

Dec. 28, 1954

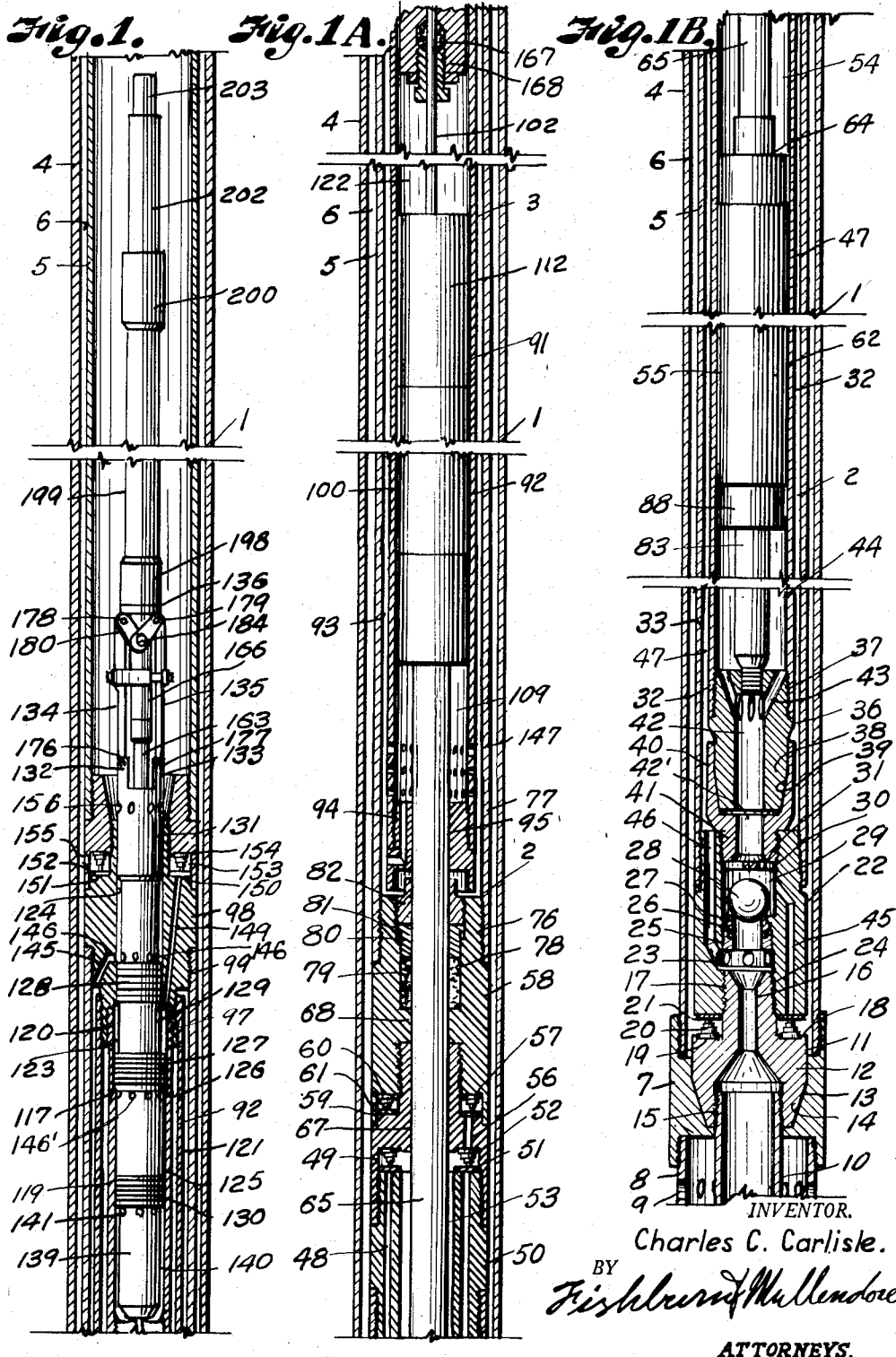
C. C. CARLISLE

2,697,985

WELL PUMP AND OPERATING MECHANISM THEREFOR

Filed Dec. 7, 1951

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Dec. 28, 1954

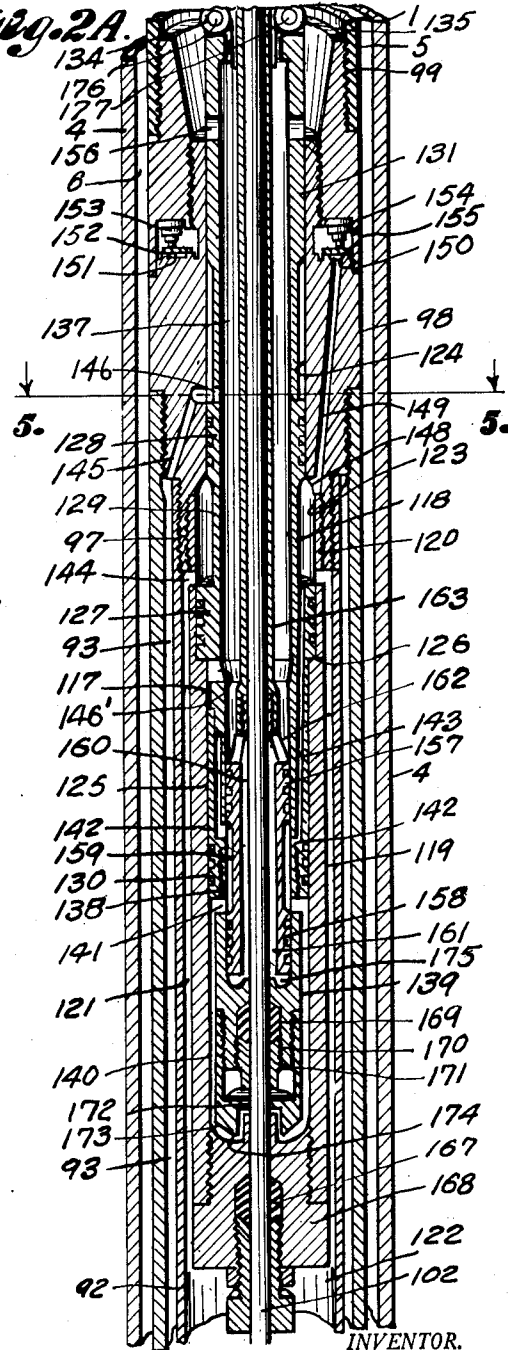
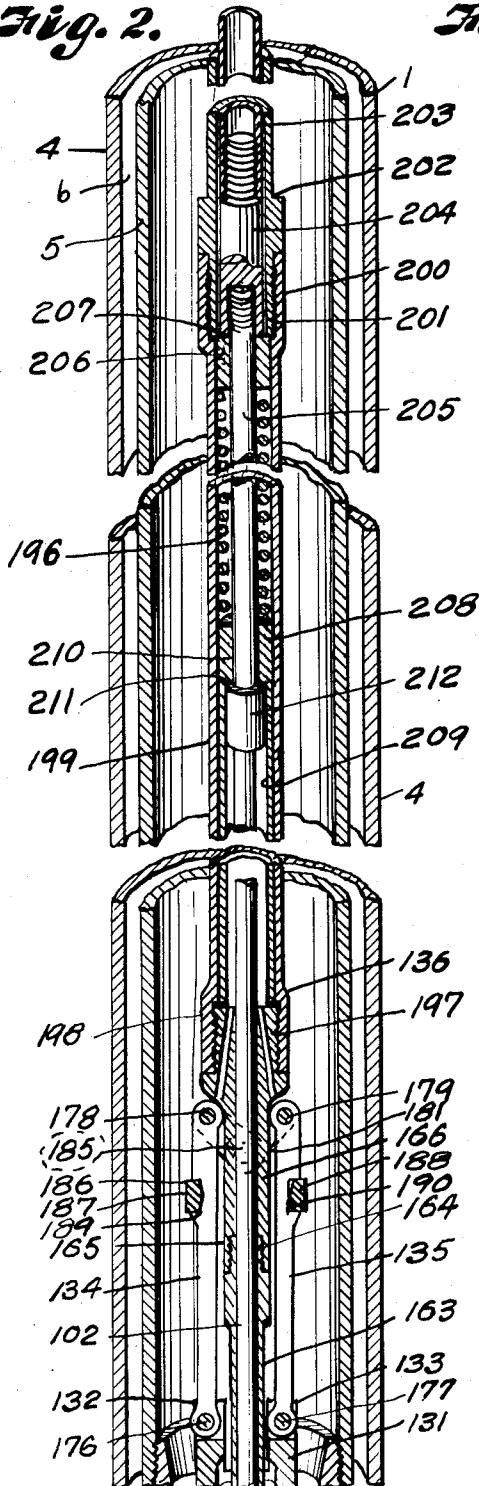
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5 Sheets-Sheet 2



