Jan. 27, 1948. A. C. McGOVNEY 2,435,179

OIL WELL PUMP

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FIG. 1.

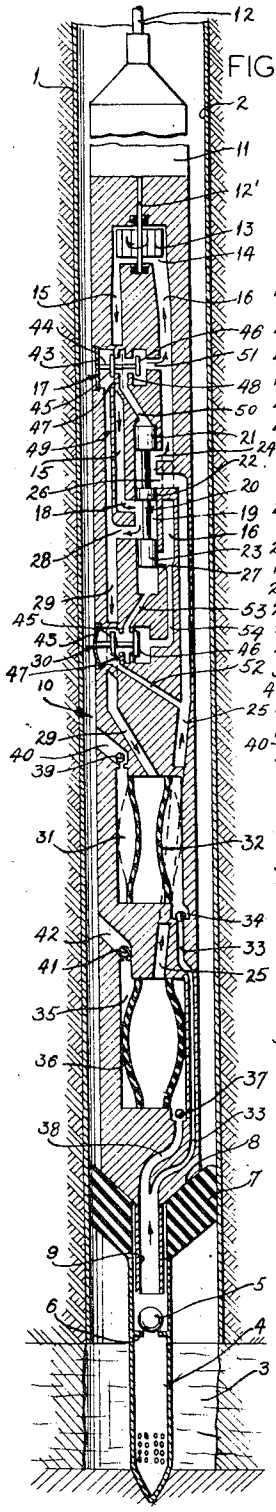


FIG. 2.

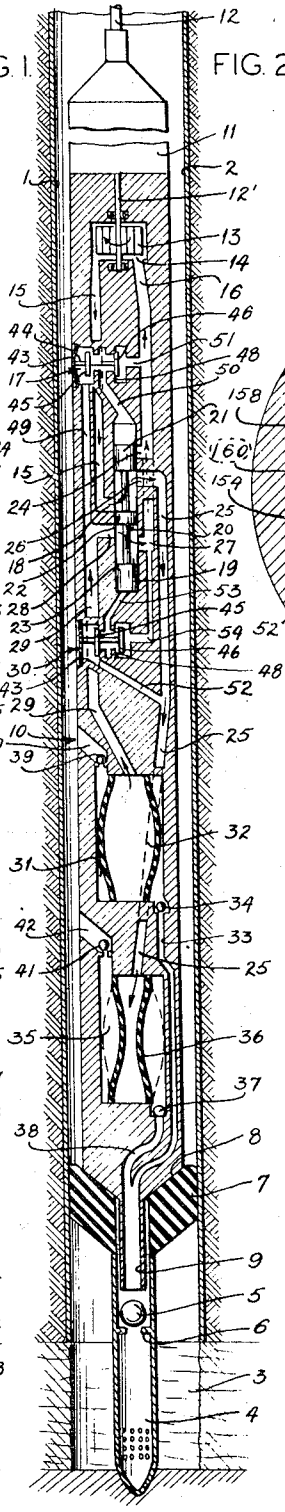
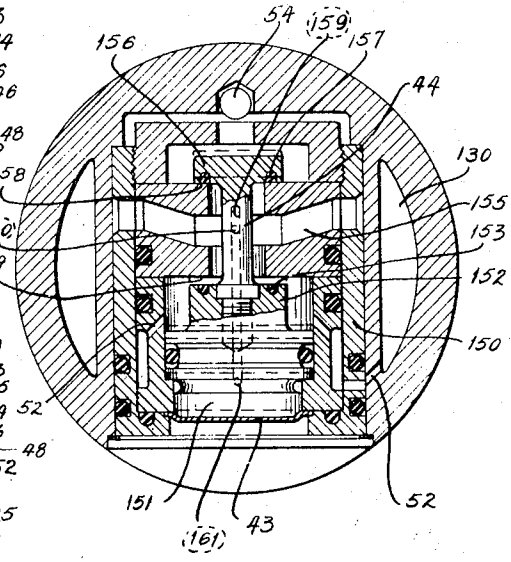


FIG. 4.



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FIG. 3.

