

June 25, 1935.

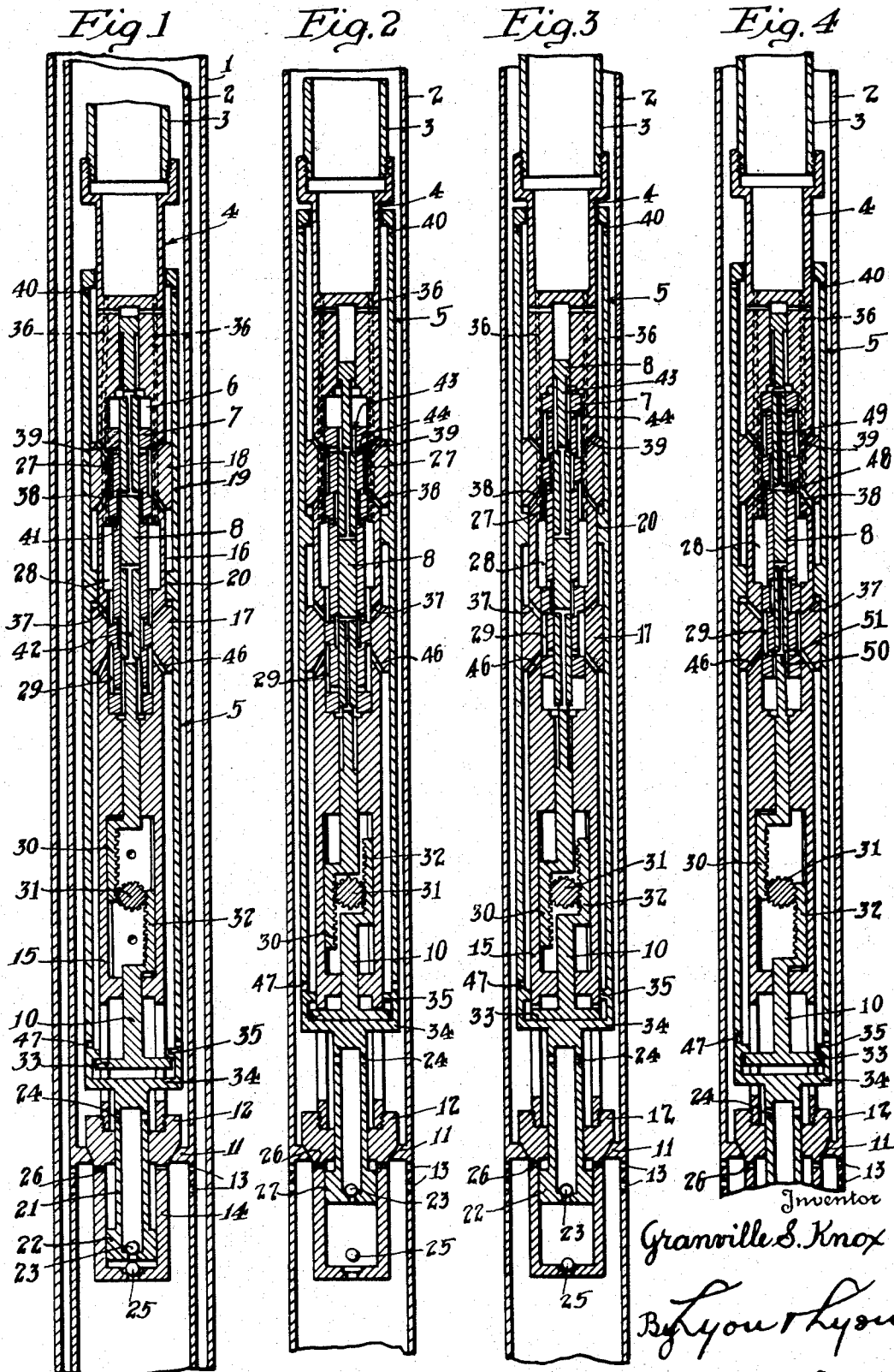
G. S. KNOX

2,005,995

RODLESS PUMP

Filed May 29, 1934

5 Sheets-Sheet 1



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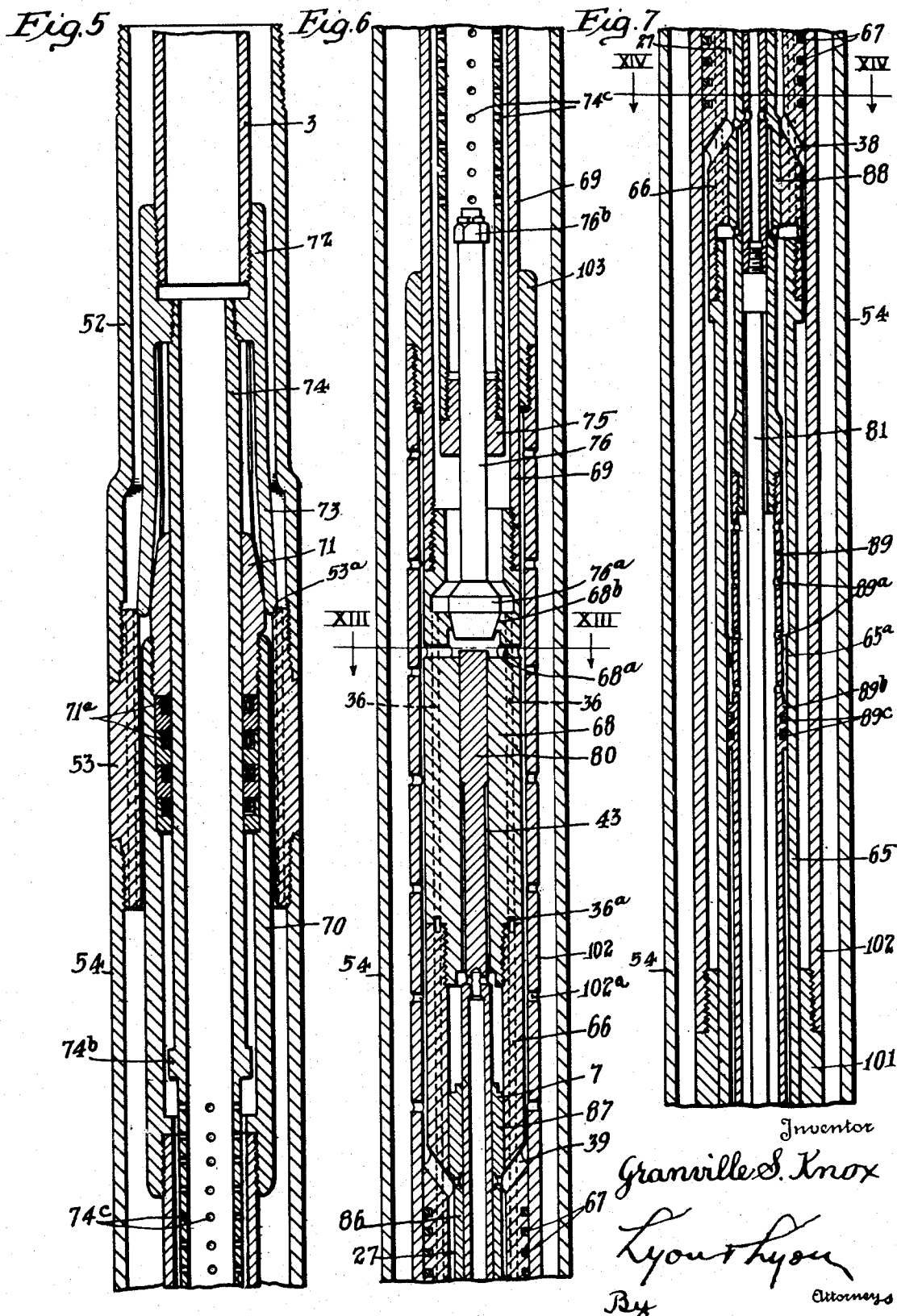
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Fig. 8