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Fig. 2B.

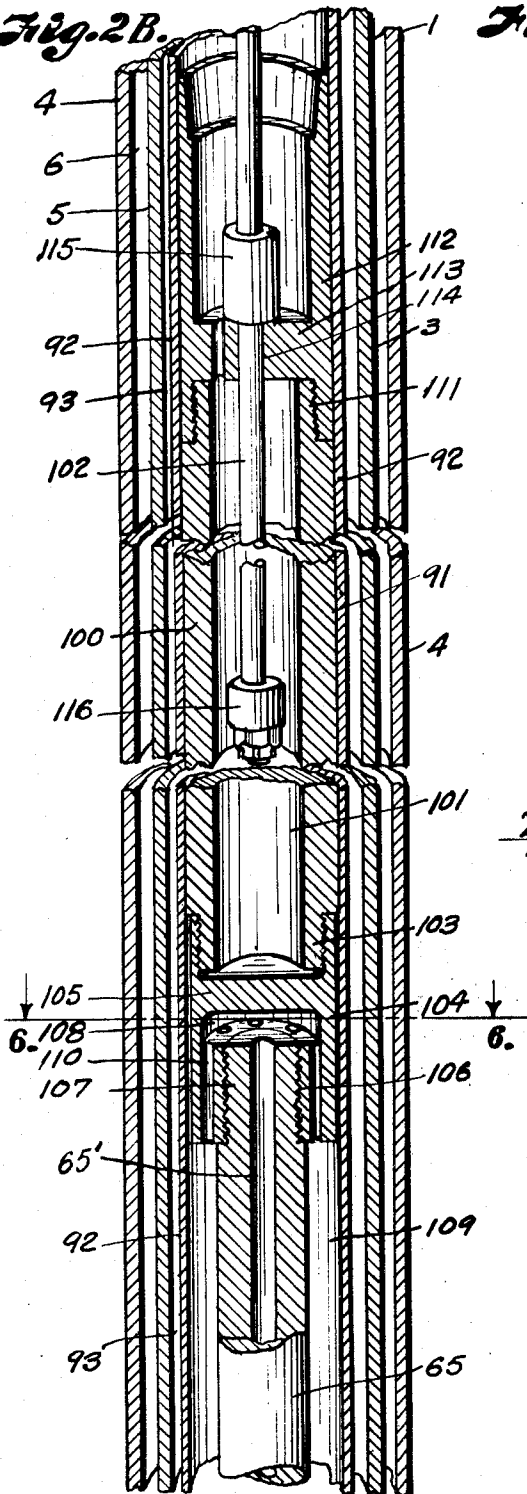
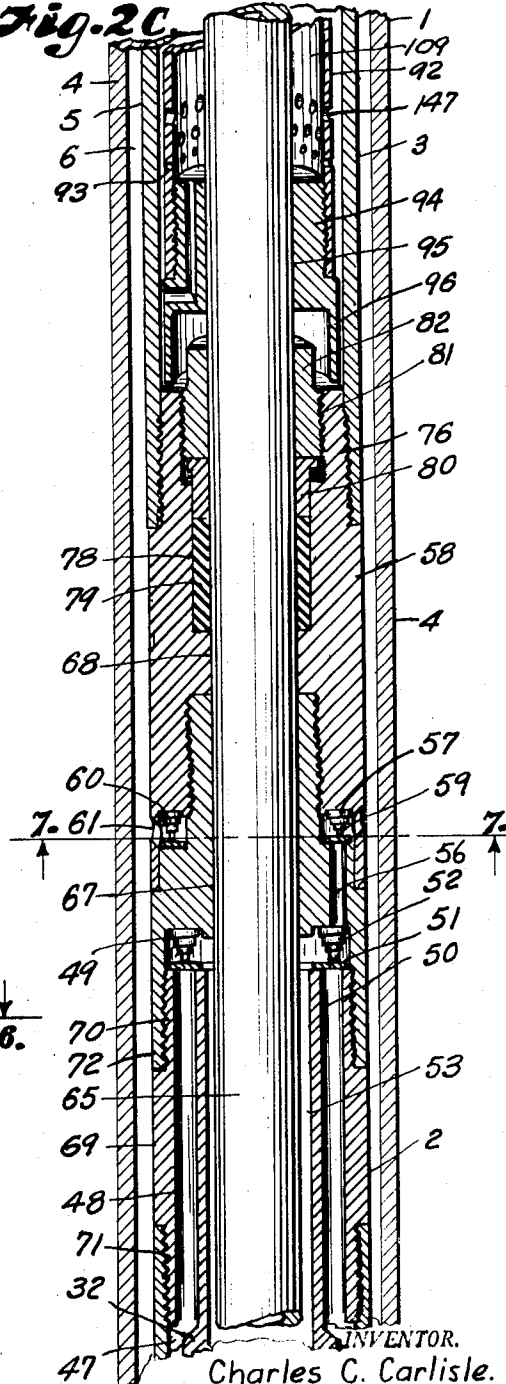


Fig. 2C.