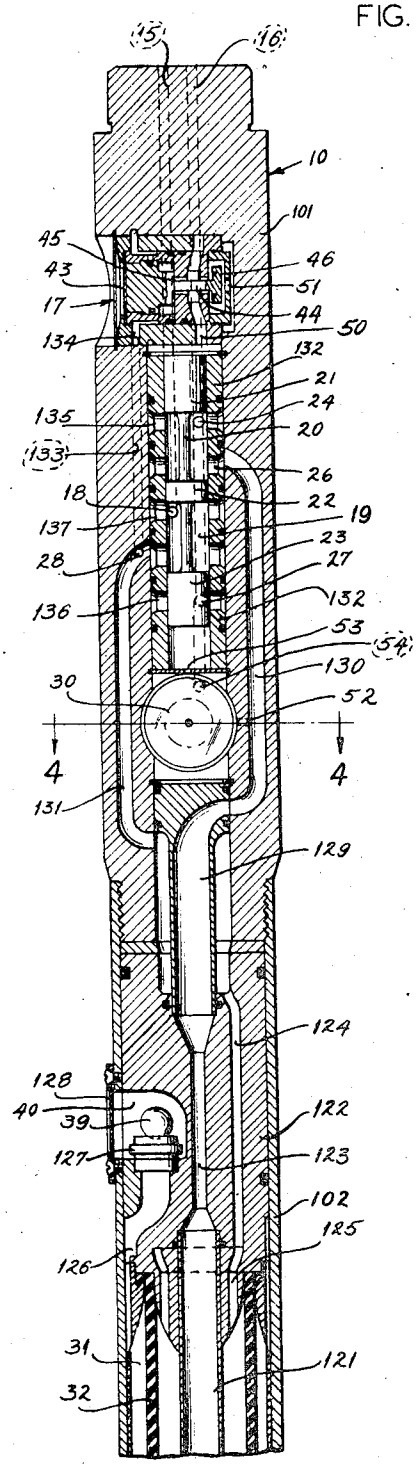
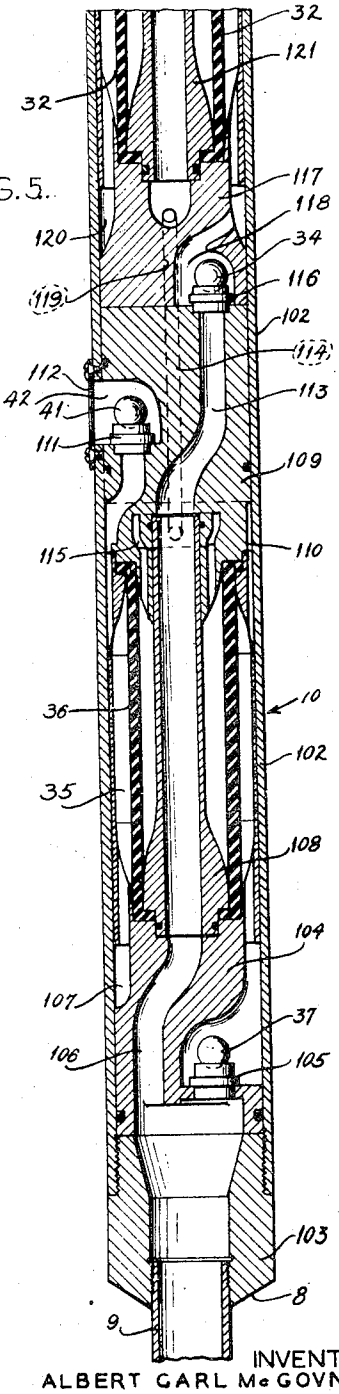


FIG. 5.



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OIL WELL PUMP

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Application March 25, 1946, Serial No. 656,910

12 Claims. (Cl. 103—46)

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This invention relates generally to the pumping of deep wells, such as oil wells, and has particular reference to a self-contained, electrically driven pumping arrangement adapted to pump oil wells without necessitating the running of tube lines from the bottom of the well to the surface of the ground.

While the conventional method of pumping oil wells involves the provision of a pump on the surface of the ground with tubing and sucker rods extending down through the bore hole to the producing formation, numerous efforts have been made to eliminate sucker rods. Such devices as have been suggested, however, have either not completely avoided the necessity of running tube lines to the surface of the ground or have been of such character that the pump was relatively short lived.

The object of the present invention, generally stated, is to provide a deep well pump adapted to be disposed near the bottom of the bore hole and having no physical connections with the surface of the ground save the electrical conductors for energizing the pump and perhaps a lifting cable.

A more specific object of the present invention is to provide a pumping arrangement so compactly coordinated that a long lived pump may be encased in a supporting structure receivable within the limited confines of a well casing.

Other objects will become apparent to those skilled in the art when the following description is read in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view showing the lower end of a deep well bore hole provided with a pump constructed in accordance with the present invention, it being understood that the illustration of Figure 1 is limited to that portion of the bore hole which is adjacent the producing formation;

Figure 2 is a view corresponding to Figure 1, but showing the operative parts of the pumping arrangement in the opposite position to that illustrated in Figure 1;

Figure 3 is a longitudinal sectional view of a practical embodiment of the upper portion of the pumping arrangement constructed in accordance with the present invention;

Figure 4 is a sectional view taken along line 4—4 of Figure 3; and

Figure 5 is a longitudinal sectional view of the lower extremity of the embodiment, the upper extremity of which is shown in Figure 3, it being understood that Figure 5 is a continuation of Figure 3.