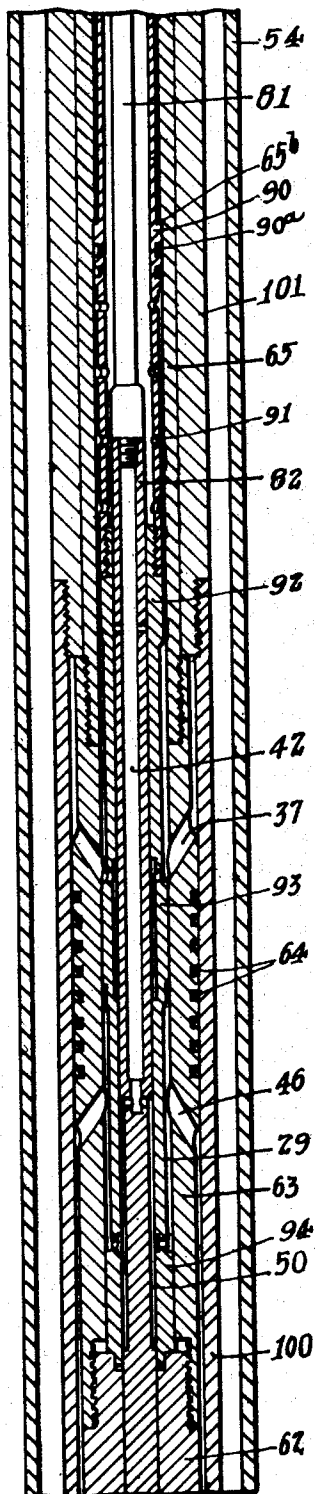


Fig. 9

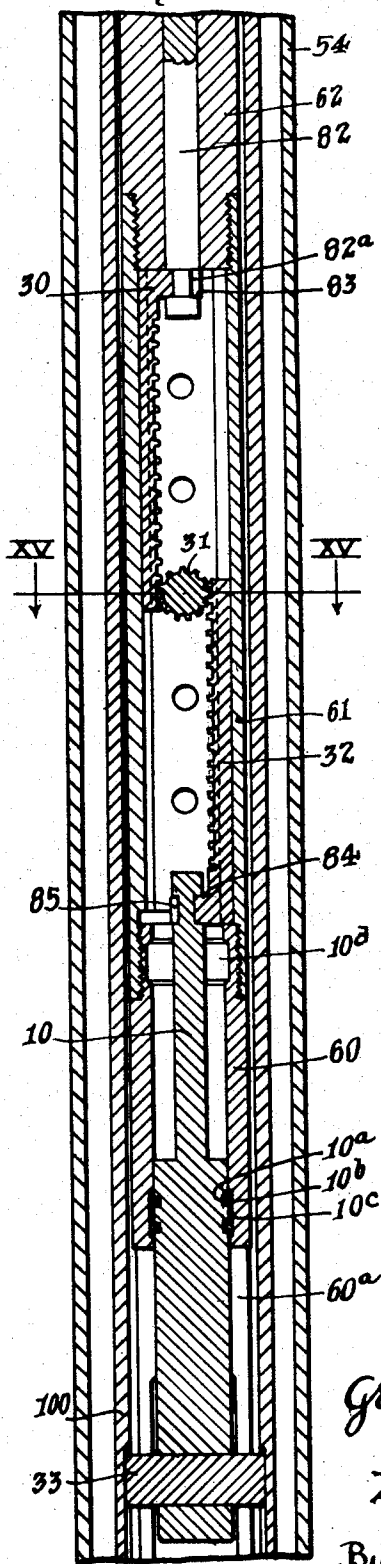
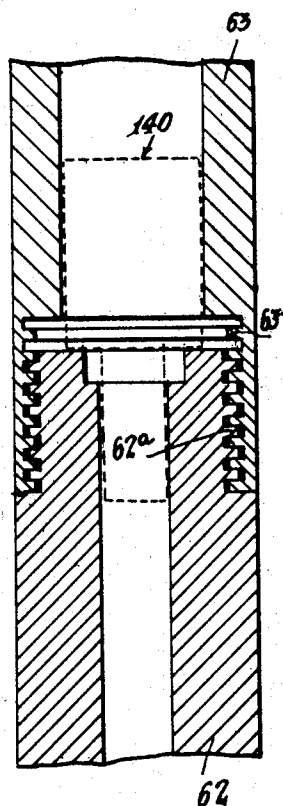