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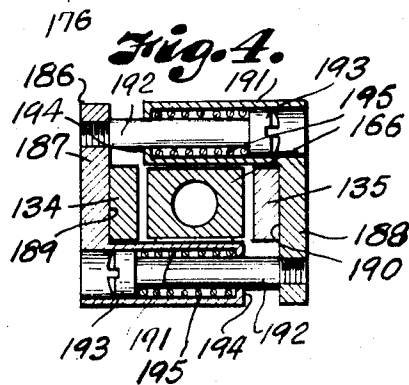
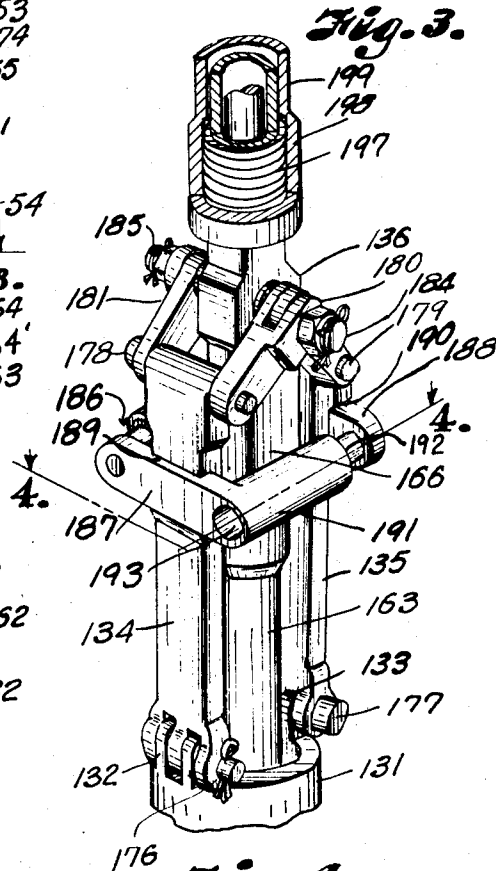
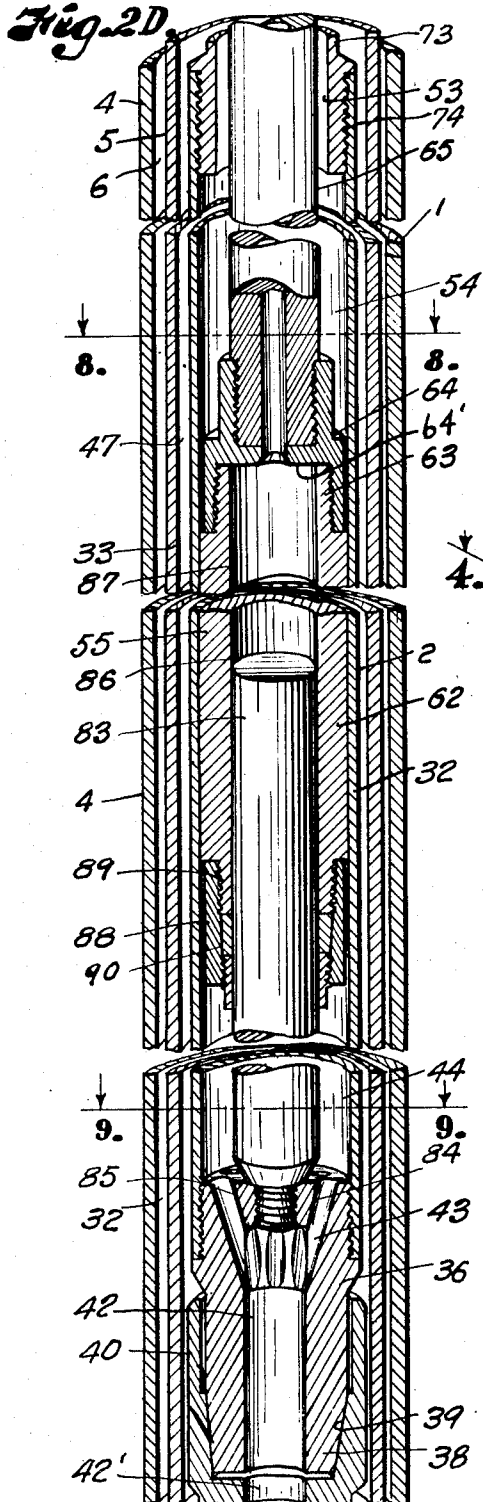
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5 Sheets-Sheet 4



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Fig. 5.

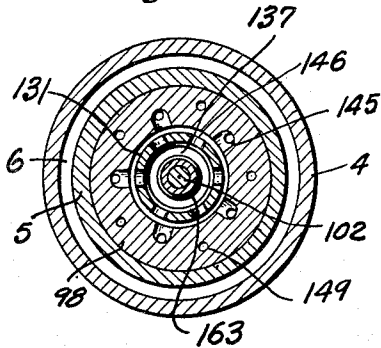


Fig. 8.

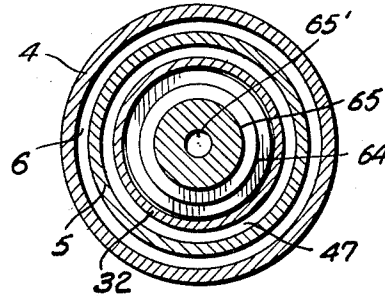


Fig. 6.

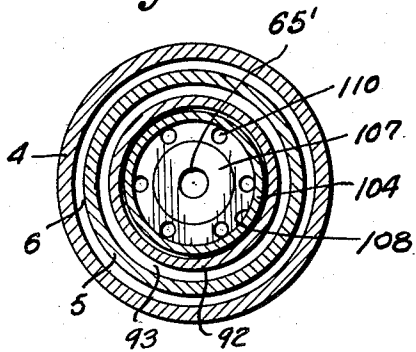


Fig. 9.

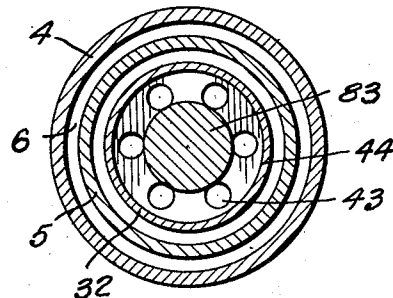
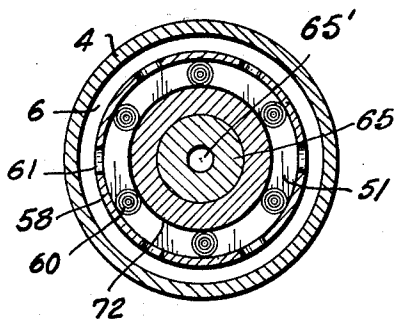


Fig. 7.



