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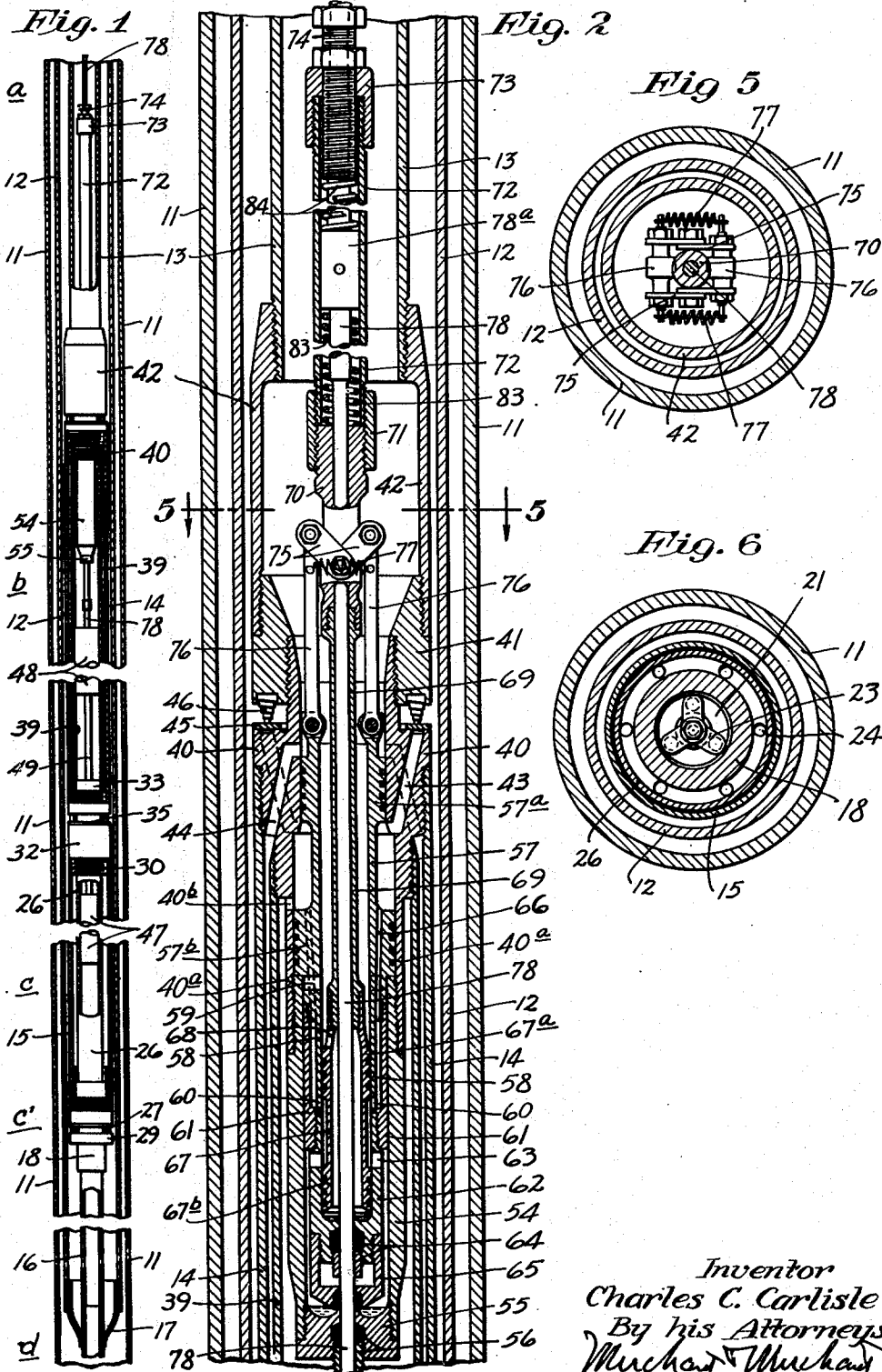
C. C. CARLISLE