Fig. 19



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Fig. 10

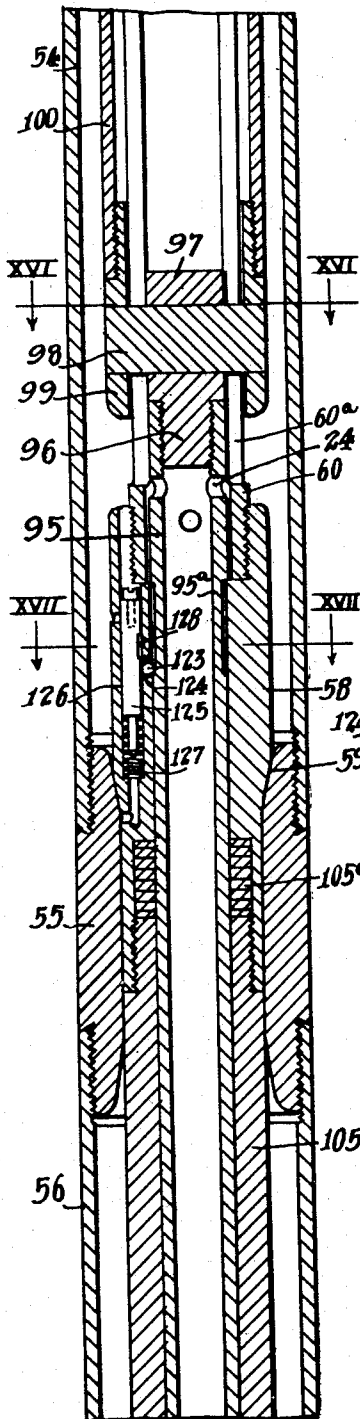


Fig. 10A

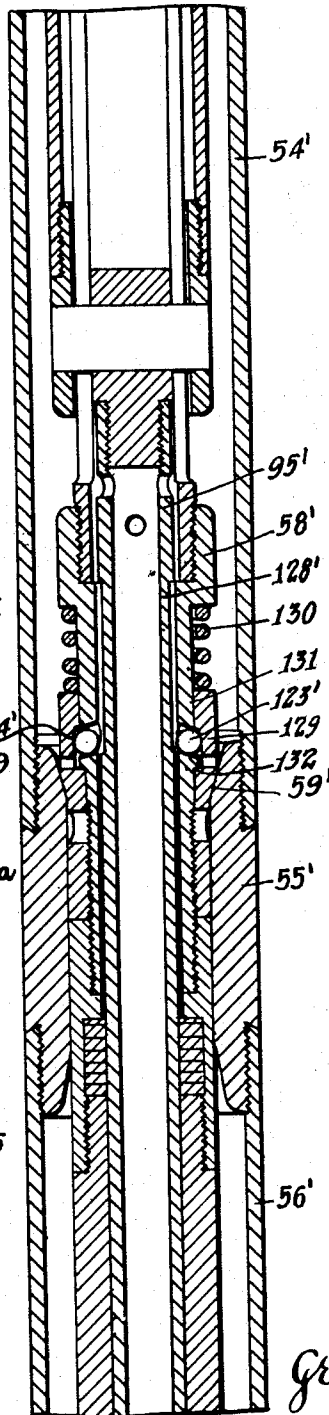
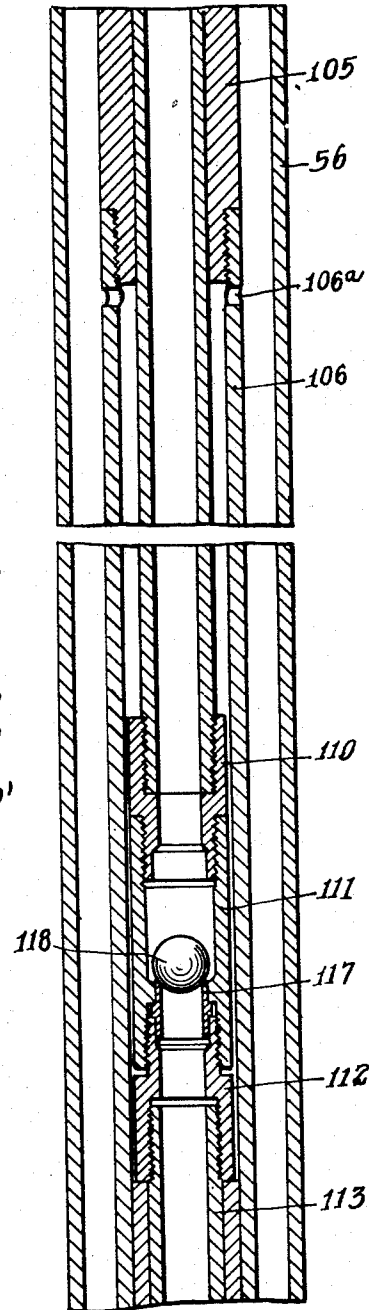


Fig. 11



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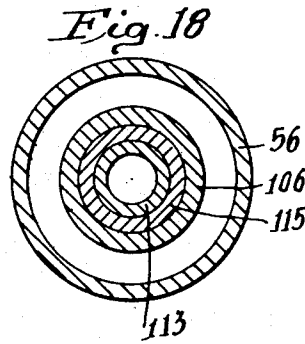