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2,697,985

WELL PUMP AND OPERATING MECHANISM THEREFOR

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Application December 7, 1951, Serial No. 260,454

13 Claims. (Cl. 103—44)

This invention relates to pumps for removing fluids from wells particularly where the fluids are to be lifted from substantial depths, the present invention being an improvement over the pumping apparatuses disclosed in Patent No. 2,118,547 issued to me May 4, 1938, for "Deep Well Motor" and Patent No. 2,287,779 issued to me June 13, 1942, for "Deep Well Pumping Mechanism." Pumps of the character disclosed in the patents are very desirable for lifting fluids from great depths for the reason that the actuator or power unit which operates the pump piston is located within the well and connected with the pump unit by a short mechanical linkage. Therefore, rod problems of deep well pumps are eliminated. The pumps also have the advantage in that they effect lift of the well fluid on both the up and down stroke of the pump piston. However, the pumps of the patents cannot produce a constantly uniform volumetric flow of the well fluid to the top of the well because of differential effective areas at the respective ends of the power piston and different volumetric capacities of the upper and lower pump chambers.

It is therefore the principal object of the present invention to provide a pump structure which overcomes these inherent inefficiencies of pumps disclosed in the patents by providing substantially the same effective areas at the respective ends of the power piston and substantially the same volumetric displacement of the well fluid from the respective pump chambers.

Other objects of the invention are to provide for smoother acting power and pump units; to provide a more positive operation of the automatic control mechanism and thereby eliminate possibility of the pump stopping on "dead center position"; and to provide a power and pump unit having greater over-all efficiency relatively to the volume of power fluid required to operate the power unit.

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

Figs. 1, 1A and 1B illustrate the upper, mid and lower portions of a well pumping apparatus including power and pump units constructed in accordance with the present invention and shown installed within a well.

Figs. 2, 2A, 2B, 2C and 2D are enlarged vertical sections through the pumping apparatus.

Fig. 3 is a perspective view of the toggle mechanism of the automatic control apparatus.

Fig. 4 is a cross section on the line 4—4 of Fig. 3.

Fig. 5 is a cross section on the line 5—5 of Fig. 2A.

Fig. 6 is a cross section on the line 6—6 of Fig. 2B.

Fig. 7 is a cross section on the line 7—7 of Fig. 2C.

Fig. 8 is a cross section on the line 8—8 of Fig. 2D.

Fig. 9 is a cross section on the line 9—9 of Fig. 2D.

Referring more in detail to the drawings:

1 designates a pumping apparatus constructed in accordance with the present invention and includes a pump unit 2, and a closely coupled actuator or power unit 3 adapted to be located within the lower portion of a well, indicated by the casing or tubing 4 that extends from near the bottom of the well to above ground and co-operates with an innerflow tubing 5 in forming an annular upflow duct 6 for the well liquid to be lifted. The lower end of the tubing 4 is connected by a collar 7 with a gas anchor 8 that is supported on the bottom of the well and is provided with suitable apertures 9 through which the well fluid flows into the gas anchor for upflow through

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an inlet tube 10 that depends from standing valve cage 11 of the pump.

The standing valve cage 11 includes a lower section 12 having an annularly tapered lower end 13 to removably seat within an internal annular taper 14 of the collar 7 and form a seal between the well gas anchor 8 and the tubing 4. The standing valve cage has an internally threaded axial bore 15 into which the upper end of the inlet tube 10 is threaded to connect with an upper reduced extension 16 of the bore. The extension 16 of the bore is formed within a reduced neck 17 of the section 12 to provide an annular shoulder 18 having a circular series of spring seats 19 for springs 20 of a valve ring 21.

The upper section 22 of the standing valve cage has an axial bore 23 that is internally threaded as at 24 to connect with external threads on the neck 17 of the lower section. Inset within the bore 23 is a ring 25 for retaining a valve seat 26 against an internal annular shoulder 27. The seat 26 mounts a ball valve 28 contained within a valve chamber 29 that is provided within the upper portion of the bore between the shoulder 27 and a transverse guard 30 having suitable openings 31 for passing well fluid into and out of the lower end of the pump unit. The pump unit, like those of the above mentioned patents, is of the double acting type so as to effect lift of the well fluid upon both up and down strokes of the pump piston. The pump unit of the apparatus includes a pump cylinder 32 that is connected within the lower end tubing 5, previously referred to. The lowermost end of the upflow passage 6 has its inner side formed by a tubing 33 that is connected with the upper cage section 22.

The pump cylinder has a lower head 36 threadedly connected therewith as indicated at 37. The head has a reduced exteriorly tapered portion 38 which removably engages within a tapered seat 39 of a seat member 40 having a reduced neck portion 41 threadedly connected with the upper end of the upper valve cage section 22. The parts 36 and 40 have registering bores 42 and 42' that connect the openings 31 with channels 43 leading to the lower end of the pump chamber 44 and through which the well fluid is drawn into and discharged from the lower end of the pump cylinder as later described.

Formed in the section 22 of the standing valve cage, in encircling relation with the bore thereof, is a series of ports 45 extending through the lower end thereof to pass fluid discharged from the lower chamber of the pump cylinder and which connect with the upflow passageway 6, the outlets being controlled by the valve ring 21.

Located intermediate the ports 45 are ports 46 that connect with the axial bore 25 below the valve 28. The upper ends of the ports 45 extend through the upper end of the cage section 22 and connect with an annular passageway 47 that is formed between the pump cylinder 32 and the tubing 33. The upper end of the passageway 47 connects through ports 48 with a valve chamber 49 in the upper pump head 50, the ports being controlled by a valve ring 51 contained within the annular valve chamber 49 and normally seated by springs 52. The upper head 50 has an axial bore 53 to pass the well fluid from the valve chamber into the upper pump chamber 54. Slidable within the pump cylinder and separating the upper pump chamber from the lower pump chamber is a piston 55 which is reciprocated by the power unit as later described. The well fluid is discharged from the upper pump chamber through ports 56 that connect the valve chamber 49 with an upper valve chamber 57 that is formed between the upper cylinder head 50 and the lower head 58 of the power unit. The ports 56 are controlled by a valve ring 59 that is seated by springs 60 as shown in Fig. 2C. The valve chamber 57 has outlet to the upflow passageway 6 through ports 61.

The pump piston 55 includes a cylindrical body 62 closely fitting within the pump cylinder to provide a sliding fit and fluid-tight seal. The upper end of the piston body has reduced exteriorly threaded neck 63 that mounts a piston rod coupling 64 to connect a piston rod 65 (Fig. 2D). The piston rod is reciprocable through registering bores 67 and 68 in the upper head of the pump and the lower head of the power unit.