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According to the present invention, an oil well or other comparable small bore deep well is pumped by an unitary electric motor and pump assembly which is lowered into the bore hole to near the producing formation, with electrical conductors, for supplying the motor, extending to the surface of the ground and energized by a suitable source. The invention contemplates that the producing formation be packed off with a suitable packer having a tube extending into the producing formation and that the pump assembly be in sealing engagement with the packer and tube so as to draw fluid from the producing formation through the tube without allowing fluid to pass by the packer in a downward direction.

In order that the pumping assembly be sufficiently compact that it can be emplaced in the well bore hole with clearance for up-flowing oil and without necessitating the running of tube lines from the bottom of the hole to the surface of the ground, the invention contemplates that a pair of oppositely acting pumps be arranged one above the other within a body whose overall diameter is sufficiently less than that of the casing of the well that ample clearance exists therebetween. In order to actuate the pumps without moving parts which would be difficult to accommodate within the limited confines of the bore hole, a fluid driving system, containing a fixed volume of working fluid such as clean lubricating oil, is provided. The working fluid system is completely closed so that the working fluid is maintained entirely separate from, and never commingles with, the crude oil being pumped. Consequently, all moving mechanical parts of the pumping apparatus are relieved of the deleterious action of sand, water, or other foreign matter with which the crude oil from the producing formation may be contaminated.

In such a fluid-driven pump system, the working fluid is forced out of the working side of one pump into the working side of the other and vice versa to move a movable wall of the respective pumps and thus expand and contract the working fluid sides of both pumps reciprocally. Concurrently with expansion of the working fluid side of a pump, the crude oil (or other pumping fluid) side of that pump is contracted and vice versa. Valves are, of course, provided to admit crude oil to the crude oil side of a pump as the working fluid side of that pump is contracting, and other valves release the crude from the pump as the working fluid side thereof expands.

In view of the impossibility of reversing the rotation of an electric motor without switches and

the desirability of eliminating the necessity for numerous conductors extending from the bottom of the well to the surface of the ground where such switches might be operated feasibly, this invention contemplates that the electric motor near the bottom of the well be rotated always in the same direction. Consequently, the impeller driven by the motor operates always in the same direction. To accomplish reversal of the direction of flow of working fluid between the respective pumps, valves are provided. A special feature of the invention is the control of such valves automatically by the differential between the hydrostatic head of crude oil on the apparatus and the fluid pressure within the working fluid system, pressure being allowed to build up on the working fluid in one pump until such pressure substantially exceeds (by for example 5 p. s. i.) the hydrostatic head of crude on the apparatus; thereupon the valves operate to reverse the flow of working fluid between the pumps until the working fluid in the opposite pump is under sufficient pressure (in excess of the hydrostatic head) to actuate the valves back to their original position. The cycle is then repeated.

In the embodiments to be described hereinafter, the movable walls which separate the working fluid side of each pump from the pumping fluid side thereof are in the form of expansible and contractible sleeves, but it will be understood that, so long as the wall is movable and yet capable of maintaining the integrity of the working fluid, any suitable wall may be utilized, such as a bellows, diaphragm, or piston.

Referring now to Figure 1 of the drawings for a diagrammatic illustration of the invention, a pump embodying the present invention is emplaced in the bore hole 1 of an oil well provided with a casing 2 extending down to near the producing formation 3. Seated upon the bottom of the bore hole 1 is a tube 4 perforated to admit oil from the formation to the interior thereof. The tube 4 is provided with a ball valve 5 resting upon a seat 6 and adapted to close upon the application of pressures from above. About the exterior of the tube 4 is a packer 7 of any suitable well known variety adapted to seat against the interior of casing 2 and effect a seal therewith. As shown in the drawings, the upper end of packer 7 is coned to receive the coned nose 8 of the pump assembly. The nose 8 of the pump assembly is also provided with a protuberance 9 adapted to pass through the packer 7 and approach ball 5 in such spaced relation that the latter has sufficient room to operate.

The pump assembly involves a cylindrical member 10 provided with a plurality of chambers, ducts, and valves so interconnected as to constitute a working system separate and apart from a pumping system. While in the diagrammatic illustration of Figures 1 and 2, the cylindrical member 10, which constitutes the housing of the entire pump assembly, is shown as one piece, it will be understood that for convenience in manufacturing it is preferred to fabricate the housing of a plurality of different pieces assembled together to constitute a composite cylindrical structure, as illustrated, for example, more in detail in Figure 3. The entire organization is energized by means of an axially elongated electric motor 11, which is relatively small in its radial dimension, so as to fit within the casing of an oil well and yet leave sufficient clearance about its periphery to permit the passage of oil upwardly through the casing. A cable 12 extends from the motor 11 to the surface of the ground where it is suitably connected to a source of electromotive power. The lower extremity of shaft 12' of motor 11 is provided with an impeller 13, so as to be driven by the motor, such, for example, as in the direction indicated by the arrow thereon. The impeller 13 is located in a chamber 14, which is provided with an outlet duct 15 and an inlet duct 16, it being understood that, in the embodiment illustrated, it is contemplated that the impeller 13 be rotated always in the same direction.