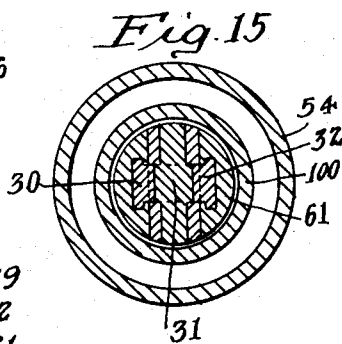
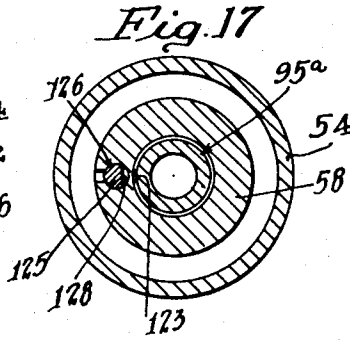
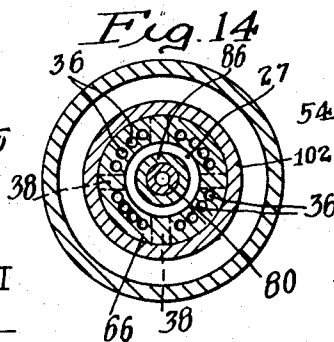
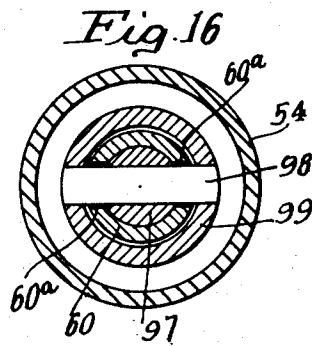
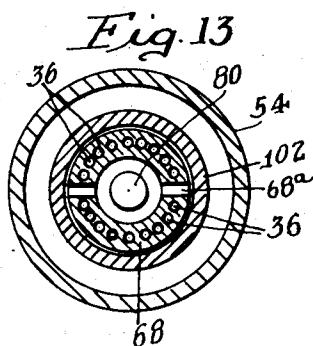
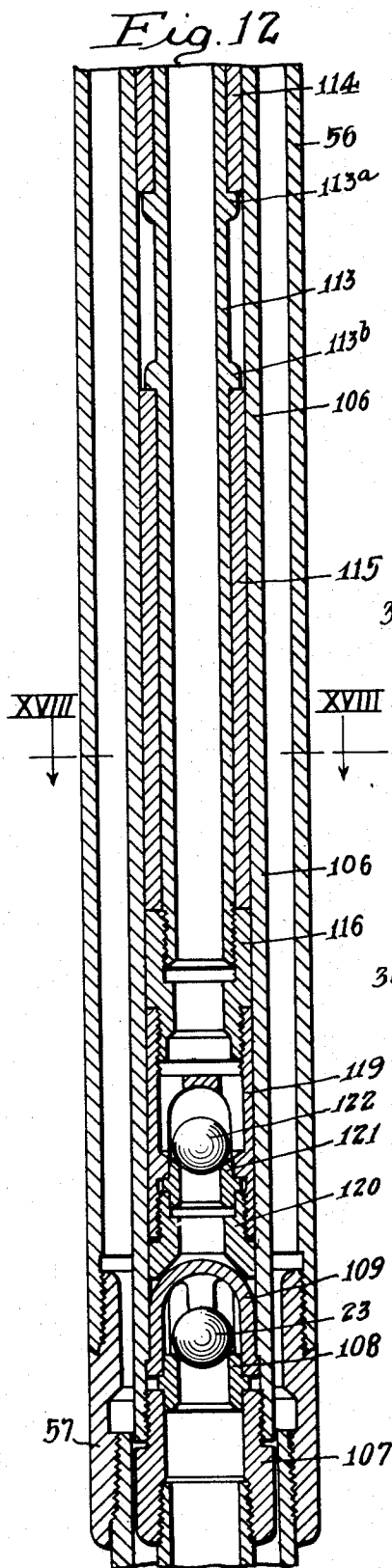
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UNITED STATES PATENT OFFICE