The cylinder head 50 is preferably composed of a cylindrical body section 69 provided with reduced externally

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threaded ends 70 and 71 to connect with the upper end of the tubing 33 which surrounds the pump cylinder and a lower skirt portion 72 of a part of the head in which the outlet ports 56 are formed. The end portion 71 has a reduced depending extension 73 that is externally threaded for connecting the upper end of the pump cylinder as indicated at 74. The lower head of the power cylinder has a reduced externally threaded neck 76 to which a section of tubing 77 of the tubing 5 connects. Formed within the neck portion of the upper section is a socket 78 for receiving a packing element 79 and which is retained in sealing contact with the piston rod by a packing gland 80 that is contained in a counterbore 81 by a nut 82.

It is obvious that when the piston 55 is moved upwardly within the pump cylinder 32, well fluid is drawn into the inlet tube 10, bores 16 and 25, past the ball valve 28 and through the openings 31, bores 42 and 42' and channels 43 into the lower end of the pump cylinder to fill the lower pump chamber 44. Simultaneously, upward movement of the piston discharges well fluid from the upper pump chamber 54 through the passageway 53 surrounding the piston rod 65, valve chamber 49 and ports 56 to unseat the valve ring 59 and pass into the upper valve chamber 57 for discharge through the ports 61 into the upflow passageway 6. On the downward movement of the pump piston 55, the ball valve 28 seats and the valve ring 21 unseats so that the fluid trapped below the piston 55 is discharged into the upflow passageway 6. Well fluid is thus lifted on both the up and down stroke of the pump piston.

From the structure thus far described, it is obvious that the space in the upper pump chamber 54 is restricted by the piston rod 65, and since the piston rod 65 must be of relatively large cross section to withstand the compression and tension stress thereon, the fluid capacity of the upper pump chamber is substantially less than the fluid capacity of the lower pump chamber. Therefore, more fluid would be displaced by the pumps of the patent on the downstroke than on the upstroke. As above stated, it is a principal object of the present invention to overcome this difficulty by providing equal capacities for the upper and lower pump chambers. This is effected by providing a standing piston or rod 83 having a length substantially corresponding with half the length of the pump cylinder and providing a displacement within the lower pump chamber substantially corresponding with the displacement caused by the pump rod 65 and which forms a guide rod over which the piston is adapted to operate.

The rod 83 is mounted coaxially of the pump cylinder and as stated has a cross sectional area conforming with the cross sectional area of the piston rod. The stationary rod is mounted on the lower cylinder head 36 and has a reduced threaded end 84 turned within a threaded opening 85 of the lower cylinder head as clearly shown in Figs. 1B and 2D. The stationary rod extends upwardly coaxially of the pump cylinder and is of sufficient length so that when the piston is at the top of its stroke, the free end portion 86 of the stationary rod is contained within an axial bore 87 of the pump piston as best shown in Fig. 2D.

A fluid-tight seal is maintained about the stationary rod by a nut or collar 88 that is threaded on a depending neck 89 of the piston and contains a packing 90. With this arrangement it is obvious that both pump chambers comprise annular spaces between the pump cylinder and the respective pump and stationary rods of equal capacities so that the amount of well fluid drawn into the respective pump chambers is substantially equal and equally displaced therefrom incidental to operation of the piston 55. Consequently, the volumetric flow of the well fluid through the upflow duct is continuous and uniform as long as the power piston of the power unit operates with the same relative speeds on the up and down strokes of the respective pistons.

The power unit includes a power piston 91 that is reciprocally mounted within a power cylinder 92. The power cylinder 92 is contained within the tubing 5 and the wall of the power cylinder is spaced inwardly thereof to provide an annular flow passageway 93. The lower end of the power cylinder is closed by a plug 94 that is threaded therein and provided with an axial bore 95 to pass the piston rod 65. The plug 94 has an annular skirt portion 96 encircling the packing nut 82 and which seats on the upper end of the part 58.

The power cylinder extends upwardly within the tubing 5 and connects with an externally threaded skirt 97 of an

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upper head 98 and to which the tubing section 92 also connects. The upper end of the head 98 in turn connects with the lower end of the well tubing 5 as indicated at 99.

The pump piston includes an elongated central body portion 100 closely fitting within the pump cylinder and having an axial bore 101 for accommodating a trip rod 102. The lower end of the piston body has a reduced externally threaded neck 103 on which is mounted a coupling 104 having a transverse web 105 closing the lower end of the bore 101 and which forms an abutment for the pressure fluid admitted to the upper end of the pump cylinder to effect downward movement of the pump piston. The coupling 104 has a threaded socket 106 mounting the upper threaded end 107 of the pump rod 65 as best shown in Fig. 2B. The coupling is formed to provide a space 108 between the transverse partition 105 and the end of the rod 65. This space 108 is connected with a lower chamber 109 of the power cylinder through ports 110 for a purpose later described.

The upper end of the central body of the power piston is provided with a reduced externally threaded neck 111 mounting a piston head 112. The piston head 112 is formed with a transverse partition 113 and which is provided with an axial opening 114 to pass the trip rod 102 therethrough as shown in Fig. 2B. The trip rod 102 has spaced collars 115 and 116 fixed thereon and which are adapted to be alternately engaged by the respective sides of the partition 113 when the piston is reciprocated responsive to control flow of pressure fluid under action of a valve mechanism 117 which substantially conforms to the valve structure disclosed in the above number Patent 2,287,779 for controlling flow and discharge of pressure fluid from upper and lower chambers of the power cylinder.

The valve mechanism comprises a main valve assembly 118 and which is described in detail in Patent No. 2,287,779. The main valve assembly is contained within a valve housing 119 which comprises a cylindrical tube having its upper end 120 threadedly engaged with threads on the inner side of the skirt portion 97 of the head 98 so that the housing depends within the tubing 92 to provide an annular passageway 121 extending the length of the housing and directly connected with the upper power chamber 122. The interior of the valve housing and head 98 provide a cylindrical valve chamber 123 which cooperates with an upper valve chamber 124 formed in the upper head 98.

The valve housing also has a lower cylindrical valve chamber 125. The valve chamber 125 is of smaller diameter than the valve chamber 123 and provides an annular shoulder 126 for seating the valve assembly in one position thereof. The valve assembly includes a main piston-like portion 127 which is slidably contained within the valve chamber 123 and connected with a piston-like valve portion 128 contained in the valve chamber 124, the piston portions being connected by a reduced sleeve portion 129. The main valve assembly also includes a lower piston-like portion 130 of smaller diameter and contained within the lower valve chamber 119 as shown in Fig. 2A. Extending upwardly from the main piston portion 128 is a sleeve portion 131 having spaced ears 132 and 133 (Fig. 3) to which toggle levers 134 and 135 are connected.