The outlet duct 15, after being deviated to by-pass a diaphragm-valve assembly 17, extends to a port 18 leading into a valve chamber 19. The valve chamber 19 is provided with a plunger 20 having three heads 21, 22, and 23, each in sealing engagement with the interior wall of chamber 19.

Similarly, the inlet duct 16 extends into communication with valve chamber 19 at port 24 and, after being deviated to by-pass a duct 25 leading from a port 26 in chamber 19, extends therebeyond to another port 27 into chamber 19. The chamber 19 is provided with a further port 28 leading to a duct 29, which, after being deviated to by-pass a diaphragm-valve assembly 30, extends to the interior of a pump chamber 31. The pump chamber 31 is provided with an elastic sleeve 32 having its ends sealed against the end walls of chamber 31, but having its interior in communication with duct 29. The space within sleeve 32 is closed, save for the duct 29, and constitutes a space for the reception of working fluid. The sleeve 32 may be constructed of any suitable resilient material which is resistant to oil, that is to say, will survive a great multiplicity of expansions and contractions while immersed in mineral oil. Any of a considerable variety of synthetic rubbers are suitable materials for the construction of sleeve 32, as, for example, a Buna N synthetic rubber known as "Hycar." Other such synthetic rubbers, such as butadiene or neoprene, may be utilized with equal advantage.

The exterior periphery of sleeve 32 is spaced from the interior periphery of chamber 31, so as to define an annular space therebetween constituting the crude oil or pumping fluid side of the pump. From the lower end of said space there extends a duct 33, controlled by a ball valve 34 adapted to close the port into duct 33 when pressure is applied within chamber 31. Duct 33 extends to the lower end of the pump assembly and communicates directly with the interior of protuberance 9 adjacent ball valve 5.

The duct 25, which, as mentioned hereinbefore, originates at port 26 of valve chamber 19, extends downwardly through the cylindrical body 10, deviating to by-pass the pump chamber 31 and finally terminates in a pump chamber 35. Pump chamber 35 is identical with pump chamber 31, previously described, being likewise provided with an elastic sleeve 36 and having a ball valve 37 controlling the port to the duct 38, which latter extends to the lower end of pump assembly and connects with the interior of protuberance 9.

At the upper end of the pumping fluid side of chamber 31, there is provided a ball valve 39 controlling a port leading into an exit passage 40. Suitable provision is, of course, made for retaining ball 39 in proximity to its seat with such freedom of movement as to cause the valve to be opened upon the application of pressures

within pump chamber 31. Similarly, pump chamber 35 is provided with a ball valve 41 controlling a port leading into exit passage 42.

Diaphragm-valve 17 is provided with an exterior flexible member 43 having its outer surface arranged to be in contact with, and consequently subject to the hydrostatic head of, the crude oil surrounding the exterior of the pump assembly. Extending from the diaphragm 43 is a stem 44 provided with a pair of tappets 45 and 46 arranged, respectively, to seal against seats 47 and 48, the former being closed and the latter being open when the hydrostatic pressure on the exterior of diaphragm 43 exceeds the hydrostatic pressure on the interior thereof. A duct 49 extends from duct 29, previously described, to the interior of diaphragm 43. From the chamber between seats 47 and 48, a duct 50 extends to the upper end of valve chamber 19. From the chamber adjacent tappet 46, a port 51 communicates with duct 16. Consequently, when the hydrostatic head acting on the exterior of diaphragm 43 is sufficiently in excess of the fluid pressure on the inside of the diaphragm, the valve 17 is actuated to the position shown in Figure 1, whereat tappet 45 is closed upon seat 47, but a passageway is open, from duct 16 to the upper end of chamber 19, through port 51, by tappet 46 and duct 50. The position of the parts shown in Figure 1 is that which they occupy immediately after actuation of the diaphragm-valve 17, while the position of the parts shown in Figure 2 is the opposite position of the parts to be described more in detail hereinafter.

Diaphragm-valve 30 is identical with diaphragm-valve 17 and the same reference characters are applied to the respective parts thereof save the ducts and ports. A duct 52 extends from duct 25, previously described, to the interior of diaphragm 43 of valve 30. A duct 53 extends from the lower end of valve chamber 19 to the chamber between the tappets of diaphragm-valve 30. A further duct 54 extends from duct 16 to the chamber adjacent tappet 46 of valve 30. In this instance, when the pressure of the fluid in duct 25 is substantially in excess of the hydrostatic head acting on the exterior of diaphragm-valve 30, the parts will be in the position shown in Figure 1.