2,005,995

RODLESS PUMP

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Application May 29, 1934, Serial No. 728,078

15 Claims. (Cl. 103—46)

This invention relates to self-contained or rodless pumps for oil wells, in which the pump unit itself contains a hydraulic motor for reciprocating the pump plunger, the motor being actuated by oil at high pressure delivered from a source at the surface to the motor through small central tubing extending down through the well within the oil tubing through which pumped oil is discharged from the pump up to the surface.

In view of the obvious advantages of pumps of the general type to which this invention relates over conventional sucker rod pumps, many attempts have been made to develop commercially successful rodless pumps. However, serious obstacles have been encountered during this development. One defect of pumps which have been otherwise satisfactory is that their over all diameter has been too great to permit their entry into oil tubing of the small dimensions necessary in many deep wells, thereby necessitating the mounting of the pump on the lower end of the oil tubing. The disadvantage of this arrangement is that both the inner and outer tubing strings have to be pulled whenever the pump is removed. On the other hand, a pump small enough to enter into the outer tubing string can be removed by pulling only the inner tubing without disturbing the outer tubing.

It has been impracticable to reduce the over-all diameter of rodless pumps, as they have been previously designed, below definite limits because, to the best of my knowledge, such pumps comprised tubular body members containing pump and/or motor barrels with several fluid passages extending past one at least of the barrels and, if the over all diameter of the body member were reduced in size, it was necessary to reduce the size of the barrel or of the fluid passages to such an extent as to greatly reduce the capacity of the pump.

An important object of the present invention is to reduce the over all diameter of a rodless pump sufficient to permit its insertion in oil tubing of reasonable size without unduly decreasing its efficiency of operation. This object is attained by employing in the motor a traveling barrel and stationary piston construction instead of the usual stationary barrel and traveling piston, and positioning the valve mechanism which controls the flow of fluid to and from the working chamber of the motor within the stationary piston assembly. This permits the use of short fluid passages extending through the piston assembly instead of longitudinally outside of the barrel, for

carrying fluid to and from the working chamber.

Another object of the invention is to provide a rodless pump assembly in which the pump is readily removable as a unit from the motor without disassembling the motor. This permits the use of the same motor operated by fluid at the same pressure in wells of different depths by merely substituting pumping units of different capacities. It also permits ready replacement of a worn pumping unit.

Another object is to provide a rodless pumping unit in which the motor is fully enclosed and all its moving parts protected from contact with pumped oil from the well, which pumped oil often contains sand and grit destructive to a moving mechanism.

Another object is to provide a pump structure adapted to be attached to the lower end of the inner tubing and lowered into and removable from the well on the inner tubing but in which the weight of the inner tubing is supported from the outer tubing independent of the pump when the latter is in working position, thereby preventing possible distortion of the pump by the weight of the inner tubing.