2,287,779

DEEP WELL PUMPING MECHANISM

Filed Sept. 18, 1940

3 Sheets-Sheet 1



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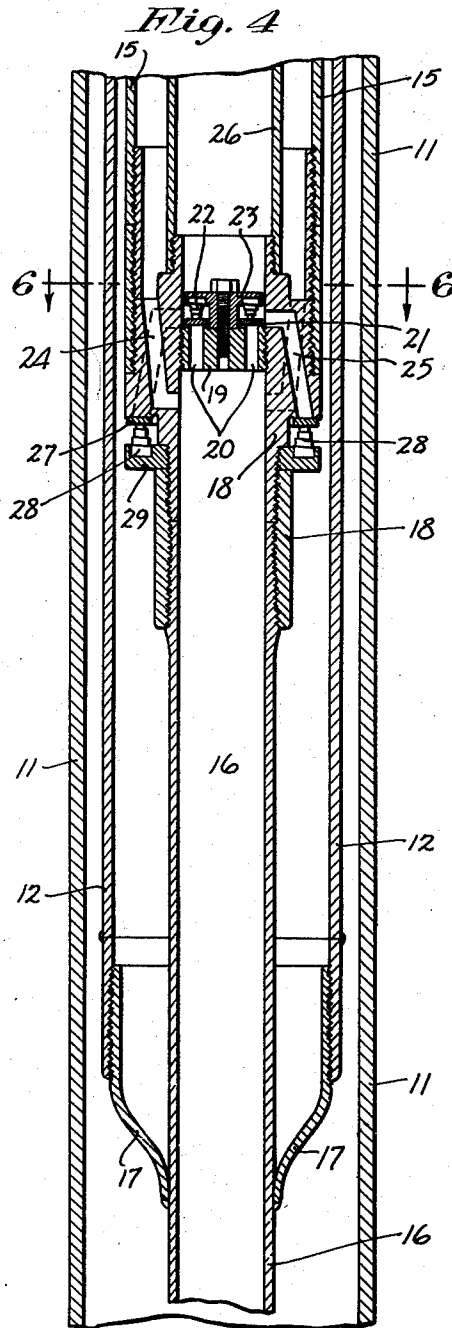
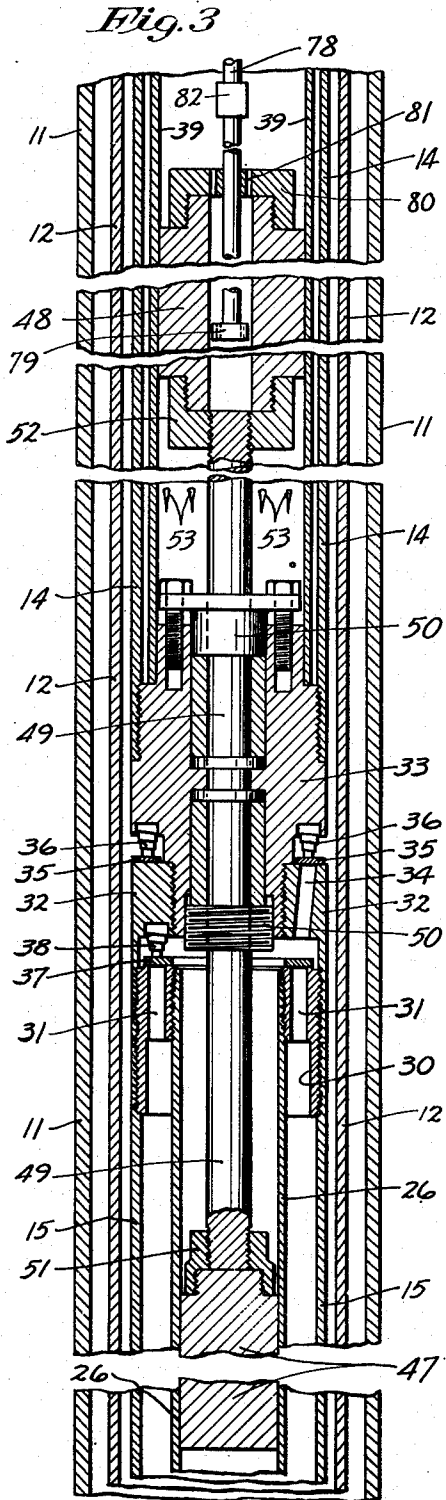
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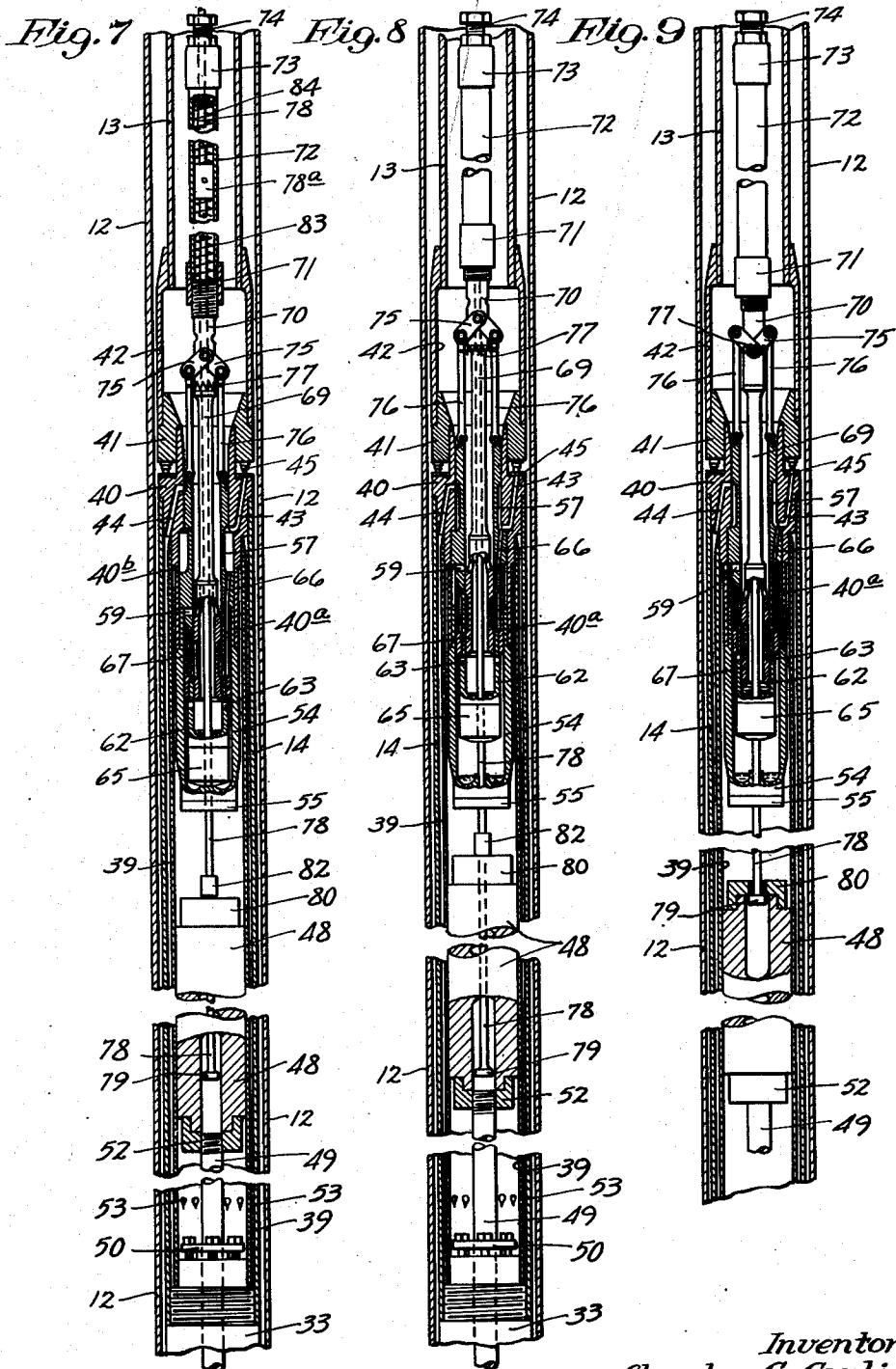
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DEEP WELL PUMPING MECHANISM