The main valve has a longitudinal bore 137 that has a reduced portion 138 extending downwardly within the piston portion 130. The lower piston portion 130 has a reduced extension 139 that operates with the lower bore of the valve housing to form an annular vertical passage 140 that connects with the pilot valve chamber through ports 141. The ports 141 are adapted to be connected with ports 142 leading to channels 143 that extend upwardly through the main valve body to connect with the valve chamber 123. The passageway 121 connects at its upper end with the valve chamber 123 through ports 144 that are under control of the piston portion 127 of the main valve while the lower end of the passageway 121 connects with the upper end of the power chamber 122. The annular flow passageway 93 extends upwardly and connects with channels 145 that have ports 146 opening into the upper valve chamber 124, the ports being under control of the upper piston portion 128. The lower end of the passageway 93 connects with the lower end of the power chamber 109 through ports 147 which are arranged in vertically spaced annular series with the

upper series being of larger diameter than the lower series for the purpose later described. The main valve also has ports 146' located directly below the piston portion 127 which supply pressure fluid to the passageway 121.

The upper valve chamber also has ports 148 that connect through channels 149 with ports 150 in an annular valve seat 151. The ports 148 are under control of the piston portion 128 of the main valve while the ports 150 are controlled by a ring-shape valve 152 that is yieldingly retained on the seat by springs 153 that are contained in an annular chamber 154 which is connected with the upflow passageway or duct 6 through ports 155.

The upper end of the pilot valve chamber is supplied with pressure fluid through the annular space around the rod member 163, Fig. 1, and inside of the sleeve portion 131 where there is ample space, yet a small portion of the pressure fluid flows through the ports 156.

The pilot valve includes piston-like valving portions 157 and 158 connected by a reduced sleeve portion 159. The pilot valve has a through bore 160 of larger diameter than the rod 102 to provide a passageway 161. The upper end of the pilot valve is connected by a cage 162 with a tubular rod 163 that extends upwardly of the trip rod and terminates in a threaded pin 164 for connecting the box end 165 of a tubular member 166 which forms an upward continuation of the tubular rod 163.

The trip rod, previously mentioned, extends upwardly through a stuffing box 167 that is carried by a plug 168 closing the lower end of the valve housing as shown in Fig. 2A. The trip rod 102 also extends through a packing 169 contained in a stuffing box 170 on the lower end of the main valve assembly. The packing is retained by a bushing 171 protected within a cap 172 which forms the terminal end of the main valve assembly. The cap 172 has an end face 173 which cooperates with the upper end face of the plug and the wall of the main valve casing to form a pressure chamber 174 to balance the pressure on the respective ends of the valve assembly. The pilot valve chamber has a similar pressure space 175 by which pressure is substantially equalized on the respective ends of the pilot valve.

The links 134 and 135 are pivotally connected with the ears 132 and 133 by pins 176 and 177. The links extend upwardly alongside the members 163 and 166 and are pivotally connected by pins 178 and 179 with the terminal ends of toggle levers 180 and 181 that are pivotally mounted on trunnions 184 and 185 that project laterally from opposite sides of the member 166 as best shown in Fig. 3. The links 134 and 135 are resiliently retained with the toggles in either their up or down positions by a clamp 186 comprising bar members 187 and 188 that engage in transverse grooves 189 and 190 of the respective links.

Projecting from one end of each bar is a tubular spring housing 191 in which is slidably mounted a stud 192 carried by the other end of each bar as best shown in Fig. 4. The studs have heads 193 which cooperate with inwardly extending flanges 194 to seat the respective ends of coil springs 195 which are sleeved over the respective studs.

To this construction the springs exert pressure between the heads 193 and flanges 194 to draw the bars 187 and 188 in contact with the links 134 and 135 to support the links with the toggles in either their up or down position. When the toggles are in their up position as shown in Fig. 3, the power piston is moving downwardly and when the toggles are in their lowermost position, as shown in Fig. 2, the power piston is moving upwardly in its cylinder.

When the power piston is moved sufficiently in either direction for the part 113 to engage the respective collars 115 and 116, the toggles are shifted through their respective positions to effect actuation of the pilot valve as later described.

The toggles are under control of a trip spring 196 which is not to be described.

The upper end of the member 166 has a threaded pin 197 connected with a box 198 of a tubular housing 199 that extends upwardly within the tubing 6 and has an internally threaded box 200 receiving a threaded pin 201 of a tubular guide housing 202. Slidable in the guide housing 202 is a pilot tube 203 that is connected by a coupling 204 with a tube 205 of substantially smaller diameter than the tube 199 to accommodate the trip spring 196 which is coiled about the inner tube 205 and has its

upper end bearing against a collar 206 which seats against a shoulder 207 on the coupling 202. The lower end of the spring seats against the upper end 208 of a tube 209 that is slidably mounted within the tube 199 and has its lower end seated upon the pin 197. The upper end of the tube 208 has an inwardly extending annular flange 210 to form an internal shoulder 211 adapted to engage a coupling collar 212 that connects the upper end of the trip rod 102 with the tube 205.

With this arrangement, the lower end of the spring 196 is supported through the tube 209 upon the member 166 which carries the trunnions 184 and 185 of the toggles 180 and 181. The upper end of the spring 196 acts against the collar 206 to support the trip rod in its upper position through its connection with the tube 205. When the trip spring 196 is in expanded position, the toggles are held in their up or down position as shown in Figs. 2 and 3 so as to retain the pilot valve in its respective positions to control flow of pressure fluid to the main valve assembly.

Assuming that the pumping apparatus is assembled and installed within a well so that well fluid flows through the openings 9 of the gas anchor and upwardly through the inlet tube 10 to the respective ends of the pump cylinder, a fluid, which may be a part of the fluid pumped from the well, is pumped into the inner tubing 5 to effect actuation of the power unit.

When the power piston and pump pistons 91 and 55 are at the lower ends of their respective cylinders 92 and 32, the part 113 of the power piston is in engagement with the lower stop 116 of the trip rod 102, and the pilot and main control valves are in the position shown in Fig. 2A.

The pressure fluid flows from the inner tubing through the ports 156, bore 137 of the main valve unit, ports 146, channels 145, annular longitudinal passageway 93, ports 147, and into the power chamber 109 to act upon the lower end of the power piston. The pressure fluid also acts through the ports 110 of the rod coupling 104, space 108 and axial bore 65' of the connecting rod 65 to exert pressure between the end 86 of the fixed rod 83 and the inner face 64' of the coupling 64 to supplement the pressure acting on the annular area at the lower end of the power piston whereby the effective pressure areas at the lower end of the power piston are substantially equal to the effective pressure area of the upper end of the power piston.

The pressure fluid thus raises the power piston in the power cylinder, the pump piston and the pump cylinder through the connecting rod 65. Upward movement of the pump piston 55 creates a vacuum within the lower pump chamber 44 so that well fluid lifts the standing valve 28 and rises through the ports 42', 42, and 43 into the lower end of the pump cylinder to fill the expanding chamber 44.