Another object is to provide a floating working barrel in the motor supported only at one end so that it automatically aligns itself with the plunger and is also relieved of all unnecessary compression or tension strains which might tend to warp the barrel and freeze the enclosed plunger.

Another object is to provide a rodless pump motor having a hydraulically actuated working valve, which valve is light in weight, has a short stroke and is cushioned at the end of each stroke to eliminate shock and thereby insure long life and high efficiency.

Another object is to provide a simple and positive locking mechanism for holding the valve mechanism in a desired position while the pump is being transported to and lowered into a well, whereby any necessity for priming the motor at the surface before lowering it into the well is eliminated. Heretofore with pumps of this type such priming has been necessary to fluid-lock the valve mechanism in an operative position.

Other objects and various specific features of the invention will become apparent from the following detailed description which refers to the drawings.

In the drawings:

Figs. 1 to 4 are schematic diagrams illustrating the principle of operation of my pump, the four

figures disclosing the various moving elements of the pump in different positions of operation;

Figs. 5, 6, 7, 8, 9, 10, 11 and 12 are longitudinal sectional views of successive portions of a pump in accordance with the invention as it would be actually constructed, Fig. 5 showing the upper end of the unit and Fig. 12 the lower end;

Fig. 10A is a longitudinal sectional view showing a modification of that portion of the pump structure disclosed in Fig. 10;

Fig. 13 is a cross section of the pump taken in the plane XIII—XIII of Fig. 6;

Fig. 14 is a cross section taken in the plane XIV—XIV of Fig. 7;

Fig. 15 is a cross section taken in the plane XV—XV of Fig. 9;

Fig. 16 is a cross section taken in the plane XVI—XVI of Fig. 10;

Fig. 17 is a cross section taken in the plane XVII—XVII of Fig. 10;

Fig. 18 is a cross section taken in the plane XVIII—XVIII of Fig. 12, and

Fig. 19 is a detail vertical section illustrating a preferred method of joining adjacent sections of my pump.

Principles of operation

A complete understanding of the construction and operation of my pump can be most quickly conveyed by first explaining the general principles of operation with reference to the schematic diagrams of Figs. 1, 2, 3, and 4 and then following through the details of construction of an actual pump as disclosed in Figs. 5 to 18, inclusive.

Referring to Fig. 1, there is shown a well casing 1, within which are positioned an outer tubing string 2 and an inner tubing string 3, these strings extending from that portion of the casing in which the pump is located upwardly through the casing to the surface. The outer tubing 2 constitutes the usual oil tubing through which pumped oil is delivered to the surface. The inner tubing 3 constitutes a conduit for the transmission of clean oil at high pressure from the surface down to the pump unit for operating the latter. It is to be understood that the outer tubing 2 may be extended clear to the bottom of the well and be supported, in part at least, by an anchor placed on the lower end thereof. Ordinarily, of course, the pumping unit is positioned closely adjacent the bottom of the well and submerged in the oil which stands in the casing 1.

The pumping unit when positioned in the well is supported from the outer tubing 2 and to this end the tubing is provided with an inwardly projecting shoulder 11, the inner edge of which is beveled to constitute a seat for supporting and sealing with a block 12 on a stationary motor plunger and pump barrel assembly 4. Block 12 and shoulder 11 together constitute a partition in the outer tubing 2 so that exhaust oil from the motor and pumped oil from the pump delivered into the outer tubing 2 above the shoulder 11 will be discharged to the surface of the well, whereas that portion of the tubing 2 below the shoulder 11 will be filled with oil from the well, this oil being permitted to enter through apertures 13. The component parts of the stationary motor plunger and pump barrel assembly 4 include a pump barrel 14 extending downwardly below the block 13, a connecting stem 15 extending upwardly from the block 12 to the plunger proper 16 having a lower shoulder 17 and an upper shoulder 18, which plunger is connected at

its upper end to the lower end of the inner tubing 3.

The traveling motor barrel and pump plunger assembly 5 comprises a barrel 19 which seals with the shoulders 17 and 18, and together with those shoulders and the portion of the motor plunger therebetween, defines the working chamber of the motor. The barrel 19 is provided with an inwardly extending shoulder 20 positioned intermediate the shoulders 17 and 18 on the plunger and which seals with the plunger and constitutes the moving piston of the motor. The barrel 19 is secured at its lower end to a pump plunger rod 21 which extends through and seals with the block 12 and terminates in a pump plunger 22. The plunger rod 21 is hollow, as shown, and is provided with a ball check valve 23 at the lower end. The upper end of the passage within the plunger rod 21 communicates through ports 24 with the interior of the outer tubing 2 above the shoulder 11. The pump barrel 14 is provided with a standing valve 25 in the lower end thereof and with surge ports 26 in its upper end, these ports communicating with the space below the shoulder 11 in the outer tubing.