With the apparatus thus described in detail from the diagrammatic illustration of Figure 1, it will be understood that, when the impeller 13 is being operated so as to force fluid out through duct 15, as indicated by the arrow therein, it will reach valve chamber 19 at port 18 and, with the plunger 20 in the position shown in Figure 1, will flow out of valve chamber 19, through duct 29, to the interior of sleeve 32. Continued flow of the fluid in this direction will expand the flexible sleeve 32 from its collapsed position, shown in full lines, to its expanded position, shown in dotted lines. During the expansion of sleeve 32, as just described, such crude oil from the formation 3 as was present in pump chamber 31 outside of sleeve 32, when the cycle began, will be forced outwardly past valve 39.

To supply the working fluid for forced expansion of sleeve 32, as just described, working fluid is drawn by impeller 13 from within sleeve 36 of pump chamber 35, through duct 25, port 26, valve chamber 19 (between heads 21 and 22), port 24, and duct 16, as indicated by the arrows in Figure 1. After this operation has continued for a time sufficient that enough working fluid has been withdrawn from pump chamber 35 to fully

expand sleeve 32 in pump chamber 31, a pressure will develop on that side of the working system, between chamber 31 and impeller 13, in excess of the hydrostatic head of the fluid on the exterior of the pump assembly. Such pressure will be communicated by duct 49 to the interior of diaphragm 43 of valve 17. When the pressure on the inside of diaphragm 43 of valve 17 sufficiently exceeds the surrounding hydrostatic head to actuate valve 17, the latter will move in a direction such as to close the passageway at tappet 46 and open the passageway at tappet 45. Such actuation of the valve changes the communication of the upper end of valve chamber 19 from the negative side of the system to the positive side thereof and thus a force is applied to the upper end of head 21 tending to move plunger 20 downwardly. When such movement of the plunger 20 has been accomplished, the parts will have assumed the position shown in Figure 2, where port 24 will have been closed by head 21, port 18 will have been opened to port 26 and duct 25, and port 28 will be in communication with port 27 and duct 16.

The parts having assumed the position illustrated in Figure 2, continued operation of the impeller 13, as previously, will force working fluid, as indicated by the arrows in Figure 2, from duct 15, through port 18, to port 26, through duct 25, to the interior of sleeve 36 in pump chamber 35, expanding the sleeve from the full line position shown in Figure 2 to the dotted line position therein, and concurrently forcing such oil as was sucked through duct 38 into chamber 35 (by the collapsing of sleeve 36), during the previous phase of the operation, outwardly past valve 41.

During the phase of the operations wherein the working fluid is being forced into pump chamber 35 to expand sleeve 36, as just described, working fluid is being drawn from within sleeve 32 of chamber 31, through duct 29, in the direction indicated by the arrows in Figure 2 to port 28, thence through port 27 to duct 16. During this phase of the operations, pressure is being built up in duct 25 and communicates through duct 52 to the interior of diaphragm 43 of valve 30. When such pressure has sufficiently exceeded the external hydrostatic pressure to actuate valve 39, duct 53 leading to the lower end of valve chamber 19 is thrown into communication with duct 52 and pressure from duct 25 is thence applied upon the lower end of head 23 of plunger 20 to actuate the latter upwardly, restoring the same to the position shown in Figure 1. The cycle of operations is then repeated.

Figure 3 of the drawings illustrates a practical embodiment of the present invention less the motor 11, the impeller 13, packer 7, and tube 4, which is to say that the device shown in Figure 3 involves an assembled structure including a system of valves, ducts, and cylinders corresponding in principle to that hereinbefore described in connection with Figures 1 and 2, but showing an arrangement of parts which may be manufactured with greater mechanical facility than the diagrammatic showing of Figure 1.

As shown in Figure 3, the counterpart of the cylindrical member 10 of the form shown in Figures 1 and 2 is represented by an upper member 101, an intermediate pipe 102, and a nose member 103, the same being assembled together by screw threads or otherwise, so as to provide a generally cylindrical barrel, within which the various parts of the valve, duct, and cylinder

arrangement are housed. The electric motor 11, with its adjunct impeller 13, is adapted to be suitably connected to the upper end of member 101.