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,287,779

DEEP WELL PUMPING MECHANISM

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Application September 18, 1940, Serial No. 357,249

14 Claims. (Cl. 121-157)

My present invention relates to deep well pumping mechanism of the type wherein the pumping mechanism is contained within a tubular casing that is insertable into and readily removable from the tubular well casing of a deep well such as employed in pumping oil from great depths.

The present invention is in the nature of an improvement on, or modification of the pumping mechanism disclosed and more broadly claimed in my prior Patent 2,118,547, issued May 24, 1938, and entitled "Deep well fluid motor." In a deep well pumping mechanism of this character, a cylinder and piston pump and cylinder and piston fluid actuated motor are located in the lower portion of the long tubular pump casing and through a valve mechanism and cooperating devices also located within the pump casing, the piston of the motor is reciprocated by fluid pressure produced at the upper end of the fluid pressure string of tubing and at the top of the well; and the pump piston is connected to the motor piston so that the two pistons are given simultaneous and like reciprocating movements. The arrangement of the valve mechanism is such that the fluid pumped down through the pressure string of tubing to reciprocate the above noted pistons will be commingled with the fluid pumped upward under the reciprocating movements of the motor and pump pistons.

The advantages of the mechanism involved in my prior patent over types of deep well pumps mechanically operated from the top of the well through a long string of sucker rods is very fully discussed in my said prior patent and these now known advantages need not here be repeated to any great length.

Obviously this type of pump mechanism may be used for pumping any or all kinds of fluids from great depths. The principal uses, however, will be the pumping of oil and water, and especially for the pumping of oil from great depths; hence hereafter in this specification the mechanism will be assumed to be for the pumping of oil, and the term oil will be used in a broad and liberal sense.

Generally stated, the objects of the present invention are simplification of construction and low cost of production; smoothness and dependability in the operation; and a certainty of operation of which there is no "dead center," or point where the mechanism might stop or require special manipulation to start it again into action.

The above and other objects accomplished by my present invention will appear in the following description and in the appended claims.

In the accompanying drawings, which show the latest improved form of the invention, like characters indicate like parts throughout the several views.

Referring to the drawings:

Fig. 1 is an axial section with some parts broken away showing the improved fluid-actuated pumping mechanism in its enclosing casing placed within the relatively fixed deep well casing;

Fig. 2 is an axial section of those parts which in Fig. 1 are between the points marked *a* and *b*;

Fig. 3 is an axial section through those parts shown between the points *b* and *c* on Fig. 1.

Fig. 4 is an axial section of those parts shown between the points *c* and *d* on Fig. 1;

Fig. 5 is a transverse section taken on the line 5-5 of Fig. 2;

Fig. 6 is a transverse section taken on the line 6-6 of Fig. 4;

Figs. 7, 8 and 9 are axial sections of those parts which in Fig. 1 are between the points marked *a* and *c'*, certain parts being broken away and some parts being shown in full, the said views 7, 8 and 9 showing the moving parts of the mechanism in different positions.

Advance statement of structure and operation

The pump illustrated and described herein is a double acting pump of the cylinder and reciprocating piston type and is mechanically connected to the piston of a cylinder and piston reciprocating fluid-actuated motor. When it is oil that is being pumped, the motive fluid will likewise be oil, and this motive fluid will, by suitable means, be located at the top of the well, and be pumped down the well to the motor through a central string of tubing. This central string of tubing and its connected parts are located within a second string of tubing of larger diameter which, in turn, is inserted within the tubular well casing.

The pump piston reciprocates as a unit with the motor piston, and at each stroke it draws into the pump cylinder, at one side of the piston, oil from the well and forces out of the pump cylinder at the other side of the piston the oil that was drawn into the cylinder on the previous stroke. The oil discharge from the pump is forced upward through an annular passage between the two strings of tubing, where it meets the oil exhausted from the motor, and the mixture of the two is forced to the top of the well, through an annular passage surrounding the

above mentioned central string of tubing through which the motive fluid is supplied to the pump.