That portion of the stationary motor plunger assembly positioned within the working chamber of the motor is hollow, constituting a valve chest 6, within which there is mounted a vertically reciprocable piston valve 7, the latter being provided with four vertically spaced shoulders which seal with the walls of the valve chest and define with the walls of the valve chest three chambers or pockets 27, 28 and 29, respectively. The piston valve 7 is actuated by fluid pressure delivered successively to opposite ends thereof and, to control the admission of the pressure fluid to the ends of the piston valve, an auxiliary valve 8 is provided.

This auxiliary valve 8 constitutes a rod extending through the valve chest and through the main valve 7 therein and sealing in guide channels in the stationary plunger assembly at opposite ends of the valve chest 6. The auxiliary valve 8 is adapted to be reciprocated by the traveling barrel of the motor through the medium of a motion reversing mechanism. Thus the lower end of the auxiliary valve 8 is secured to a rack 30 meshing with a pinion 31 rotatably supported within the stationary plunger assembly 4, which pinion also meshes with a rack 32 connected to an actuating rod 10 provided with a cross head 33 on its lower end which is engaged either by a cross head 34 or a shoulder 35 on the traveling barrel assembly.

The remaining structural details of the mechanism disclosed in the schematic diagram of Fig. 1 will be described in connection with the description of operation which follows.

Assume that all the elements of the mechanism are in the position shown in Fig. 1, that the lower portion at least of the outer tubing 2 is submerged in well oil in the casing 1, that the outer tubing 2 is connected at the surface to a discharge line for pumped oil, and that a substantially continuous stream of clean oil (hereinafter referred to as pressure oil) is forced down from the surface through the inner tubing 3.

The pressure fluid from tubing 3 passes through longitudinal passages 36 into the pocket 28 of the valve 7, from which it is admitted through passages 37 to the under side of the shoulder 20 on the traveling barrel, which shoulder constitutes the moving piston in the working chamber. It will be observed that at the same time the upper

end of the working chamber above the shoulder 20 is connected by passage 38 to valve pocket 27 which, with the valve 7 in lowermost position, is connected through exhaust passages 39 to the space surrounding the stationary motor plunger and within the projecting upper end of the traveling barrel 19. This space within the upper end of the traveling barrel is vented to the outer tubing through ports 40 at the upper end of the barrel.

The traveling barrel thereupon moves upwardly, carrying with it the pump plunger 22. Movement of the pump plunger rod 21 upwardly through the block 12 displaces a quantity of oil in the outer tubing 2 in which the pump mechanism is submerged, forcing this oil upwardly to the surface through the tubing 2. At the same time the upward movement of the traveling motor barrel and pump plunger assembly 5 causes the cross head 34 to engage the cross head 33 on the auxiliary valve actuating rod 18, moving the latter upwardly and causing the rack 32 to rotate the pinion 31 in a counterclockwise direction, thereby forcing the rack 33 and the auxiliary valve 8 downwardly. The traveling motor barrel and pump plunger assembly 5 continue their upward movement and the auxiliary valve 8 continues its downward movement until the parts are in the relative position shown in Fig. 2. (It will be observed that in Figs. 2, 3 and 4, the well casing 1 has been omitted to simplify the drawings).

With the parts in the position shown in Fig. 2, the central valve pocket 28, which is at all times supplied with pressure fluid from the inner tubing string 3 through the passages 36, is connected through passages 41 in the piston valve 7 with a passage 42 in the auxiliary valve 8, the opposite end of which passage communicates with the extreme lower end of the valve chest 6, thereby applying pressure fluid to the under end of the piston valve 7. In the position of the parts shown in Fig. 2, the upper end of the valve chest 6 is connected by passages 43 in the auxiliary valve 8 and passages 44 in the piston valve with the upper pocket 27 of the piston valve, which pocket is also connected to the exhaust passage 39 leading to the exterior of the plunger rod. As a result of the differential pressure between the pressure fluid supplied through the inner tubing 3 and the pumped fluid and exhaust fluid in the outer tubing 2 applied to the piston valve 7, the latter moves upwardly into the position shown in Fig. 3.

With the parts in the position shown in Fig. 3 pressure fluid from the valve pocket 28 is applied through passages 38 to the upper end of the working chamber above the shoulder 20, which constitutes the moving piston within the working chamber, and the lower end of the working chamber is connected through passages 37 to the lower valve pocket 29, which is connected through exhaust passages 46 to the space surrounding the plunger below the shoulder 17, from which space exhaust fluid is exhausted through ports 47 to the outer tubing 2 and thence up to the surface. The differential pressure acting upon the shoulder 20 thereupon forces the latter, together with the traveling motor barrel and pump plunger assembly 5, down into the position shown in Fig. 4.

During the preceding upward movement of the pump plunger 22 oil was drawn into the pump barrel 14 through the standing valve 25. Therefore, during the downward movement of the pump plunger 22 the fluid previously drawn into the pump barrel is displaced upwardly past the check valve 23 in the pump plunger through

the hollow pump plunger and the ports 24 into the outer tubing 2. The area of the pump plunger rod 21 is preferably equal to half the area of the plunger 22 so that equal quantities of pump fluid are discharged into the outer tubing 2 on both the up and down strokes of the plunger.