Simultaneously, well fluid which has been previously admitted to the upper pump chamber 54 on a previous downstroke of the pump piston is being discharged through the passageway 53 into the valve chamber 49 for discharge through the ports 56, valve chamber 60 and ports 61 into the upflow passageway 6. When the power piston reaches the position where the part 113 thereof engages the upper stop 115 on the trip rod 102, the trip rod is moved upwardly therewith to cause the collar 212 to lift the tube 208 which seats the lower end of the spring 196. This movement begins to compress the spring 196 until the action therein is sufficient to lift the tube 199.

As the tube 199 is lifted, the trunnions 185 on the connecting tube 166 move upwardly to press the toggles outwardly against action on the springs 195 through the links 134 and 135 and bars 187 and 188 of the clamp 186. As the trunnions continue their travel, the toggles pass dead center position, and the stored-up action in the springs 195 and 196 are effective to cause the clamp 186 to return the links to their original position and to effect upward breaking of the toggles so that the pilot valve has snap action through the tube 163 and its position is changed with respect to the ports of the main valve so that the ports 141 are in connection with the passageway 161.

Pressure fluid now acts through the passageway 137, ports 162, passageway 161, ports 141, annular space 140, and against the lower end 173 of the main valve. The main valve, therefore, moves upwardly under this pressure so that the piston portion 128 passes the ports 146, and the piston portion 127 passes the ports 144. Now, the pressure fluid passes through ports 146' and 144 and

the passageway 121 into the upper end of the power cylinder to act against the upper end of the power piston and start downward movement thereof.

Simultaneously, the pressure fluid in the lower end of the power cylinder is discharged through the ports 147 into the passageway 93 to be vented through the passages 145 which are then in communication with the valve chamber 123, ports 148, channels 149, valve chamber 154 and ports 155 for upflow with the well fluid which moves upwardly through the upflow duct 6.

The power piston is now moving downwardly to effect downward movement of the pump piston to displace the well fluid from the lower pump chamber 44 and to draw in well fluid into the upper pump chamber 54 by way of the ports 16, 46, passageway 47, ports 48, valve chamber 52, and passageway 53 and to the upper pump chamber 54.

Simultaneously, the well fluid in the lower pump chamber 44 is being discharged through ports 43, 42, 42', 45 to the upflow passageway 6.

When the portion 113 of the power piston engages the stop 116, the trip rod 102 is shifted downwardly to apply load on the upper end of the spring 196 to push against the tubular rod 209 and carry the toggles downwardly. When the toggles pass dead center the springs snap the pilot valve to a position with the ports 141 in communication with the ports 142 so that the fluid pressure acting in the chamber 174 is allowed to exhaust through the passageway 140, port 141, ports 142, passageways 143, ports 148, passageway 149 to the valve chamber 154 and from the valve chamber through the ports 155 to the upflow passageway 6. This allows the main valve to return to the position shown in Fig. 2A. An up stroke is started to continue lift of the fluid in the upflow passage 6 as previously described.

With the structure described, it is obvious that the effective areas at the respective ends of the power cylinder are equalized so that the power piston has the same effective up and down strokes. Also, it is obvious that the pump chambers in the respective ends of the pump cylinder have substantially the same volume so that the discharge from the respective chambers is equal, with the result that the upflow of the well fluid is continuous and of uniform volume flow.

It is also obvious that I have provided improved and simplified operation for the pilot valve since with the present structure only a single trip spring is used.

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

1. A double-acting pump including a working barrel, having fluid passageways at the respective ends thereof, a reciprocatory piston in the working barrel, an actuating rod connected with the piston and extending through one end of the working barrel, and a compensating rod having fixed support within the other end of the working barrel in substantially close relation to the fluid passageway at that end of the working barrel and having displacement corresponding to displacement of the actuating rod, said piston being slidably movable over the compensating rod to effect admission and discharge of a well fluid to and from the respective ends of the working barrel and to discharge any sand that may settle around said fixed end of the compensating rod through said closely related fluid passageway.

2. In combination with a double acting pump having fluid intake and discharge means at respective ends of the pump and provided with a reciprocatory piston, a double action pressure actuated power means, means connecting the power means with the piston of the pump, means for supplying and exhausting pressure fluid alternately from the respective ends of the power means, compensating means for equalizing volume of fluid displaced from the respective ends of the pump, and means for admitting fluid pressure to said compensating means for establishing substantially equal pressure areas at the respective ends of the power means and for exhausting the fluid pressure from said compensating means with pressure fluid exhausted from the power means.

3. In a double acting pump having upper and lower sections for elevating a fluid, a double acting power unit directly connected with the upper section of the pump, means returning a portion of the pumped fluid to effect actuation of the power unit for operating the pump, means for equalizing displacement of fluid on both actions of the pump, means cooperating with the displacement means in the lower section of the pump for establishing

substantially equal pressure areas on both actions of the power unit, valve means for the power unit for supplying a portion of the returned fluid to the displacement means in the lower section of the pump to render the pressure equalizing means effective and to vent the returned fluid from the said displacement means in the lower section of the pump simultaneously with the actuation of the power unit.

4. A pump including a working barrel, a reciprocatory piston slidable in the working barrel, an actuator, a rod connecting the actuator with the piston, means for admitting and discharging a fluid to be pumped alternately to and from respective ends of the cylinder, and a compensating rod having fixed support within the working barrel on the side of the piston opposite the connecting rod and having a displacement corresponding with the displacement of the connecting rod whereby the capacities at the respective ends of the working barrel are substantially equal, said piston being slidably upon the compensating rod to form a pressure chamber within the piston, means for supplying a pressure medium to the pressure chamber, and a valve mechanism for controlling the supply of pressure medium to the actuator, and to and from the pressure chamber in the piston.

5. A pump including coaxial pump and power cylinders, pistons slidable in said cylinders, a rod extending coaxially through adjacent ends of the cylinders and interconnecting said pistons, compensating means in the pump cylinder on the side of the pump piston opposite said connecting rod for substantially equalizing the displacement of the pump rod in that end of the pump cylinder, means for admitting a fluid to be pumped into the respective ends of the pump cylinder, and valve means for alternately admitting and exhausting a pressure fluid to and from said compensating means simultaneously with control of the pressure fluid supply for the power cylinder.

6. A pump including coaxial pump and power cylinders, pistons slidable in said cylinders, a rod extending coaxially through adjacent ends of the cylinders and interconnecting said pistons, a fixed rod in the pump cylinder on the side of the pump piston opposite said connecting rod for substantially equalizing the displacement of the pump rod in that end of the pump cylinder, said pump cylinder being slidably over the fixed rod and cooperating therewith in forming a pressure chamber within the pump piston in direct connection with the end of the power cylinder adjacent to the pump cylinder, means for admitting a fluid to be pumped into the respective ends of the pump cylinder, and means for alternately admitting and discharging a pressure fluid to and from the respective ends of the power cylinder and to and from the pressure chamber of the piston, said pump piston having a bore cooperating with said pump piston to form a pressure chamber having connection with the pressure fluid inlet at the end of the power cylinder passing said rod which interconnects the pistons.

