4, other non-compressible liquids may be substituted therefor such as selected low viscosity, non-volatile hydrocarbon fractions. For example a kerosene or gas oil fraction may suitably be used. When hydrocarbon fractions are employed as the non-compressible liquid the constructional material for the diaphragm should be selected to resist attack by the hydrocarbon. Various synthetic rubbers are available on the market which resist attack by hydrocarbons.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. Apparatus for pumping drilling fluid which comprises, in combination, a pair of interconnected vessels defining first and second chambers, a liquid piston arranged in and adapted to reciprocate between said chambers, an inlet and an outlet for each of said chambers provided

with a valve adapted to resist flow of fluid in a direction opposite to normal flow through said inlets and outlets, a housing provided with a piston cylinder, interconnected first and second conduits connected to said housing and to said second chamber fluidly communicating said housing with said second chamber, interconnected third and fourth conduits connected to said housing and to said first chamber fluidly communicating said housing with said first chamber, a centrifugal pump, conduits defining an inlet to and an outlet from said pump fluidly connected to said housing and to said pump, an elongated member vertically arranged in the first of said chambers with respect to the horizontal axis of said apparatus extending substantially the length thereof defining first and second shoulders at points corresponding generally with first and second ends of said first chamber, a float having a central opening slidably mounted on said elongated member adapted to raise and depress same on rise and fall of said float, a pilot valve adapted to be actuated by said float connected to said first chamber and to said elongated member and communicating fluidly with said first chamber and with said third conduit and with the piston cylinder defined by said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and to said first conduit, a piston arranged in said cylinder, and a piston rod attached to said piston and to said first and second valves, the rise and fall of said float actuating said pilot valve to cause movement of said liquid piston into said piston cylinder and against said piston attached to said piston rod and from said first chamber to said second chamber and vice versa on actuation of said pump.

2. Apparatus in accordance with claim 1 in which the liquid piston comprises a body of mercury.

3. Apparatus for pumping drilling fluid which comprises, in combination, a pair of first and second interconnected vessels, a diaphragm in each of said vessels defining an inner chamber and an outer chamber, said outer chambers being adapted to receive drilling fluid, an inlet and an outlet in each of said outer chambers provided with means adapted to resist flow of drilling fluid in a direction opposite to normal flow through said inlets and outlets, a liquid piston arranged in and adapted to reciprocate between said inner chambers, a housing provided with a piston cylinder, interconnected first and second conduits connected to said housing and to said vessel fluidly communicating said housing with a second of the inner chambers, interconnected third and fourth conduits connected to said housing and to said first vessel fluidly communicating said housing with a first of the inner chambers, a centrifugal pump, conduits defining an inlet to and an outlet from said pump connected to said housing and to said pump, an elongated member arranged vertically in the first of said inner chambers with respect to the horizontal axis of said apparatus extending substantially throughout the length thereof defining first and second shoulders at points corresponding generally to first and second ends of said first inner chamber, a float having a central opening slidably mounted on said elongated member adapted to raise and depress same on the rise and fall of said float, a pilot valve adapted to be actuated by said float connected to said first vessel and to said elongated member fluidly communicating with said first inner chamber and said housing and with the piston cylinder defined by said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and to said first conduit, a piston arranged in said piston cylinder, and a piston rod attached to said piston and to said first and second valves, the rise and fall of said float actuating said pilot valve to cause movement of said liquid piston into said piston cylinder and against said piston attached to said piston rod and from said first inner chamber to said second inner chamber and vice versa on actuation of said pump.

4. Apparatus in accordance with claim 3 which the liquid piston comprises a body of mercury.

5. Apparatus for pumping drilling fluid which comprises, in combination, a pair of interconnecting vessels, a diaphragm in a second of said vessels defining an inner chamber and an outer chamber, said outer chamber being adapted to receive a body of drilling fluid, an inlet and outlet for said outer chamber provided with means to resist flow of drilling fluid in a direction opposite to normal flow through said inlet and outlet, a diaphragm in a first of said vessels defining an upper and a lower chamber, said upper chamber being adapted to receive a body of drilling fluid, an inlet and an outlet for said upper chamber provided with means to resist flow of drilling fluid in a direction opposite to normal flow through the inlet and outlet in said upper chamber, a liquid piston arranged in and adapted to reciprocate between said inner chamber and said lower chamber, a housing provided with a piston cylinder, interconnected first and second conduits connected to said housing and to said second vessel fluidly communicating said housing with said inner chamber, interconnected third and fourth conduits connected to said housing and said first vessel fluidly communicating said housing with said lower chamber, a centrifugal pump, conduits defining an inlet and an outlet to said pump connected to said housing and to said pump, an actuating member connected to the diaphragm in said first vessel, a pilot valve connected to said first vessel and to said actuating member fluidly communicating with said lower chamber and with said housing and with the piston cylinder defined by said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and to said first conduit, a piston arranged in said piston cylinder, and a piston rod attached to said piston and to said first and second valves, the rise and fall of said diaphragm in said first vessel actuating said pilot valve to cause movement of said liquid piston into said piston cylinder and against said piston and from the lower chamber to the inner chamber and vice versa on actuation of said pump.