In assembling the apparatus shown in Figure 3, a core piece 104, provided with a ball valve seat 105 arranged to accommodate the ball valve 37, hereinbefore referred to, and having a duct 106, is seated upon the upper surface of nose member 103, so that the duct 106 and the chamber leading to seat 105 are in communication with a central opening in nose 103 and protuberance 9, hereinbefore mentioned. The upper end of core piece 104 is circumferentially reduced, as shown at 107, in order to provide a communication with the chamber surrounding ball valve 37. The top surface of core piece 104 is shouldered to receive a rigid tube 108 and also flexible sleeve 36, the same being secured in hermetically sealed relation to the upper surface of core piece 104. The upper ends of sleeve 36 and tube 108 are likewise secured in hermetically sealed relation to a core piece 109, the exterior of which is reduced at its lower end, as shown at 110, in order to provide a channel of communication from the space within member 102 (but outside sleeve 36) to a valve seat 111 for the reception of ball valve 41. Adjacent ball valve 41, member 102 is provided with a window 112, across which a suitable screen or guard member may be provided for preventing the escape of ball 41.

The core piece 109 is provided with two distinct ducts 113 and 114 extending in a generally axial direction therethrough without intersecting the chamber surrounding ball valve 41. Duct 113 is connected to the hollow interior of tube 108, while duct 114 extends into communication with the space between the exterior of tube 108 and the interior of sleeve 36, the lower end of duct 114 being annular, as shown at 115. At the upper terminus of duct 113, core piece 109 is provided with a ball valve seat 116 for the reception of ball valve 34.

Seated upon the upper end of core piece 109 is a further core piece 117, which is hollowed out at 118 to provide a chamber surrounding ball valve 34 and also provided with a duct 119 for connection with duct 114 in core piece 109. The outer periphery of the upper end of core piece 117 is reduced, as shown at 120, to provide a communicating passageway from chamber 118 into the crude oil side of a pump chamber corresponding to chamber 31, described in connection with Figure 1. Seated in hermetically sealed relation upon the upper end of core piece 117 are parts 121 and 32, being duplicates, respectively, of parts 108 and 36, described above. The upper extremities of parts 121 and 32 are connected in hermetically sealed relation to the lower end of a core piece 122, which is provided with two separate axially extending ducts 123 and 124, the lower end of the latter being annular, as shown at 125, and communicating with the space between sleeve 32 and tube 121. Duct 123 connects with the interior of tube 121. Core piece 122 is exteriorly reduced at its lower end, as shown at 126, to provide a channel of communication to the ball valve seat 127, upon which ball valve 39 operates. Adjacent ball valve 39, member 102 is provided with a window 128 having a screen or guard suitable for preventing the escape of ball 39.

In hermetically sealed engagement with the upper end of core piece 122, and communicating with duct 123, is a tube 129 extending within a central bore of member 101. As shown, the tube

129 is of less diameter at its lower end than the central bore of member 101, so as to provide an annular channel about the exterior of tube 129 communicating with duct 124 in core piece 122. The upper end of tube 129 communicates with a duct 130 in member 101. Member 101 is provided with another duct 131, which communicates with the annular channel surrounding tube 129. Immediately above tube 129, the diaphragm-valve 30 is inserted in member 101 and above the latter a valve sleeve 132 is inserted in the central bore of member 101 for the reception of, and cooperation with, plunger 20. The sleeve 132, therefore, defines the valve chamber, designated as 19 in Figures 1 and 2. An auxiliary duct 133 extends upwardly from duct 131 parallel with the central bore in member 101 to a chamber 134 for the reception of diaphragm-valve 17.

Member 101 is also provided with ducts 15 and 16, which, in the preferred construction, extend in a generally axial direction on opposite sides of the diameter along which sectional view of Figure 3 is taken, but, for clearness of illustration, are shown in dotted lines as on the same side of said diameter. Duct 16 has its port 24 opening in alignment with ports 135 of sleeve 132. Said duct 16 has its lower port 27 opening in alignment with port 136 of sleeve 132. Duct 15 has its port 18 opening in alignment with port 137 of sleeve 132.

In order to facilitate an understanding of the manner in which the embodiment shown in Figure 3 corresponds in principle to the diagrammatic showing of Figures 1 and 2, the various fluid circuits will now be traced, it being understood that, when the same reference characters occur on Figures 1 and 3, identical parts are indicated. The inlet and outlet ducts 15 and 16, with their respective ports 18, 24, and 27, are indicated by the same reference characters on Figure 3. The duct 29 of Figure 1 has its counterpart in duct 131 of member 101, the annular space surrounding tube 129, and duct 124 in core piece 122.

The duct 25, shown in Figure 1, has its counterpart in duct 130 of member 101, the interior of tube 129, duct 123 in core piece 122, the interior of tube 121, duct 119 through core piece 117, and duct 114 through core piece 109.

The crude oil supply duct 33 of the form shown in Figure 1 for supplying crude to pump chamber 31 has its counterpart in the Figure 3 embodiment consisting of duct 106 in core piece 104, the interior of tube 108, and duct 113 through core piece 109. Thus it will be seen that a tube passing centrally through the respective pump chambers of the apparatus contributes to the compactness of the device and enables the supply of crude to the upper pump chamber centrally through the lower pump, while maintaining the integrity of the working fluid system in the latter. Conversely, working fluid for the lower pump chamber is supplied centrally through the upper pump chamber.