7. A pump including coaxial pump and power cylinders, pistons slidable in said cylinders, a connecting rod between the pistons and extending coaxially through adjacent ends of the cylinders, a compensating rod having substantially the same displacement capacity as the connecting rod, means supporting the compensating rod in the end of the pump cylinder opposite the connecting rod, said piston having a bore for slidably passing the compensating rod, means for admitting and exhausting an actuating fluid alternately to the respective ends of the power cylinder, means for alternately admitting and discharging fluid to and from the pump cylinder, and means for admitting the actuating pressure medium from the power cylinder to act on the compensating rod when the pistons are moved in one direction and for venting said pressure medium to the exhaust of the actuating means on movement of the pump piston in the opposite direction for providing substantially equal pressure areas at the respective ends of the power piston.

8. A pump including coaxial pump and power cylinders, pistons slidable in said cylinders, a rod interconnecting the pistons and extending coaxially through adjacent ends of the cylinders, a compensating rod having substantially the same displacement capacity in the pump cylinder as the connecting rod, means supporting the compensating rod in the end of the pump cylinder opposite the connecting rod, said piston having a bore for slidably passing the compensating rod and forming a

pressure chamber and piston area substantially equal to the cross sectional area of the connecting rod, means for admitting an actuating fluid alternately to the respective ends of the power cylinder, means for alternately admitting and discharging fluid to and from the pump cylinder, and said connecting rod having a bore in connection with the power cylinder and pressure chamber formed by the pump piston and said fixed rod for admitting the actuating pressure medium from the power cylinder to act on the compensating rod for providing substantially equal pressure areas at the respective ends of the power piston.

9. In a pump of the character described a power cylinder, a power piston slidably mounted in the power cylinder and forming pressure chambers at opposite ends of the power cylinder, a pump cylinder connected in tandem with the power cylinder, a connecting rod coupling having passageways in connection with one of the pressure chambers in the power cylinder, a pump piston slidable in the pump cylinder and having an axial bore, a connecting rod coupling closing the bore at the end of the piston nearest the power piston, a connecting rod having ends interconnecting the couplings and having a longitudinal duct for connecting the passageways of the coupling on the power piston with the bore of the pump piston, a compensating rod fixed within the pump cylinder and having an end extending into the bore of the pump piston to form a pressure chamber in cooperation with said one pressure chamber of the power cylinder to effect equalization in pressure areas on the respective ends of the power piston, means for admitting pressure fluid to the respective ends of the power cylinder to reciprocate the power and pump pistons, and means for admitting and discharging fluid to be pumped to and from the ends of the pump cylinder.

10. In a pump of the character described a power cylinder, a power piston slidably mounted in the power cylinder and forming pressure chambers at opposite ends of the power cylinder, a pump cylinder connected in tandem with the power cylinder, a connecting rod coupling having passageways in connection with one of the pressure chambers in the power cylinder, a pump piston slidable in the pump cylinder and having an axial bore, a connecting rod coupling closing the bore at the end of the piston nearest the power piston, a connecting rod having ends interconnecting the couplings and having a longitudinal duct for connecting the passageways of the coupling on the power piston with the bore of the pump piston, a compensating rod fixed within the pump cylinder and having an end extending into the bore of the pump piston to form a pressure chamber in cooperation with said one pressure chamber of the power cylinder to effect equalization in pressure areas on the respective ends of the power piston, means for admitting pressure fluid to the respective ends of the power cylinder to reciprocate the power and pump pistons, and means for admitting and discharging fluid to be pumped to and from the ends of the pump cylinder, said compensating rod having substantially the same diameter as the connecting rod whereby the capacities of the pump cylinder at opposite sides of the pump piston are substantially equal.

11. In a pump of the character described a double acting fluid pressure actuator, a valve housing in connection with the actuator, a main pressure actuated valve slidable in the valve housing to control alternate inlet and discharge of pressure fluid to the actuator, a pilot valve slidable relative to the main valve for controlling the actuating fluid to the main valve, a trip rod having spaced stops for contact by a movable part of the actuator, a toggle mechanism connecting said trip rod with the main valve, spring means normally retaining the toggle mechanism in position to retain the pilot valve

in one and the other of two positions relatively to the main valve, spring abutments on the trip and pilot valve rods, and a single spring having ends engaging the respective abutments and adapted to be compressed when the trip rod is actuated to provide the power for shifting the toggle mechanism in opposition to said spring means for changing the relative position of the pilot and main valves in controlling admission of the pressure fluid to the actuator.

12. In a pump of the character described a power cylinder, a piston slidable in the power cylinder, a valve housing in connection with the power cylinder, a main pressure actuated valve slidable in the valve housing to control alternate inlet and discharge of pressure fluid to the respective ends of the power cylinder, a pilot valve slidable relative to the main valve for controlling the actuating fluid to the main valve, a trip rod having spaced stops for contact by a part of the power piston near the respective ends of the stroke of the power piston, a toggle mechanism connecting said trip rod with the main valve, spring means normally retaining the toggle mechanism in positions to retain the pilot valve in one and the other of two positions relatively to the main valve, spring abutments on the trip and pilot valve rods, and a single spring having ends engaging the respective abutments and adapted to be compressed when the power piston engages the respective stops on the trip rod to provide the power for shifting the toggle mechanism in opposition to said spring means for changing the relative position of the pilot and main valves in controlling admission of pressure fluid to and from the respective ends of the power cylinder.

13. A pump including coaxial pump and power cylinders, pistons slidable in said cylinders, a rod interconnecting the pistons, a compensating rod at the end of the pump cylinder opposite the connecting rod to substantially equalize the pump capacities at the respective ends of the pump cylinder and cooperating with the pump piston for forming a pressure area which in conjunction with the pressure area on the connecting rod end of the power piston substantially equals the pressure area at the opposite end of the power piston, a valve housing in connection with the power cylinder, a main pressure actuated valve slidable in the valve housing to control alternate inlet and discharge of pressure fluid to the respective ends of the power cylinder, a pilot valve slidable relative to the main valve for controlling the actuating fluid to the main valve, a trip rod having spaced stops in the path of the power piston and adapted to be engaged by a part of the power piston at the respective ends of the stroke for the power piston, a toggle mechanism connecting said trip rod with the main valve, spring means normally retaining the toggle mechanism in position to retain the pilot valve in two positions relatively to the main valve, spring abutments on the trip and pilot valve rods, and a single spring having ends engaging the respective abutments and adapted to be compressed when said part of the power piston engages the respective stops on the trip rod to provide the power for shifting the toggle mechanism under action of said spring means for changing the relative position of the pilot and main valves in controlling admission of the pressure to and from the respective ends of the power cylinder.

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