6. Apparatus in accordance with claim 5 in which the liquid piston comprises a body of mercury.

7. Apparatus for pumping drilling fluid which comprises, in combination, a plurality of interconnected vessels defining at least first and second chambers, a liquid piston arranged in and

adapted to reciprocate between said chambers, an inlet and an outlet for each of said chambers provided with means adapted to resist flow of fluid in a direction opposite to normal flow through said inlets and outlets, a housing provided with a piston cylinder, interconnected first and second conduits connected to said housing and to said second chamber fluidly communicating said housing with said second chamber, interconnected third and fourth conduits connected to said housing and to said first chamber fluidly communicating said housing with said first chamber, a pump, conduits defining an inlet to and an outlet from said pump connected to said housing and to said pump, an actuating member extending into said first chamber adapted to be actuated by a reciprocation of said liquid piston in said first chamber, a pilot valve connected to said actuating member communicating fluidly with said first chamber and with said third conduit and with the piston cylinder defined by said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and to said first conduit, a piston arranged in said cylinder, and a piston rod attached to said piston and to said first and second valves, the actuation of said actuating member shifting said pilot valve to cause movement of said liquid piston into said piston cylinder against said piston attached to said piston rod and from said first chamber to said second chamber and vice versa on actuation of said pump.

8. Apparatus for pumping drilling fluid which comprises, in combination, a plurality of interconnected vessels defining at least first and second chambers containing a body of mercury, an inlet and outlet for each of said chambers provided with means adapted to resist flow of fluid in a direction opposite the normal flow through said inlets and outlets, a housing provided with a piston cylinder, interconnected first and second conduits connected to said housing and to said second chamber fluidly communicating said housing with said second chamber, interconnected third and fourth conduits connected to said housing fluidly communicating said housing with said first chamber, a pump, conduits defining an inlet to and an outlet from said pump connected to said housing and to said pump, an actuating member arranged in said first chamber adapted to rise and fall with the rise and fall of mercury in said first chamber, a pilot valve connected to said actuating member fluidly communicating with said first chamber and with said third conduit and with the piston cylinder defined by said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and to said first conduit, a piston arranged in said cylinder, and a piston rod attached to said piston and to said first and second valves, the rise and fall of said actuating member shifting said pilot valve and causing flow of mercury against said piston and movement thereof and flow of mercury from said first chamber to said second chamber and vice versa on actuation of said pump.

9. Apparatus for pumping drilling fluid which comprises, in combination, at least first and second interconnected vessels, a diaphragm in each of said vessels defining first and second inner chambers containing a body of mercury and a body of a non-compressible liquid and first and second outer chambers adapted to receive drilling fluid, an inlet and an outlet for each of said outer chambers provided with valve members adapted to resist flow of drilling fluid in a direction opposite the normal flow through said inlets and outlets, a housing provided with a piston cylinder, interconnected first and second conduits connected to said second vessel and to said housing fluidly communicating said housing with said second vessel, interconnected third and fourth conduits connected to said housing and to said first vessel fluidly communicating said housing with said first vessel, a pump, conduits defining an inlet to and an outlet from said pump connected to said housing and to said pump, an elongated member arranged in a first of said inner chambers extending substantially the length thereof defining first and second shoulders at points corresponding generally to first and second ends of said first inner chamber, a float having a central opening slidably mounted on said elongated member adapted to raise and depress same on rise and fall of said float, a pilot valve connected to said elongated member fluidly communicating with said first vessel and with the piston cylinder in said housing, first and second valves in said housing adapted to connect sequentially said pump inlet to said second conduit and to said third conduit and said pump outlet to said fourth conduit and said first conduit, a piston arranged in said piston cylinder, and a piston rod attached to said piston and to said first and second valves, the rise and fall of said float actuating said pilot valve to cause flow of mercury against said piston and movement thereof and flow of mercury from said first inner chamber to said second inner chamber and vice versa on actuation of said pump.

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