March 17, 1953 O. E. DEMPSEY 2,631,541

HYDRAULIC PUMP

Filed May 2, 1949 3 Sheets-Sheet 1

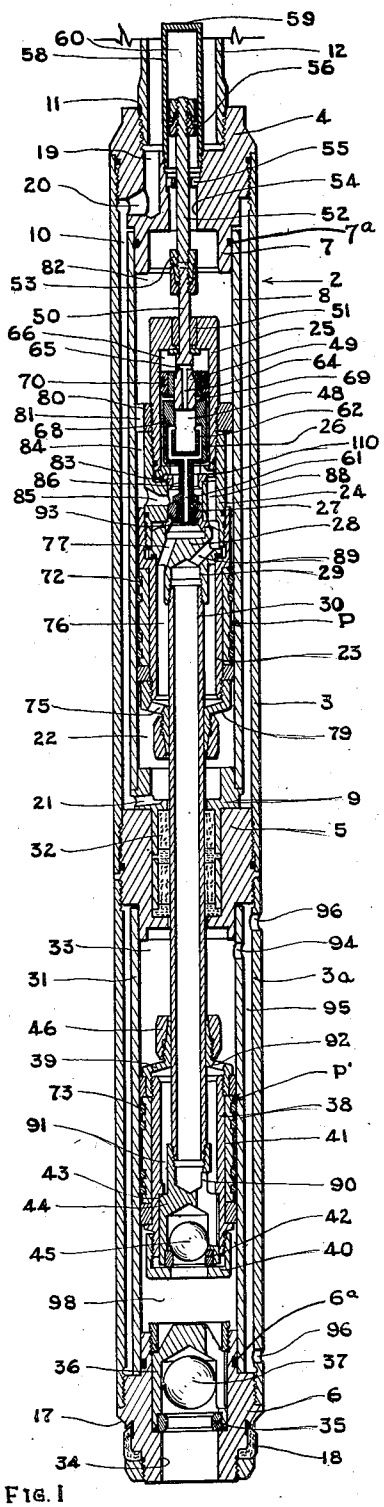


FIG. 1

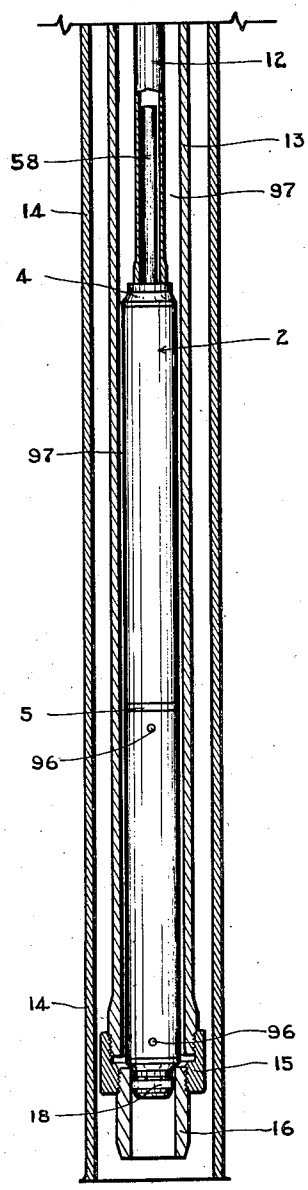


FIG. 2

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HYDRAULIC PUMP

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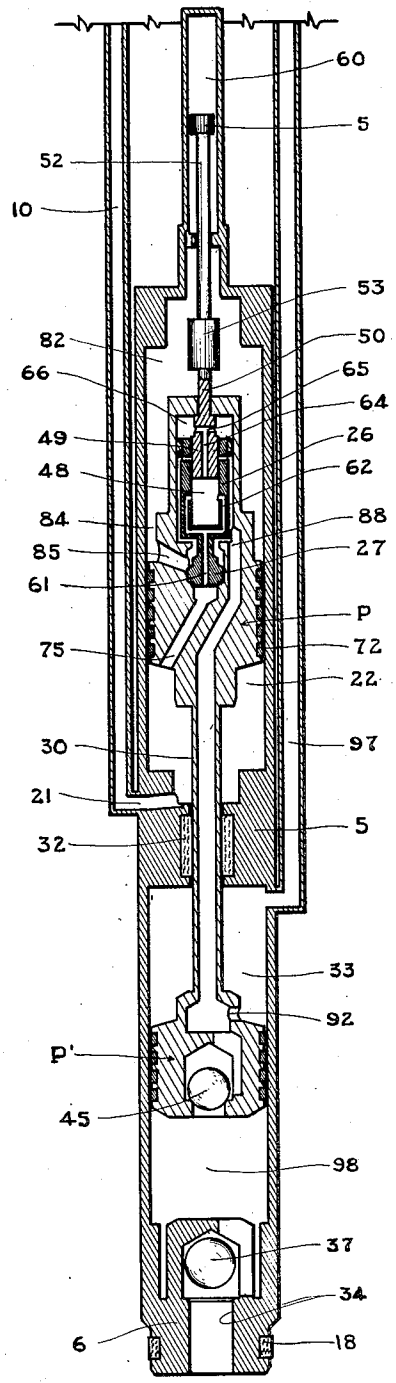