Referring now to Figure 4 of the drawings, the diaphragm-valves of the character utilized at 17 and 30 are shown in detail and consist of a case 150 having a centrally open flanged outer end. Hermetically sealed upon the flanged outer end of case 150 is the diaphragm 43 and resting against the interior thereof is a follower 151 mounted upon a stem 44. Associated with follower 151 is a shoulder 152 having a packing ring 153 adapted to seat against a shoulder 154 of an intermediate member 155 fixedly mounted within case 150. The shoulder 152, with its pack-

ing ring 153, therefore, constitutes the counterpart of tappet 45, referred to in connection with Figures 1 and 2. At the opposite end of stem 44 is a head 156 having a packing ring 157 adapted to seat against a shoulder 158 of member 155 and constituting the counterpart of tappet 46, described in connection with Figure 1. Stem 44 is provided with a central bore 159 having an orifice 160 communicating with the central chamber of member 155 and another orifice 161 communicating with a groove about follower 151, so as to maintain a sealing film of oil. As previously indicated, ducts 52 effect communication between duct 130 and the space surrounding shoulder 152, so that, as the pressure in duct 130 increases, follower 151 will be forced in a downward direction to bulge diaphragm 43 outwardly, as shown.

From the foregoing description, those skilled in the art should understand the construction, operation, the principle of the pumping arrangement of the present invention and realize that it provides an efficient mode of pumping deep wells without necessitating the running of tube lines or mechanical connections from the bottom of the well to the surface of the ground, and further that it provides an apparatus which may be safely and conveniently located thousands of feet below the surface of the ground without requiring frequent removal for replacement and repair of moving parts because, as hereinbefore indicated, the only mechanical moving parts of the apparatus are confined within the working fluid system, which is totally closed, and, assuming that the working fluid is free of contaminant when the apparatus is lowered into the well, no wear by abrasion or corrosion will be encountered.

While the invention has been disclosed with reference to diagrammatic showings, as well as a complete practical embodiment, it is realized that those skilled in the art will envision divers modifications and variations of the specific arrangement of parts which has been described without departing from the spirit of the invention. It is, therefore, to be distinctly understood that the invention is not limited to the specific arrangement of parts described.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. A deep well pump comprising an axially elongated body having a diameter less than the bore hole of the well, a pair of oppositely acting pumps arranged in axially displaced relation in said body; each of said pumps having a chamber for pumping fluid, a chamber for working fluid, and a movable wall separating the pumping fluid from the working fluid; fluid conduits interconnecting the working fluid chambers of said pumps, said working fluid chambers and conduits constituting a closed system containing a fixed volume of working fluid; powered means located in one of said conduits for forcing circulation of working fluid through said conduits; and valves controlling the flow of pumping fluid.

2. A deep well pump comprising an axially elongated body having a diameter less than the bore hole of the well, a pair of oppositely acting pumps arranged in axially displaced relation in said body; each of said pumps having a chamber for pumping fluid, a chamber for working fluid, and a movable wall separating the pumping fluid from the working fluid; fluid conduits interconnecting the working fluid chambers of said pumps, said working fluid chambers and conduits constituting a closed system containing a fixed volume of working fluid; valves controlling the flow of pumping fluid, means in said body for circulating fluid in said system, and means for reversing the direction of flow of working fluid in and out of said working fluid chambers.

3. A deep well pump comprising an axially elongated body having a diameter less than the bore hole of the well, a pair of oppositely acting pumps arranged in axially displaced relation in said body; each of said pumps having a chamber for pumping fluid, a chamber for working fluid, and a movable wall separating the pumping fluid from the working fluid; fluid conduits interconnecting the working fluid chambers of said pumps, said working fluid chambers and conduits constituting a closed system containing a fixed volume of working fluid; valves controlling the flow of pumping fluid, means in said body for circulating fluid in said system, and means responsive to the hydrostatic head of fluid without the body for reversing the direction of flow of working fluid in and out of said working fluid chambers.

4. A deep well pump comprising an axially elongated body having a diameter less than the bore hole of the well, a pair of oppositely acting pumps arranged in axially displaced relation in said body; each of said pumps having a chamber for pumping fluid, a chamber for working fluid, and a collapsible and expansible tubular wall separating the pumping fluid from the working fluid; fluid conduits interconnecting the working fluid chambers of said pumps, powered means located in one of said conduits for forcing circulation of working fluid through said conduits, said working fluid chambers and conduits constituting a closed system containing a fixed volume of working fluid; and valves controlling the flow of pumping fluid.