Before describing in detail the various parts of the mechanism, attention is particularly called to Fig. 1, which on a small scale indicates substantially the full length of the pumping mechanism inserted in the well casing. In this view, and in the views on a larger scale, the fixed outer or well casing is indicated at 11. The pump tubing, which will usually be a string of pipe sections, and which is extended within the well casing 11, is indicated by the numeral 12, and, of course, extends to the top of the well and nearly to the bottom of the well. Within the pump tubing 12 is a string of tubes including tubular sections 13, 14, 15 and 16, coupled together by tubular members presently to be described. The lower tube 16 extends to the bottom of the well and to the source of oil well fluid supply, while the lower end of the tube 12 is closed by a swedge nipple 17 connecting with the lower tube 16, as shown in Figs. 1 and 4.

It will of course be noted that the well casing is of considerable larger diameter than the pump tubing 12 so that the pump mechanism can be freely inserted into or removed from the well casing. Also it will be noted that the tubular sections 13, 14, 15 and 16 are spaced from the enclosing tubing 12. The lower or fluid pick-up tube 16, at its upper end, is extended through a tubular coupling 18, the expanded portion of which is threaded into the lower end of tube 15 as best shown in Fig. 4. Within the upper end of tube 16 is a plug or head 19 that has ports 20 normally closed against downward movement of fluid by an annular check valve 21 subject to gravity and springs 22, which latter are compressed between said check valve and a flanged cap 23 secured on the head 19. The expanded portion of the coupling 18 has ports 24, and reversing acting ports 25.

The extreme upper portion of coupling 18 is connected by screw threads, or otherwise to the lower end of a pump cylinder 26 that is located axially within and extends from the tube 15. The ports 24 connect the upper portion of intake tube 16 to the space between the pump cylinder 26 and surrounding tube 15; while the ports 25 connect the lower portion of the pump cylinder to the space between the tubing 12 and tube 16. Ports 25 are normally closed against upward flow of fluid by an annular check valve 27 that is subject to springs 28 seated against a collar 29 secured on the coupling 18. An annular collar 30, by threaded engagement or otherwise, is secured to the upper end of cylinder 26 and to the upper end of tube 15, see particularly Fig. 3. This collar 30 has ports or fluid passages 31. An annular collar 32, by threaded engagement or otherwise, is secured on the threaded upper end of collar 30 and has a thickened upper annular portion, which, as shown, is screw threaded on the reduced end of a coupling head 33, which in turn is screw threaded into the lower end of tube 14. Collar 32 has ports, or fluid passages 34, normally closed against the downward flow of fluid by an annular check valve 35, subject to gravity and to springs 36, which latter react against annular shoulders of the head 33. The ports 31 in thickened portion of collar 30 are normally closed against the downward flow of fluid by an annular check valve 37 subject to gravity and springs 38, which latter react against the annular shoulder of collar 32. The motor cylinder 39, also best shown in Fig. 3, is spaced from the tube 14 and is tele-

scoped with a tight joint around a reduced portion of the coupling head 33. The upper end of the motor cylinder 39, as best shown in Fig. 2, is threaded onto an annular valve housing 40, the reduced portion of which is threaded into coupling collar 41. Collar 41 is shown as threaded into tubular casing 42, which in turn is screw threaded onto the lower end of tube 13. The expanded lower portion of valve housing 40 is also screw threaded into the upper end of tube 14.

Tube 13, it will be remembered, extends to the top of the well and is connected to a source of fluid supply under pressure, which in an oil well will be oil, but in case of a water pumping mechanism will be water. The annular valve housing 40 is provided with ports or fluid passages 43 and 44. The ports 43 are closed against downward flow of fluid by an annular check valve 45 subject to springs 46 that react against the annular shoulder of coupling sleeve 41. Working in the pump cylinder 26 is a pump piston 47 and working in the motor cylinder 39 is a motor piston 48. The said pump and motor pistons are connected for simultaneous and like movements by a piston rod 49, which as shown works through stuffing boxes 50 applied to the coupling head 33. Also in the particular structure illustrated, the lower end of piston rod 49 is connected to pump piston 47 by a threaded coupling cap 51 and the upper end of said rod in a similar manner is connected to the motor piston 48 by a threaded coupling cap 52.

The motor cylinder 39 at points always below the piston 48, is formed with circumferentially spaced ports 53, which are best shown in Fig. 3, and have an upward flare or increased cross section, which assists in producing a cushioning action of the downward movement of the two pistons. The annular valve house or casing 40 has a tubular skirt or portion 40a formed with ports 40b, see Fig. 2.

The valve housing further includes a tubular body 54 which is detachably secured to the skirt 40a, preferably by threaded engagement, and the lower end of which is closed by a detachable head 55 having an axial stuffing box 56.

Working within the valve housing 40 and within the skirt 40a is a reversing valve 57 having piston-like valve heads 57a and 57b, and has a depending skirt 58 formed with ports 59 and 60. The skirt 58 has a supplemental tubular outer portion 61 secured thereto by welded or threaded engagement and extended below said skirt. This supplemental outer portion 61 has a close sliding fit with the tubular body 54. Secured to the lower portion of supplemental section 61 is a tubular section 62 that is formed with ports 63. The lower end of 62 is closed except for a stuffing box 64. An inverted cap 65 is shown as applied to the lower end of said member 62. The lower piston-like head 57b is formed with fluid passages or ports 66 that lead from the space between the heads 57a and 57b down into the annular space that leads to port 60.