FIG. 3

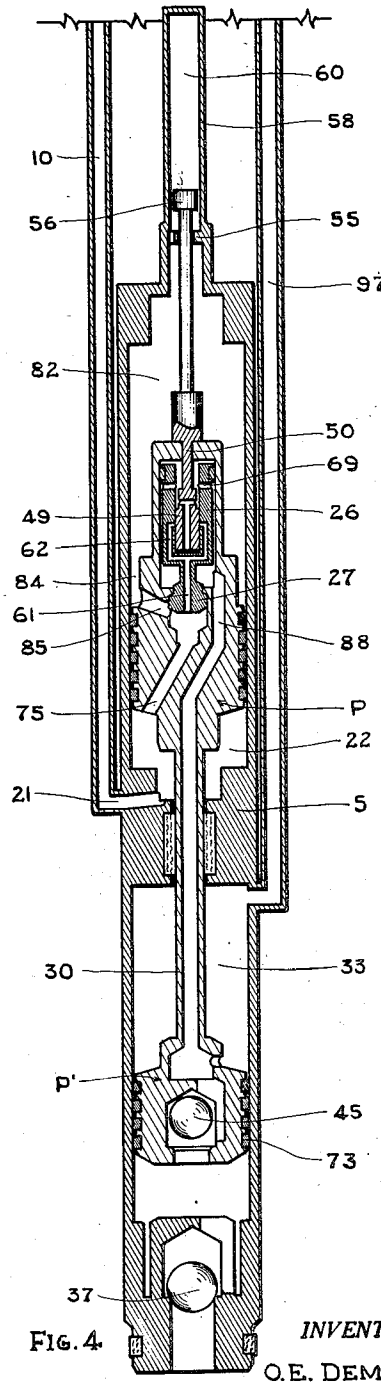


FIG. 4

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HYDRAULIC PUMP

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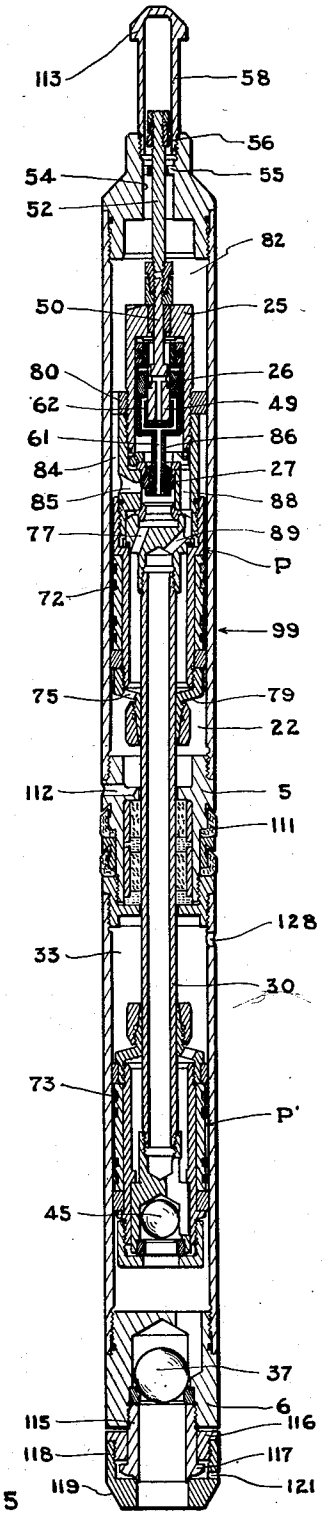


FIG. 5

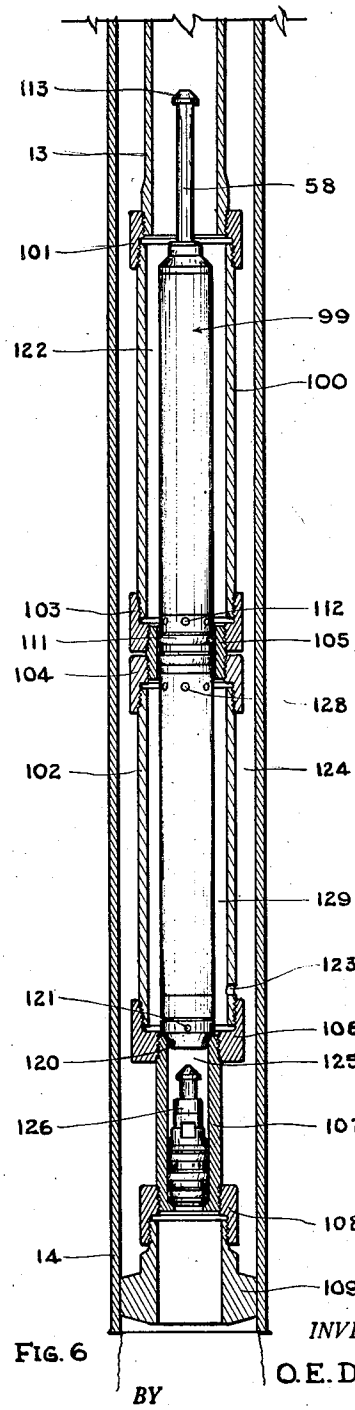


FIG. 6

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UNITED STATES PATENT OFFICE

2,631,541

HYDRAULIC PUMP

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Application May 2, 1949, Serial No. 90,953

12 Claims. (Cl. 103—46)

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This invention relates to a fluid-actuated pump apparatus, and more particularly, but not by way of limitation, to a fluid-actuated bottom hole pump for oil wells and the like. This application is an improvement on applicant's co-pending application Serial No. 764,668, filed on July 30, 1947.