5. Apparatus for pumping oil wells comprising a packer sealing the interior of the well above the producing formation, a tube extending through the packer into the producing formation, a pair of oppositely acting pumps located adjacent said packer; each of said pumps having a crude oil supply conduit communicating with said tube and a crude oil discharge opening above the packer; each of said pumps having a movable imperforate wall one side of which is in fluid communication with the supply conduit and discharge opening therefor, and the other side of said wall being connected to a working fluid supply duct; and means adjacent said pumps for circulating working fluid from one pump into the other and alternately reversing the direction of circulation between said pumps.

6. Apparatus for pumping oil wells comprising a packer sealing the interior of the well above the producing formation, a tube extending through the packer into the producing formation, a pair of oppositely acting pumps arranged one above the other adjacent said packer, working fluid circulating means arranged adjacent said pumps; each of said pumps having an imperforate resilient tubular wall separating the same into a crude oil side and a working fluid side; ducts interconnecting the working fluid sides of said pumps and extending to said circulating means, the working fluid duct to the lowermost pump extending axially through the tubular wall of the uppermost pump.

7. Apparatus for pumping oil wells comprising a packer sealing the interior of the well above the producing formation, a tube extending

through the packer into the producing formation, a pair of oppositely acting pumps arranged one above the other adjacent said packer, working fluid circulating means arranged adjacent said pumps; each of said pumps having an imperforate resilient tubular wall separating the same into a crude oil side and a working fluid side; ducts connecting the crude oil side of the respective pumps with said tube; the crude oil duct for the uppermost pump extending axially through the tubular wall of the lowermost pump.

8. A pump of the character described for operation near the bottom of a column of fluid comprising, a cylindrical barrel having an electric motor at the upper end thereof arranged for rotation about an axis extending longitudinally of the barrel, an impeller driven by said motor, a pair of pumps having movable walls, ducts interconnecting one side of the movable wall in each of said pumps with said impeller to constitute a completely closed working fluid system, and valves controlling the direction of fluid flow in said system, so that when one pump is being charged with working fluid the other pump is being discharged.

9. A pump of the character described for operation near the bottom of a column of fluid comprising, a cylindrical barrel having an electric motor at the upper end thereof arranged for rotation about an axis extending longitudinally of the barrel, an impeller driven by said motor, a pair of pumps having movable walls, ducts interconnecting to said pumps and impeller to constitute a completely closed working fluid system, valves controlling the direction of fluid flow in said system so that when one pump is being charged with working fluid the other pump is being discharged, said valves including a valve responsive to the differential between the hydrostatic head of said column of fluid and the working system pressure upon a pump to reverse the direction of fluid flow in said system.

10. A pump of the character described for operation near the bottom of a column of fluid comprising, a cylindrical barrel having an electric motor at the upper end thereof arranged for rotation about an axis extending longitudinally of the barrel, an impeller driven by said motor, a pair of pumps having movable walls, ducts interconnecting to said pumps and impeller to constitute a completely closed working fluid system, valves controlling the direction of fluid flow in said system so that when one pump is being charged with working fluid the other pump is being discharged, said valves including a slide valve having one end selectively connectable to receive the working system pressure in one pump, the other end of said slide valve being selectively connectable to receive the working system pressure in the other pump, and means responsive to predetermined working system pressure within said pumps respectively to selectively connect an end of said slide valve to receive such pressure.

11. A pump of the character described for operation near the bottom of a column of fluid comprising, a cylindrical barrel having an electric motor at the upper end thereof arranged for rotation about an axis extending longitudinally of the barrel, an impeller driven by said motor, a pair of pumps having movable walls, ducts interconnecting to said pumps and impeller to constitute a completely closed working fluid system, valves controlling the direction of fluid flow in said system so that when one pump is being charged with working fluid the other pump is being discharged, said valves including a slide valve having one end selectively connectable to receive the working system pressure in one pump, the other end of said slide valve being selectively connectable to receive the working system pressure in the other pump, and means responsive to substantial excess of working system pressure on one pump above the hydrostatic head of the column of fluid to selectively connect an end of said slide valve to receive such pressure.

12. A pump of the character described for operation near the bottom of a column of fluid comprising, a cylindrical barrel having an electric motor at the upper end thereof arranged for rotation about an axis extending longitudinally of the barrel, an impeller driven by said motor, a pair of pumps having movable walls, ducts interconnecting to said pumps and impeller to constitute a completely closed working fluid system, valves controlling the direction of fluid flow in said system so that when one pump is being charged with working fluid the other pump is being discharged, said valves including a slide valve having one end selectively connectable to receive the working system pressure in one pump, the other end of said slide valve being selectively connectable to receive the working system pressure in the other pump, means responsive to excess of working system pressure on one pump to selectively connect one end of said slide valve to such pressure, and means responsive to excess of working system pressure on the other pump to selectively connect the opposite end of said slide valve to such pressure.

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