Working within the cylinder formed by the skirt 58 of reversing valve 57 and the tubular section 62, which latter has the ports 63, is a pilot valve 67, which has an upper piston-like head 67a, and a lower piston-like head 67b. Above its upper head 67a, tubular pilot valve 67 is provided with ports 68.

Extended axially upward from the pilot valve 67 and through the valve housing or casing 40 is a tubular stem 69. Secured to the upper end of stem 69 is a tubular stem extension member or

portion 70 to which, by a coupling sleeve 71, is attached a tubular plunger guide or stem extension 72. A cap 73 is applied to the upper end of tube 72. An externally threaded tubular member 74 works with threaded engagement through the cap 73. As indicated, the tubular member 70 forms an element of the pilot valve 67. Toggle acting links 75, which are shown in duplicate, see Figs. 2 and 5, are at their inner ends pivotally connected to the stem element 70. Connecting rods 76 are pivoted to the outer ends of the links 75 and to the upper end of reversing valve 57. Coil springs 77 or the like applied to the rods 76 tend to hold the toggles 75 buckled.

Attention is now directed particularly to Figs. 2 and 3. Extended axially through the above mounted members 74, 72, 70 and 69, pilot valve 67, and downward into the axial cavity of the motor piston 48, is a pilot-valve actuating rod 78, which has limited vertical movements with respect to all the members through which it has passed. Within the cavity of the motor piston 48 the rod 78 has a head 79.

In the particular structure illustrated, piston 48 has a rigidly secured but detachable upper end cap 80 with vent passages 81. Under extreme downward movements, cap 80 will engage the head 79 of rod 78, but under extreme upward movements of said piston cap 80 will engage a collar 82 that is rigidly but adjustably secured on said rod 78 above said cap. Within the tubular element 72 of the string of pilot valve stem forming elements, rod 78 has a plunger or collar 78a. Within the said tubular element 72, below collar 78a is a coiled spring 83 that reacts against the upper end of element 70; and in the upper portion of said member 72 above said collar 78a is a coiled spring 84 that reacts against the adjustable screw-acting element 74. The tension of the opposing springs 83 and 84 will be so adjusted that they will tend to hold the pilot valve actuating rod 78 in the position shown in Fig. 3. It will be noted, by reference particularly to Fig. 2, that the cavity of the element 62 below the pilot valve 67 and the bottom forming surface of the head or plug 55, which is below the reversing valve carried element 65, are annularly dished so that sediment or solid material will be flushed and carried out with the flowing stream of oil or fluid. Also within the said annularly dished chamber a limited amount of mercury may be placed if necessary to keep sediment or solid particles from settling within said chamber or pocket, thereby facilitating the flushing out of such sediment at the intermitting flow of fluid therethrough. Likewise, the pocket at the base of pilot valve 67, below 67b, may be supplied with mercury for the same purpose as above stated, if necessary.

In the structure of my prior patent there was provided a "fluid motor" to operate the main slide valve; but in my present improved pump, the main slide valve, which in itself is a reversing valve, is controlled directly by a pilot valve which controls alteration of pressures on the differential cross-sectional areas of said main slide valve or reversing valve, the main elements of which latter are indicated by the numerals 57, 61 and 65. Otherwise stated, in the prior patent, pressure was alternated on opposite sides of the auxiliary or so-called fluid motor which, in turn, operated the main slide valve, but in my present device, the auxiliary motor is eliminated and the main slide valve is operated by alternating pressure on opposite sides thereof. These differences

in structure are highly important not only because the structure is simplified, but because the operation is rendered more certain and all points of dead center or stopping positions, where the device will not be self-starting, are eliminated.

Operation

In the position of the parts shown in Fig. 2, oil under pressure is being forced downward through tube 13, casing 42, cavity of reversing valve housing 40, its ports 44, the annular space between tubes 39—14, and ports 53 into interior of cylinder 39; and the pressure of oil will then force motor piston 48 to move upward carrying with it pump piston 47. The simultaneous upward movements of the motor and pump pistons cause oil to be drawn upward through and into the lower portion of pump cylinder 26, through the tubing 16 and ports 20 and past check valve 21, which freely rises to permit such flow. At this time, oil cannot flow upward through ports 24 partly because of the partial vacuum produced therein at this time and the pressure of oil that is delivered into the upper portion of the pump cylinder under previous strokes.

Under this first noted upward stroke the oil previously delivered into the upper portion of the pump cylinder 26 will be forced upward through ports 34 lifting check valve 35 and from thence upward through the annular space between the tubing 12 and 14 and from thence to the delivery point at the top of the well. Also under this first noted upward movement of the motor and pump pistons, the oil contained in motor cylinder 39 above piston 48 will be forced upward from the upper portion of the motor cylinder 39 through the annular space between said cylinder 39 and housing 54, and thence through ports 40b and 43 lifting check valve 45, and from thence on upward through the annular space between 42 and 12, and 12 and 13 to the top of the well.