It is an important object of this invention to provide a fluid-actuated bottom hole pump for oil wells which will provide a positive working stroke with the utilization of either oil, water or gas as a power fluid.

Another object of this invention is to provide a bottom hole hydraulic pumping unit which includes a reciprocating piston element the movement of which is controlled by a valving mechanism which includes a pilot valve to control the position of a main valve wherein the movement of said pilot valve is accomplished by the travel of the piston element and wherein the position of said pilot valve is maintained throughout the effected piston travel by high-pressure fluid acting thereagainst into which pressure the pilot valve connecting rod must be moved to effect the reversal of the main valve and the subsequent reversal of the piston element.

And still another object of this invention is to provide a hydraulic bottom hole pumping unit where the input supply pressure is constantly maintained on one face of the engine piston and wherein a regulated exhausting pressure relief from the opposite face causes the movement of of the piston in one direction and wherein the controlled flow of supply fluid pressure directed against said opposite face of the engine piston becomes effective upon the piston rod to cause the movement of the piston element in the opposite direction.

And still another object of this invention is to provide a bottom hole fluid-actuated pumping unit utilizing a valve mechanism contained within the engine piston for regulating and causing the reversal of the reciprocating stroke of the piston and wherein said valve mechanism includes a pilot valve whose position can be altered by the continued travel of the engine piston into a position to cause a reversal of the supply fluid pressure relationship that is actuating the engine plunger's movement prior to the completion of said reciprocation of the pump plunger in either direction.

And still another object of this invention is to provide a bottom hole fluid-actuated pump for oil wells having a valve controlling the stroke of the piston and which includes a pilot valve for controlling the position of the control valve mechanism and wherein the pilot valve is initially moved by supply inlet pressure prior to any change of position of the control valve.

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And another object of this invention is to provide a fluid-actuated pump having supply pressure fluid constantly maintained on one face of the engine plunger and a regulated pressure directed to the opposite face of the engine plunger to cause a working stroke, and wherein said supply pressure during one stroke of the engine plunger is disposed at both sides of the plunger to provide a balanced pressure condition.

And still another object of this invention is to provide a fluid-actuated pump for oil wells and the like, wherein the piston element is reciprocated by constantly maintained supply pressure fluid in such a manner that there is a balanced pressure condition within the engine piston cylinder on one stroke of the plunger whereby the plunger is moved against the flow of supply pressure fluid, while on the opposite stroke of the piston there is an exhaust at one end of the plunger permitting movement of the piston by supply pressure fluid.

And still another object of this invention is to provide a fluid-actuated pump having constantly maintained supply pressure on one face of the engine piston and wherein the engine cylinder cavity adjacent an opposite face of said piston is alternately filled with supply pressure fluid to cause one reciprocal movement, and the exhausting of said spent supply fluid directed through an engine piston rod and into the pumping column.

A further object of this invention is to provide a bottom hole hydraulic pumping unit in which the valving mechanism is contained within the engine piston, and so positioned that the flow of the motivating fluid maintains a progressively forward movement into and through the engine cavity, and subsequently exhausting as spent pressure fluid into the pumping cavity.

And still another object of this invention is to provide a fluid-actuated bottom hole pump for oil wells having an engine piston and a pumping piston wherein supply pressure fluid is contantly maintained against one face of the engine piston, and wherein spent power fluid is exhausted from an opposite face through the piston and into contact with the upper face of the pump piston for washing any debris, or abrasive foreign material carried in the pumped fluid into the pumping column at a displacement rate of speed in excess of the pump piston speed.

And an additional object of this invention is to provide a fluid-actuated pump wherein an engine piston moves through one of its power

strokes without any spent or exhausted power fluid leaving the piston cylinder, and where the combined fluid displacement of a complete piston cycle is effected during a sequent reversal or back stroke of the piston.

A further object of this invention is to provide a hydraulically driven deep well reciprocating pumping apparatus in which the valve mechanism is so arranged that all passageways, ports and seating faces necessary for the complete function of the valve parts are contained within the valve assembly, and wherein movement of one part of the valve assembly causes a reversal of the motive fluid pressure thrust reacting upon another part to move said part in the opposite direction.

A further object is to provide a pumping unit in the manner described in which all the reciprocating elements of the unit are flexibly articulated one to the other so that a minimum regard for specific alignment of parts is necessary, and wherein the threaded connections of the piston rod to the engine and pump piston are protected from the fatiguing stresses caused by misalignment and the normal vibrations incident to reciprocal movement.

A further object of this invention is to provide a hydraulically driven deep well reciprocating pumping apparatus of the so-called "insert" type wherein both the engine and pump cylinder barrels are allowed a full floating position within the engine and pump jackets, and wherein O ring gaskets or other similar flexible sealing elements are employed to maintain a fluid tight relationship where necessary.

Other objects and advantages of the invention will be evident from the following detailed description, read in conjunction with the accompanying drawings, which illustrate my invention.

In the drawings:

Fig. 1 is a sectional elevational view of one form of the pump unit.

Fig. 2 is an elevational view with certain parts in section showing the pump unit disposed in an oil well bore.

Fig. 3 is a schematic view of the mechanism showing at least one disposition of the various parts with the main valve in one seating position.

Fig. 4 is a similar view showing the main valve in a seating position opposite to that shown in Fig. 3.

Fig. 5 is a sectional elevational view of a modified form, but showing the main valve in a position opposite to that shown in Fig. 1.

Fig. 6 is a view similar to Fig. 2, showing an adaptation of the modified embodiment in Fig. 5 in an oil well bore.

Referring to the drawings in detail and particularly Figs. 1 and 2, the pump unit 2 comprises an outer sectional housing or cylindrical jacket 3 having an upper apertured head 4 and an intermediate apertured head 5 connecting the opposite ends of the housing 3. A lower cylindrical housing 3a is secured at its upper end to the intermediate head 5 and at its lower end to an apertured plug or head 6. The upper head 4 is provided with a downwardly extending circular flange 7 for receiving the upper end of an inner cylinder 8, secured at its lower end to an upwardly extending circular collar 9 secured in any suitable manner to the intermediate head 5. The inner cylinder 8 is spaced from the outer cylinder 3 to provide a passageway or annulus 10. The lower end of cylinder 8 loosely engages the collar 9, and at its upper end is in snug engagement with flange 7. Any suitable ring gasket 7a is indented in flange 7 to form a fluid tight joint. The cylinder 8 may have slight radial movement at its lower end, and is allowed a certain axial movement. The head 4 is provided with a threaded bore 11 for receiving a string of macaroni tubing 12 adapted to extend to the top of the well (not shown) and permit suspension of the pump unit 2 in the well tubing 13 arranged in spaced relation with the well casing 14 (Fig. 2).

The lower end of the tubing 13 is provided with a collar 15 having a seating nipple 16 secured thereto. The bottom plug 6 is provided with a tapered outer periphery 17 for supporting the pump unit 2 on the nipple 16 in the well tubing 13. Circular sealing gaskets 18 are provided below the tapered periphery 17 and are disposed to seat in the nipple 16. The bore 11 of head 4 is in communication with a vertical passageway 19 in turn communicating with the annulus 10 through a port 20. The collar 9 is provided with a port 21 providing communication between the passageway 10 and a piston chamber 22 provided by cylinder 8. A circular piston unit P is disposed in the chamber 22 and comprises an outer sleeve 23 connecting with the engine valve manifold 24 of slightly smaller diameter, which in turn is connected with main valve housing 25 of still smaller diameter. A main valve unit 26 is disposed within the housing 25 and is provided with an extension valve 27 adapted to cooperate with an apertured seating member 93 provided between the members 23, 28 and 24. The crossover member 28 is provided with a downwardly extending collar 29 to which is secured a tubular rod 30 spaced from sleeve 23 and extending through the piston unit P, collar 9, the apertured intermediate plug 5 and into connection with a lower pumping piston P'. The apertured plug 5 is provided with any suitable packing 32 encircling the tubular member 30 providing a seal between the chamber 22 and a lower chamber 33 in which is disposed the piston unit P'.

The lower head 6 is provided with a shouldered bore 34 in which is provided a valve seat 35 held therein by a valve cage 36 threadedly secured in the bore 34 and in which is disposed a ball valve 37 acting as an inlet standing valve for the pump unit 2 as will be hereinafter set forth.

The pump piston unit P' is disposed in chamber 33 provided by the sleeve 31 loosely fitting the lower flange of the plug 5 at its upper end, and forming a flexible but fluid tight contact with the upper flange of the lower plug 6. The upper flange of plug 6 is indented to receive a gasket such as an O ring sealing element 6a. The sleeve 31 is allowed a certain axial movement between the plug members 5 and 6. The piston unit P' comprises and inner cylinder 38 threadedly secured between an upper collar 39 and a lower collar 40. An outer sleeve 41 is also secured between the collars 39 and 40. A valve seat 42 is supported by the collar 40. The inner sleeve 38 is provided with shoulders 43 for maintaining a valve cage 44 therein, which in turn is provided with a ball valve 45 acting as a traveling valve within the piston unit P'. The lower end of the tubular member 30 is threadedly secured to the upper end of the cage 44. Furthermore, a locking collar 46 is threaded onto the upper collar 39 for maintaining the connection for the tubular mem-

ber 30 with the piston unit P'. The collar 39 has a split tapered extension beyond the threads engaging a similar tapered bore in nut 46 to firmly secure the tubular member 30. Like members are provided in the engine piston assembly which when made up relieve all vibrational stress from the threaded make-up at each end of the rod member 30.

The main valve 26 is provided with a centrally disposed recess 48 in which is slidable a pilot valve 49. The pilot valve is provided with a pilot valve rod 50 extending upwardly through a sleeve bearing 51 disposed in the upper apertured portion of the housing 25. The pilot rod 50 is coupled with a pilot extension rod 52 through collar member 53, and the extension rod 52 extends upwardly into the bore 54 of the head 4. The bore 54 is provided with an apertured shoulder 55 for a purpose as will be hereinafter set forth. The upper end of the extension rod 52 extends through the apertured shoulders and is provided with a stop nut locking device 56. The rod 52 and nut 56 are disposed in a tubular member 58 closed at the top end 59 and threadedly secured at its lower end in the bore 54 to provide a chamber 60 for a purpose as will be hereinafter set forth. The collar and nut members are of two-piece construction so devised as to provide a split tapered and female threaded member to seize the male threads of the rod when the male threads of said rod draw the mating members tapered faces into interference.