When under the upward movement of the two pistons, motor piston 48 engages collar 82 on the pilot rod 78, said rod will be moved upward by and with said motor piston, thereby pressing upward collar 78a of said rod 78 against the action of the upper spring 84, see particularly Fig. 2. When spring 84 has been compressed to a certain predetermined extent it will cause upward snap movement of the elements 72, 70, 69, and pilot valve 67. It will be remembered that the pivotal connection between the toggle links 75 is made directly on the stem extension 70. Hence, when the pilot actuating elements just noted are moved to a predetermined extent so that when this pivotal connection is moved past the dead center, the said toggle will, under tension of spring 77, snap from the position shown in Fig. 2 into the reversed position in Fig. 7. This snapping movement of the toggle from one side to the other of the dead center does not cause any movement of reversing valve 57 in respect to the annular valve housing 40 in which it is mounted. However, the above noted upward movement of the pilot valve actuating stem made up of the several elements noted, moves the pilot valve 67 from the position shown in Fig. 2 into the position shown in Fig. 7. At this time the motor and pump pistons have substantially completed the upward movements. In the position of the valve mechanism incorporating parts shown in Fig. 7, the oil under pressure is forced downward from the tubular casing 42 through the annular valve housing 40, downward through the center of the tubular

reversing valve, through ports 68, through the tubular pilot valve 57 and through ports 63 to the closed bottom of fixed housing 54. The oil thus forced into the bottom of said housing 54 acts on the lower end of inverted cap 65 and imparts an upward movement to the tubular reversing valve 57, which latter is then forced into the position shown in Fig. 8.

In the position of the parts shown in Fig. 8, the oil under pressure of the head of the pump or source of pressure will as before be downward through tubular housing 42 through the interior of the reversing valve 57 through ports 59-40b, through annular space between motor cylinder 39 and valve housing 54 to the top of motor cylinder 48, and this pressure thereby forces the motor piston 48 and the pump piston 47 downward. Under downward movement of the two pistons just noted, the oil from below the motor piston 48 will be discharged through ports 53 into the annular space between the motor cylinder 39 and tube 14, and from thence upward through ports 44 and 43, check valve 45 and into the annular space between tubular casing 42 and 12 to the top of the well.

At this time, and under the same downward piston movements, the oil previously drawn into the pump cylinder 26 will be discharged downward through ports 25 and check valve 27 into the annular space between the tubing 12 and 15.

It will now be noted that the oil pumped down from the top of the well to operate the motor piston is returned to the top of the well with the oil pumped from the bottom of the well.

When the motor and pump pistons closely approach the limit of their downward movements, the head 79 of pilot rod 78 will be engaged by the cap 80 on the top of the motor piston 48, and said rod 78 will be forced downward against the action of lower spring 83, thereby causing the pilot valve and its multisection operating stem, including the elements 70 and 75, to snap back to the positions first noted and shown in Fig. 9. This takes place, prior to movement of the reversing valve, and the pilot valve will be set in respect thereto, so that the flow of the oil will be as follows: the oil under pressure flowing downward through the tubular reversing valve will pass through ports 68, and the interior of the pilot valve 57, to the bottom of the cylindrical chamber in which said pilot valve is mounted. The oil pressure then will act on the top of reversing valve 57 and on the bottom of the cylindrical surface in which the pilot valve is mounted and which cylindrical surface, it will be remembered, is formed in the extension 62 of said reversing valve; and this pressure will move the reversing valve from the position shown in Fig. 9 to the position shown in Fig. 2.

At the time just noted, when the reversing valve is moved back into the position shown in Fig. 2, the pilot valve will, through the connections 76-75, be caused to move with the reversing valve without changing the relative position in respect thereto. When the reversing valve and pilot valve are simultaneously moved downward and back to the position shown in Fig. 2, the flow of the oil caged in the lower end of the valve housing 54 will be forced upward through ports 63, 60, passage 66, ports 43, and past check valve 45, thereby entering the annular space between pump casing 12 and tube casing 42 where it commingles with the oil pumped from the bottom of the well in a manner already described.

Further comments and more detailed description of certain operations

Ports 53 are axially elongated so that when the power piston begins to cover them their effective areas are progressively restricted until the piston reaches the limit of its downward movement. The power piston is further cushioned by the reversing of the pressure fluid to the opposite end of the piston just before it reaches the limit of its stroke in either direction, thereby further cushioning, if not entirely arresting and reversing its motion.

As the links are thus thrust apart, the thrusting force of compressed spring 84 will increase the effective lateral thrust on links 75 as the angle between them approaches 180 degrees. Since this effective thrust increases faster than the resisting force of the springs 77, the movement results in a quick snap action, producing a quick upward movement of the elements 72, 70, 69 and the pilot valve 57. It will be remembered that the pivotal connections between the toggle links 75 are made directly on the stem extension 70. Hence when the pilot actuating elements just noted are moved through toggle action, this pivotal connection is moved, in snap action, by the compressed spring 84, through and past dead center of the toggles and from which latter position onward by the assistance of contracting springs 77, from the position shown in Fig. 2, into the reverse position in Fig. 7.

It will be noted that the parts of reversing valve 57 are so designed and constructed that 57a, 57b, and 61, each has circular cross-sectional areas so proportioned that they have proper differential areas exposed to the operating pressure. When pilot valve 57 is moved from one extreme position to the other, thus alternating opening and closing ports 63, the resulting fluid pressure on the differential areas of the main or reversing valve 57 will cause alternations of the latter.