The extension valve 27 is provided with a vertical passageway 61 communicating with a forked passageway 62 in turn communicating with the recess or bore 48 of the main valve 26. In like manner the pilot valve 49 is provided with a vertical passageway 64 communicating with a transverse passageway 65 in turn communicating with a chamber 66 above the main valve 26. The lower portion of the main valve 26 is spaced from the sleeve 25 to permit a slight clearance thereby providing a passageway 68 in communication with a transverse bore 69 in the main valve body 26. The outer periphery of the valve 26 above the passageway 69 is provided with sealing rings 70 to prevent fluid leakage to or from the chamber 66. The outer periphery of the piston unit P is provided with a plurality of vertically spaced piston rings 72 and in similar manner the piston unit P' is provided with a plurality of vertically spaced rings 73.

The main valve manifold 24 has a central bore into which opens the port 85 and is adapted to receive valve seating collar 83 at its upper termination and a similar valve seating collar 93 at its lower termination. Interposed between collar 83 and the main valve housing 25 is an apertured ring 110 establishing communication between the central bore of manifold 24 and the port 88 when the main valve is in one position. Valve seating collar 93 is adapted to form a fluid tight engagement with the crossover member 28 by seating into and against a recess provided at its upper end thus providing fluid passage from port 77 to the central bore of manifold 24.

Operation

Figs. 3 and 4 disclose a schematic arrangement of the pump apparatus disclosed in Fig. 1 and is operated in the following manner.

Supply pressure fluid from the surface of the well is provided from any suitable source (not shown) and is constantly maintained in the

macaroni tubing 12 where it is discharged through the passageway 19, port 20 and into the annulus 10 and through a port 21 into chamber 22. The piston unit P is provided with a port 75 directing the power fluid into chamber 76 and through a passageway or port 77 provided in the crossover member 28, and into contact with the lower face of the extension valve 27. When the pilot valve is in an upward position as shown in Fig. 3, the supply pressure fluid may discharge through passageways 61, 62 into chamber 48, passageway 64, ports 65 and into chamber 66 above the main valve 26 thereby assisting the seating relationship of the extension valve 27 with its valve seating collar 93. With the pilot valve 49 and the main valve 26 disposed in this position as shown in Figs. 1 and 3, the supply pressure fluid in chambers 22 and 76 will cause movement upwardly of the piston unit P. A circular bearing or guide member 80 is in threaded engagement with main valve housing 25 and acts as a locking device with member 24. The guide 80 is provided with a plurality of circumferentially spaced apertures 81.

Upward movement of the piston unit P will displace any power fluid present in chamber 82 above the piston unit P through the apertures 81 and the passageway 84 provided by the annulus between the inner periphery of the barrel 8 and the outer periphery of the members 25 and 24. The spent power fluid from chamber 82 is discharged through the passageway 85 and through the annular space between the reduced neck portion 86 of the extension valve 27, and the opening in the valve seating collar 83 and thence through the apertured ring 110 into the exhaust passageway 88, in turn communicating with a port 89 in the crossover member 28 which is in communication with the tubular member 30 for discharge through port 90 and into a chamber 91 provided between the tubular member 30 and the valve cage 44, and hence outwardly through a port 92 into the chamber 33. It will be apparent that the upward movement of the motor piston unit P will cause a simultaneous upward movement of the pumping piston unit P' to displace fluid present in chamber 33 through a port 94 and into the annulus 95 and the vertically spaced discharge ports 96 provided in the lower jacket 3*a*, and into the pumping column 97 provided by the tubing 13.

It will be apparent during the upward movement of the piston unit 31 the traveling valve 45 precludes any flow of power fluid into the chamber 98 below the pumping piston unit P', at the same time relieves pressure against the standing valve 37 to allow the production fluid from the well to flow into the chamber 98 for a subsequent displacement.

As the piston unit P moves upwardly the constantly sustained supply pressure fluid in the main valve recess 48 maintains the pilot valve 49 and rods 50 and 52 in their fully extended position until the upper face of the coupling collar member 53 contacts the underside of the shoulder 55 disposed in the bore 54, thereby arresting further upward movement of the pilot valve rod and the pilot valve. However, the supply pressure fluid will cause continued upward movement of the piston unit P and the main valve 26 to a point where the discharge ends of the passageways 62 are closed off by the arrested pilot valve 49. Simultaneously correspondence is provided between the chamber 66 and the exhaust port 69 in turn communicating with the exhaust passageway 88 through the annulus 68, thereby relieving the

supply fluid pressure condition in chamber 66. In this condition supply fluid pressure constantly reacting against the cross sectional area of the extension valve member 27 will move the main valve upwardly away from valve seat 93 past port opening 85 and into forcible contact with valve seat 83. With the valve 27 moved to its upper position as shown in Figs. 4 and 5, the supply pressure fluid from chambers 22 and 76, port 77 will discharge through port 85 into passageway 84, apertures 81, and into the chamber 82 at the top of the piston unit P.

Supply fluid pressure is established in chamber 60 above the pilot rod assembly by passing by the loosely fitting member 53 and its recess 54 and the nut 56 and the bore of the tube 58. As soon as the pressure in chamber 82 is increased sufficiently it will cause movement of the motor piston unit P in a downward direction with a simultaneous downward movement of the pump piston P' to cause displacement of production fluid disposed in chamber 98 through the traveling valve 45, port 92 and into the chamber 33. It will be apparent that a portion of the fluid may be displaced through the ports 94 and 96 and into the pumping column 97. During the downward stroke (Fig. 4) of the piston units P and P' the standing valve 37 is seated to preclude any flow of the well fluid in chamber 93 into the production strata. It is apparent that downward movement of the piston units P and P' is accomplished without a pressure exhaust relief against the lower face 79 of the piston P since the constantly maintained supply pressure in chamber 22 is balanced by supply pressure now existing in chamber 82 above the piston unit. However, the differential area provided by the tubular rod 30 causes the downstroke of the motor piston unit P and the pumping piston P'. It will be apparent from the above that during the downstroke of the piston unit P there is no exhaust condition in the chamber 22, but the piston unit P is moved through and against the flow of the constantly maintained supply pressure fluid.

As the motor piston unit P is caused to move downwardly (Fig. 4) by the power fluid, the power fluid in chambers 60 and 82 also acts against the cross sectional area of the pilot rod extension 50 to cause a simultaneous movement of the pilot valve rod, and the pilot valve 49 until the upper nut 56 abuts the upper face of the shoulder 55 thereby arresting any further downward movement of the pilot valve 49. However, downward movement of the motor piston unit P and the main valve 26 is continued. The continued downward movement of the piston unit after the pilot valve assembly has been arrested alters the relative position of main valve to pilot valve porting; closing chamber 66 to exhaust correspondence by the movement of the pilot valve over ports 69 and in simultaneous sequence opening the porting of passageways 62 to chamber 48. By virtue of this continued movement the chamber 66 above the main valve is in correspondence with supply fluid pressure. It will be apparent that with an increased pressure condition in chamber 66 the larger area of the main valve 26 relative to the extension valve 27 will cause movement of the main valve 26 downwardly to seat the extension valve 27 forcibly against the valve seating collar 93 thus precluding correspondence of the power fluid beyond this point of seal. This downward movement of the main valve establishes direct correspondence between chamber 82 above the piston unit P by way of portage 81, 84, 85, through valve seat 83, apertured ring 110, ports 88 and 89 into and through the piston rod 30 towards the lower pressure condition of the pumping column. Consequently the movement of the motor piston unit P is reversed to move the piston in an upward stroke due to the presence of the power fluid in chamber 22 acting against the piston face 99.

It will be apparent from the above described operation that the pilot valve 49 is moved by movement of the piston assembly P and P' from one position to another, and is maintained in either position by the supply pressure fluid acting thereagainst. Furthermore, the movement of the pilot valve is always into or against a high pressure condition. Furthermore, it is arrested in its movement by the shoulder 55 prior to any movement of the main valve 26 and its extension valve 27 for controlling the intermittent discharge of inlet fluid to the chamber 82 causing a downstroke of the piston units P and P'. It is to be further noted that the length of the pilot rod determines the complete pilot valve stroke and that the depth of cavity 48 accommodates the complete pilot valve movement plus the movement of the main valve with a sufficient clearance in addition thereto. Thus it is evident that a desirable portage over-travel can be provided to meet divers operating conditions. This relationship of ports therefore assures that the pilot valve at either end of its travel, held in said position either by a pressure differential reacting thereagainst or confined by the interference shoulders 55 will either alter or maintain the pressure relationship influencing the main valve position as the case may be, regardless of abnormal or "out of phase" positions such as do occur during installations or nonpredictable bottom hole conditions. It will be apparent that in this manner there is a more positive operation of the pilot valve to assure a responsive movement of the main valve.

In Figs 5 and 6, is shown a modification of the invention which is particularly adapted for a wire line installation in the well bore. The pump apparatus shown in Fig. 5 is substantially the same as that shown in Figs. 1 to 4 inclusive, except that it is modified to eliminate the outer jackets 3 and 3a of the preferred embodiment, and the passage of the power fluid through the apertured head 4 and the passageway 10. It will be apparent that the elimination of the outer jackets provides a pump of smaller diameter which may be utilized in smaller sized tubing, yet provides for substantially the same volume of fluid displacement as that disclosed in the preferred embodiment, or a larger diameter pump in the same size tubing for greater volume. Furthermore, the placement and removal of the pump unit in the well bore by any suitable wire line apparatus (not shown) expedites the placement of the pump without the necessity of utilizing the string of macaroni tubing 12.

In Fig. 6, is shown the modified pump unit 99 disposed in the tubing string 13 wherein a lower section of tubing 100 is coupled by a collar 101 to the lowermost end of the tubing string 13. Furthermore, the section 100 is connected with a lower section, 102, through coupling collars 103 and 104 interconnected by a seating nipple 105 threadedly secured at the collars. A cylindrical seating nipple 107 is threaded to the lower collar 106 and extends downwardly therefrom into threaded connection with a lower nipple 108 supported by an apertured plug or conventional oil

well packer 109 disposed in the casing 14. The pump unit 99 of reduced diameter is modified further to provide a plurality of vertically spaced sealing rings 111 disposed on the outer periphery of the intermediate plug 5. The sealing rings 111 are adapted to contact the inner periphery of the seating nipple 105. It will be apparent that outer housing for the unit 99 is substantially the same as cylinders 8 and 31 of the preferred embodiment with a modification of the plug 5.