It will be noted that the fluid pressure in the chamber around the valve 57 between 57a and 57b and through port 59 is constantly the static or discharge pressure as in the annular space between tubing sections 12 and 14 and that the pressure within the reversing changing valve 57, on top of the upper end of 57a and in the valve chamber below pilot valve 57 is constantly equal to that of the pressure fluid within tubing 12, while that within the chamber below cap 65 within the chamber encompassing it varies between that of the pressure fluid within tubing 12, and the discharge pressure within the annular space between tubings 12 and 14, depending on the position of pilot valve end 67b, that is, whether it is above or below port 63.

The cross-sectional areas of valve 57 and its associated parts are so proportioned that such areas multiplied by the pressure in contact with them are such that the valve 57 is forced to move within its restricted limits as the pilot valve 57 uncovers or blocks the passage of pressure fluid through port 63 and thereby changes the fluid pressure within the power cylinder 39, alternately on the ends of power piston 48, all as heretofore described.

What I claim is:

1. In an apparatus of the character described, a motor cylinder, a motor piston in said cylinder, a reversing valve casing connected with the motor cylinder, a reversing valve slidable in the casing and adapted to alternately connect the

opposite ends of the motor cylinder with a high pressure fluid supply and with a low pressure exhaust, an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber, a pilot valve slidable in said extension of the reversing valve to alternately connect the high pressure fluid supply with said chamber and with said low pressure exhaust to effect movement of the reversing valve in the casing, and a reciprocating member having lost motion connection with the motor piston and having connection with said pilot valve to effect shifting of the pilot valve in selective positions of the motor piston.

2. In an apparatus of the character described, a motor cylinder, a motor piston in said cylinder, a reversing valve casing connected with the motor cylinder, a reversing valve slidable in the casing and adapted to alternately connect the opposite ends of the motor cylinder with a high pressure fluid supply and with a low pressure exhaust, an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber, a pilot valve slidable in said extension to alternately connect the high pressure fluid supply with said pressure chamber and with said low pressure exhaust to effect movement of the reversing valve in the casing, a reciprocating member having lost motion connection with the motor piston and having connection with said pilot valve for shifting of the pilot valve in said reversing valve at selected positions of the motor piston to effect alternate admission and exhaust of the high pressure fluid to and from said chamber for moving the reversing valve, and connecting means between the pilot valve and the reversing valve to maintain relative position of said valves during movement of the reversing valve.

3. In an apparatus of the character described, a motor cylinder, a motor piston in said cylinder, a reversing valve casing connected with the motor cylinder, a reversing valve slidable in the casing and adapted to alternately connect the opposite ends of the motor cylinder with a high pressure fluid supply and with a low pressure exhaust, an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber, a pilot valve slidable in said extension to alternately connect the high pressure fluid supply with said high and low pressure chamber and with said low pressure exhaust to effect movement of the reversing valve in the casing, a reciprocating member having lost motion connection with the motor piston and having yielding connection with said pilot valve to effect shifting of the pilot valve in selective positions of the motor piston to effect alternate admission and exhaust of the high pressure fluid to and from said chamber for moving the reversing valve in said cylinder, and a snap acting toggle connection between the pilot valve and the reversing valve, said toggle connection being adapted to maintain relative position of said valves during movement of the reversing valve.

4. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing having spaced ports connected with the motor cylinder on opposite sides of the motor piston and having an exhaust port, a reversing valve slidable in the casing and adapted to alternately connect said spaced ports with a high pressure fluid supply for effecting reciprocation of said motor piston,

an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber and having a port connected with the exhaust port and a port connected with said chamber, a pilot valve slidable within said extension to alternately connect the port which is connected with said chamber with the port which is connected with the low pressure exhaust and with the high pressure fluid supply, and a reciprocating member having lost motion connection with the motor piston and a connection with the pilot valve to effect shifting of the pilot valve in said extension.

5. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing having spaced ports connected with the motor cylinder on opposite sides of the motor piston and having an exhaust port, a reversing valve slidable in the casing and adapted to alternately connect said spaced ports with a high pressure fluid supply for effecting reciprocation of said motor piston, an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber and having a port connected with the exhaust port and a port connected with said chamber, a pilot valve slidable within said extension to alternately connect the port which is connected with said chamber with the port which is connected with the low pressure exhaust and with the high pressure fluid supply, a reciprocating member having lost motion connection with the motor piston and a yieldable connection with the pilot valve to effect shifting of the pilot valve in said extension, and a snap acting connection between the pilot and reversing valves.

6. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing connected with the motor cylinder, a tubular reversing valve adapted for reciprocation in the reversing valve casing for controlling inlet and discharge of high pressure fluid to the motor cylinder for reciprocating said motor piston, an extension on the reciprocable valve and cooperating with the reversing valve casing to form an alternate high and low pressure chamber, a tubular pilot valve reciprocable in said extension for alternately admitting a high pressure fluid to said chamber and to exhaust said pressure for effecting reciprocation of the reversing valve, a tubular stem connected with the pilot valve and extending through the reversing valve, a rod extending through said stem and having lost motion connection with the motor piston, a collar on said rod, a spring housing connected with the pilot valve stem, coil springs sleeved over the rod on the respective sides of the collar and enclosed in said housing, toggle links having connection with the pilot valve stem, links connecting the toggle links with said reversing valve, and springs normally retaining the toggle links in collapsed position.

7. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing connected with the motor cylinder, a tubular reversing valve adapted for reciprocation in the reversing valve casing for controlling inlet and discharge of high pressure fluid to the motor cylinder for reciprocating said motor piston, an extension on the reciprocable valve and cooperating with the reversing valve casing to form an alternate high and low pressure chamber, a tubular pilot valve reciprocable in said extension for alternately admitting a high pressure fluid to said chamber and to exhaust

said pressure for effecting reciprocation of the reversing valve, a tubular stem connected with the pilot valve and extending through the reversing valve, a rod extending through said stem, spaced stops on said rod, means on the motor piston for engaging said stops to shift the rod, a collar on said rod, a spring housing connected with the pilot valve stem, coil springs sleeved over the rod on the respective sides of the collar and enclosed in said spring housing, toggle links having connection with the pilot valve stem, links connecting the toggle links with said reciprocable valve, and springs normally retaining the toggle links in collapsed position.

8. In an apparatus of the character described, a motor cylinder, a motor piston in said cylinder, a reversing valve casing connected with the motor cylinder, a reversing valve slidable in the casing and adapted to alternately connect the opposite ends of the motor cylinder with a high pressure fluid supply and with a low pressure exhaust, an extension on said slide valve cooperating with the valve casing to form an alternate high and low pressure chamber and having a greater effective pressure area than the effective area of said reversing valve, a pilot valve slidable in said extension to alternately connect the high pressure fluid supply with said high and low pressure chamber and with said low pressure exhaust to effect movement of the reversing valve in the casing, and a reciprocating member having lost motion connection with the motor piston and having connection with said pilot valve to effect shifting of the pilot valve in selective positions of the motor piston.

9. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing having spaced ports connected with the motor cylinder on opposite sides of the motor piston and having an exhaust port, a reversing valve having piston-like heads of differential diameters movable over the spaced ports alternately admitting a high pressure fluid to the respective ends of the motor cylinder and to exhaust said fluid for effecting reciprocation of said motor piston, an extension on said valve having a differential diameter than the piston-like heads and cooperating with the valve casing to form an alternate high and low pressure chamber and having a port connected with the exhaust port and a port connected with said chamber, a pilot valve slidable within said extension to alternately connect the port which is connected with said chamber with the port which is connected with the low pressure exhaust and with the high pressure fluid supply, a reciprocating member having lost motion connection with the motor piston and a connection with the pilot valve to effect shifting of the pilot valve in said extension, and a snap acting toggle connecting the pilot and reversing valves.

10. In an apparatus of the character described, a motor cylinder, a motor piston in the cylinder, a reversing valve casing connected with the motor cylinder, a tubular reversing valve adapted for reciprocation in the reversing valve casing for controlling inlet and discharge of high pressure fluid to the motor cylinder for reciprocating said motor piston, an extension on the reciprocable valve and cooperating with the reversing valve casing to form an alternate high and low

pressure chamber, a tubular pilot valve reciprocable in said extension for alternately admitting a high pressure fluid to said chamber and to exhaust said pressure for effecting reciprocation of the reversing valve, a tubular stem connected with the pilot valve and extending through the reversing valve, a rod extending through said stem, spaced stops on said rod, means on the motor piston for engaging said stops to shift the rod, a collar on said rod, a spring housing connected with the pilot valve stem, coil springs sleeved over the rod on the respective sides of the collar and enclosed in said spring housing, toggle links having connection with the pilot valve stem, links connecting the toggle links with said reciprocable valve, springs normally retaining the toggle links in collapsed position, and packing means sealing the rod relatively to said extension and the reversing valve casing.

11. In an apparatus of the character described, a reversing valve casing having an annularly dished pocket in an end thereof, a reversing valve slidable in the casing, an extension on said valve having an end cooperating with said pocket to form an alternate high and low pressure chamber, and a pilot valve slidable in said extension to alternately connect a high pressure fluid supply with said pressure chamber to effect shifting of the reversing valve.

12. In an apparatus of the character described, a reversing valve casing having an annularly dished pocket in an end thereof, a reversing valve slidable in the casing, an extension on said valve having an end cooperating with said pocket to form an alternate high and low pressure chamber and having an interior pilot valve chamber provided with a similarly shaped pocket, and a pilot valve slidable in the chamber of said extension to alternately connect a high pressure fluid supply with said pressure chamber, said high pressure fluid being admitted to said pilot valve chamber coaxially of the pilot valve for effecting a flushing action relatively to said pocket therein.

13. In an apparatus of the character described, a reversing valve casing having an annularly dished pocket in an end thereof, a reversing valve slidable in the casing, an extension on said valve having an end cooperating with said pocket to form an alternate high and low pressure chamber, a pilot valve slidable in said extension to alternately connect a high pressure fluid supply with said pressure chamber, and a body of mercury contained in said pocket.

14. In an apparatus of the character described, a reversing valve casing having an annularly dished pocket in an end thereof, a reversing valve slidable in the casing, an extension on said valve having an end cooperating with said pocket to form an alternate high and low pressure chamber and having an interior pilot valve chamber provided with a similarly shaped pocket, a pilot valve slidable in the chamber of said extension to alternately connect a high pressure fluid supply with said pressure chamber, said high pressure fluid being admitted to said pilot valve chamber coaxially of the pilot valve for effecting a flushing action relatively to said pocket therein, and bodies of mercury contained in said pockets.

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