Furthermore, the intermediate plug 5 of the modification is provided with an inlet port 112. The top tubular member 58 is provided with a projection or flange member 113 adapted to receive any suitable type wire line hook member (not shown) providing for insertion, seating and removal of the pump unit from the tubing string.

The lowermost apertured plug 6 of the preferred embodiment is modified in the disclosure of Fig. 5 by providing a seating nipple 115 extending downwardly therefrom. A circular ring 116 of inverted L-shape in cross section is disposed below the plug 6 and slidable upon the nipple 115, and is maintained therein by a circular shoulder 117 provided on the outer periphery of the nipple. A lower collar 118 is threadedly secured to the ring 116. The collar 118 is provided with tapered or angled end portions 119 for seating the pump unit 99 into the angled portions 120 of the seating nipple 107. The collar 118 is provided with an aperture 121.

From the above it will be apparent that the pump may be run into the well tubing 13 on any suitable wire line connecting with the flange 113, not shown, and the tapered portion 119 seats on the nipple 107 simultaneous with the rings 111 contacting the inner periphery of the nipple 105 in a fluid tight seal. With the pump in position as shown in Fig. 6, high pressure supply fluid from the top of the well (not shown) is discharged through the tubing 13 into the annulus 122 and through the inlet port 112 and into the chamber 22. It will be apparent that the operation of the main valve 26, pilot valve 49, motor piston P, and pumping piston P' is substantially the same as that shown in the preferred embodiment in Figs. 1 to 4 inclusive.

When it is desired to remove the modified pump unit 99 from the well by a wire line and jar apparatus (not shown), the pump unit is lifted or jarred upwardly allowing the sleeve 115 to slide slightly upward on the L-shaped ring 116 thereby unseating the bottom of the collar 115 from the collar 118 and placing the chamber 125 below the tapered seat 120 in correspondence with the pumping column through the port 121. The annulus 129 is provided with a port 123 communicating with the annulus 124 between the tubing 13 and the casing 14 defining the pumping column of the displaced well fluid. As the pump unit 99 is lifted the hydrostatic head of fluid in the pumping column will flow through the port 121 into the chamber 125 below the unit 99 thereby balancing the pressure at both sides of the unit to afford an easy withdrawal of the unit from the well by the wire line apparatus. The initial movement of the collar 115 does not of necessity unseat from the tapered portion 120 of the nipple 107, however, after the balancing of pressure in chambers 125 and 129, continued pulling by the wire line apparatus will unseat the tapered portions 119 of collar 118 as well as the cups 111 from the nipple 105 to remove the unit 99 from the well. It will be apparent that the tapered seat portion 119 may be modified in a manner (not shown) such as the use of a straight nipple of reduced diameter and having suitable sealing cups encircling the nipple for a fluid seal with the inner periphery of the nipple 107.

A stationary standing valve 126 of any suitable type is disposed in the nipple 107 and precludes retrograde fluid travel from the pumping column towards the production strata as well as permitting balancing of the pressure on both sides of the pump unit 99. It will be apparent that the modified installation facilitates the placement and removal of the pump unit 99 in the tubing string by any suitable wire line apparatus and thus eliminates the necessity of a pulling job on the macaroni tubing 12 as disclosed in the preferred embodiment. Furthermore, the pump unit 99 is of reduced diameter from that shown in the preferred embodiment to permit the use of smaller size tubing. Furthermore, it will be apparent that the reduced diameter of the unit 99 will permit a larger pump to be utilized in standard size tubing to provide an increased displacement of well fluid.

Changes may be made in the combination and arrangement of parts as heretofore set forth in the specification and shown in the drawings, it being understood that any modification in the precise embodiment of the invention may be made within the scope of the following claims without departing from the spirit of the invention.

I claim:

1. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid and a discharge outlet for spent operating fluid, said last-named discharge outlet including a passageway extending axially through said piston rod and communicating with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet.

2. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid and a discharge outlet let for spent operating fluid, said last-named discharge outlet including a passageway extending axially through said piston rod and communicating with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet; and valve means, operable in response to predetermined reciprocal movement of said motor piston for controlling the application of operating fluid pressure to the opposite ends of said motor piston and for controlling the discharge of spent operating fluid from said motor cylinder through said pump fluid discharge outlet.

3. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid and a discharge outlet for spent operating fluid, said last-named discharge outlet including a passageway extending

axially through said piston rod and communicating with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet; and valve means carried by said motor piston and operable in response to predetermined reciprocal movement of said motor piston for controlling the application of operating fluid pressure to the opposite ends of said motor piston and for controlling the discharge of spent operating fluid from said motor cylinder through said pump fluid discharge outlet.

4. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid at one side of said motor piston; said motor piston having a valve-controlled first fluid passageway therethrough adapted, when open, to by-pass operating fluid from said one side to the opposite side of said piston; said motor cylinder having a discharge outlet for spent operating fluid including a valve-controlled second fluid passageway in said motor piston and a passageway extending axially through said piston rod and communicating said second fluid passageway with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet.

5. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid at one side of said motor piston; said motor piston having a valve-controlled first fluid passageway therethrough adapted, when open, to by-pass operating fluid from one side to the opposite side of said piston; said motor cylinder having a discharge outlet for spent operating fluid including a valve-controlled second fluid passageway in said motor piston and a passageway extending axially through said piston rod and communicating said second fluid passageway with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet; and valve means operable in reponse to predetermined reciprocal movement of said motor piston to alternately open one of said piston passageways and close the other piston passageway.

6. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid at one side of said motor piston; said motor piston having a valve-controlled first fluid passageway therethrough adapted, when open, to by-pass operating fluid from said one side to the opposite side of said piston; said motor cylinder having a discharge outlet for spent operating fluid including a valve-controlled second fluid passageway in said motor piston and a passageway extending axially through said piston rod and communicating said second fluid passageway with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet, and valve means carried by said motor piston and operable in response to predetermined reciprocal movement of said motor piston to alternately open one of said piston passageways and close the other piston passageway.

7. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod interconnecting said pistons; said pump cylinder having a suction inlet and a discharge outlet for pump fluid; said motor cylinder having an inlet for operating fluid and a discharge outlet for spent operating fluid, said last-named discharge outlet including a passageway extending axially through said piston rod and communicating with said pump cylinder, whereby spent operating fluid from said motor cylinder is discharged into and through said pump cylinder and through said pump fluid discharge outlet; fluid-actuated main valve means carried by said motor piston for controlling the application of operating fluid pressure to opposite ends of said motor piston and for controlling the discharge of spent operating fluid from said motor cylinder, and pilot valve means carried by said motor piston and operable in response to predetermined reciprocal movement of said motor piston to actuate said main valve means.

8. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder; a piston rod reciprocable in each cylinder; said pump cylinder having suction inlet means and discharge outlet means for pump fluid; said motor cylinder having inlet means for operating fluid and discharge outlet means for spent operating fluid, said last-named discharge outlet means including a passageway extending axially through said piston rod and communicating with said pump cylinder adjacent a pumping face of said pump piston, whereby during a pumping stroke a stream of spent operating fluid is discharged into said pump cylinder adjacent said pumping face of said pump piston to agitate and remove in suspension any sand or other solids which may have accumulated on said pump piston.

9. A fluid-actuated pump comprising, in combination: a motor cylinder, a pump cylinder and a piston reciprocable in each cylinder, each piston dividing its respective cylinder into upper and lower chambers; a piston rod interconnecting said pistons; said pump cylinder having suction inlet means and discharge outlet means for pump fluid; said motor cylinder having inlet means for operating fluid and discharge outlet means for spent operating fluid, said last-named discharge outlet means including a passageway extending axially through said piston rod and communicating with said upper pump chamber adjacent the lower end thereof, whereby during the upward pumping stroke a stream of spent operating fluid is discharged into said upper pump chamber adjacent the upper surface of said pump piston to agitate and remove in suspension any sand or other solids which may have accumulated on said pump piston.

10. In a fluid-actuated deep well pump, the combination of: a double-acting motor including a cylinder and a motor piston reciprocable therein, said piston having oppositely directed faces of different areas, the smaller of said faces being

adapted to be in continuous open communication with a source of operating fluid; a pump including a cylinder and a pump piston reciprocable therein; a piston rod interconnecting said pump and motor pistons, said rod having a fluid passageway extending axially therethrough and communicating at one end with said pump cylinder; and valve means carried by said motor piston and operable to provide communication between the larger of said motor piston faces and, alternately, said source of operating fluid and said fluid passageway in said piston rod.

11. In a fluid-actuated deep well pump, the combination of: a double-acting motor including a cylinder and a motor piston reciprocable therein, said piston having oppositely directed faces of different areas, the smaller of said faces being adapted to be in continuous open communication with a source of operating fluid; a single-acting pump including a cylinder and a pump piston reciprocable therein, said pump piston having a by-pass passage therethrough and a check valve in said passage adapted to close said passage during one stroke and to open said passage to by-pass pump fluid through said piston during the opposite stroke; a piston rod interconnecting said motor and pump pistons, said rod having a fluid passageway extending axially therethrough and communicating at one end with said pump cylinder at the discharge side of said check valve; and valve means carried by said motor piston and operable to provide communication between the larger of said motor piston faces and, alternately, said source of operating fluid and said fluid passageway in said piston rod.

12. In a fluid-actuated deep well pump, the combination of: a double-acting motor including a cylinder and a motor piston reciprocable therein, said piston having oppositely directed faces of different areas, the smaller of said faces being adapted to be in continuous open communication with a source of operating fluid; a single-acting pump including a cylinder and a pump piston reciprocable therein, said pump piston having a by-pass passage therethrough and a check valve in said passage adapted to close said passage during one stroke and to open said passage to by-pass pump fluid through said piston during the opposite stroke; a piston rod interconnecting said motor and pump pistons, said rod having a fluid passageway extending axially therethrough and communicating at one end with said pump cylinder at the discharge side of said check valve; main valve means carried by said motor piston and operable to provide communication between the larger of said motor piston faces and, alternately, said source of operating fluid and said fluid passageway in said piston rod; and pilot valve means operable in response to movement of said pistons to control operation of said main valve means.

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