Of course, as the traveling motor barrel and pump plunger assembly 5 travel down into the position shown in Fig. 4, the auxiliary valve 8 was moved into its uppermost position. In this position pressure fluid is admitted from the pocket 28 in the valve 7 through passages 48 in the main valve and passage 49 in the auxiliary valve to the upper end of the valve chest, thereby applying pressure fluid to the upper end of the piston valve. At the same time the lower end of the valve chest is connected through passages 50 in the auxiliary valve and passages 51 in the main valve with the valve pocket 29, which is connected through passages 46 with the outer tubing. The piston valve 7 thereupon moves downwardly into the lowermost position in which all of the parts are positioned as shown in Fig. 1, thereby completing a cycle of operation.

It is essential to the proper operation of a pump mechanism of the type described that the piston valve 7 substantially complete its movement before the traveling barrel of the motor begins to move and it is also important that the valve thereafter remain in the end position to which it was last moved until the traveling barrel has completed its movement.

Completion of the movement of the piston valve before any appreciable movement of the traveling barrel is effected in the mechanism disclosed by virtue of the fact that the pressure of the operating fluid required to shift the piston valve is less than that required to shift the traveling barrel. Thus the upper and lower faces of the piston valve are of equal areas so that the differential pressure required to shift the piston valve is only that necessary to overcome the friction between the sliding parts. On the other hand, a greater differential pressure between the operating fluid supplied through the inner tubing 3 and the exhaust fluid and pump fluid discharged through the tubing 2 is required to shift the traveling barrel because movement of the latter is not only opposed by the pressure of the exhaust fluid acting against the end of shoulder 20 (the area of both ends of which are the same) but also by the pressure of the exhaust fluid acting against the pump plunger. In other words, the exhaust fluid is always exerting its pressure against an area on the traveling motor barrel and pump plunger assembly that is larger than the area to which pressure fluid is applied, whereas the surfaces of the piston valve exposed to pressure fluid and exhaust fluid, respectively, are always equal.

After having been once moved to an end position, the piston valve is urged to remain in that position not only because of the pressure fluid trapped in the opposite end of the valve chest but also by virtue of the fact that the auxiliary valve 8 is moved, during the major portion of the movement of the traveling barrel, in a direction tending to maintain the piston valve in the end position to which it was last shifted. Thus, in Fig. 1 the piston valve 7 is in lowermost position and during the upward movement of the traveling barrel into the position shown in Fig. 2 the auxiliary valve 8 is moved downwardly, thereby tending to maintain the piston valve in its lowermost position. Similarly, during the se-

quence of operations occurring between the positions indicated in Figs. 3 and 4, the piston valve is urged upwardly, thereby tending to maintain it in its upper position, by the upward movement of the auxiliary valve.

The schematic diagrams of Figs. 1 to 4 are provided principally to illustrate the principles of operation and make it easier to understand the construction and operation of the practical pump illustrated in Figs. 5 to 18 in which, because of the fact that diametrical space is at a premium, a pumping capacity sufficient to make the unit practicable is obtained by making the stroke of the traveling motor barrel and pump plunger assembly, and the over all length of the unit, much greater in proportion to the diameter of the unit than is shown in the schematic diagrams of Figs. 1 to 4. It is also to be noted at this point that the practicable pump to be described incorporates many structural features which in the interests of clarity are omitted from the schematic diagrams although many of these features in themselves involve invention.

However, the schematic diagrams of Figs. 1 to 4 illustrate some of the advantages of that feature of my construction consisting in the mounting of the motor valve mechanism within the motor plunger rod and employing a stationary plunger and traveling barrel instead of the conventional traveling plunger and stationary barrel. Thus it is apparent from an inspection of Fig. 1 that my construction provides relatively short straight passages between the valve chest and the two ends of the working chamber and between the valve chest and the exhaust passages surrounding the plunger member above and below the working chamber. My construction also reduces the length of the pressure fluid conduits (passages 36) connecting the inner tubing with the valve chest and reduces the pressure drop in those passages. It should be noted particularly that in my construction only a single passage for conveying fluid (the fluid discharged from the pump intermingled with motor exhaust fluid from the passages 46) upwardly past the motor, is necessary; therefore, the entire annular space between the motor barrel 19 and the outer tubing 2 can be used for this purpose.

Construction of practicable pump as illustrated in Figs. 5 to 18

The construction of a practicable pump embodying the principles of operation disclosed in the schematic diagrams of Figs. 1 to 4, together with other important details of construction, will now be explained with reference to Figs. 5 to 18, in which elements corresponding to elements disclosed in Figs. 1 to 4 bear the same reference numerals. It will be convenient to discuss separately the various groups of elements in the practicable pump which correspond to parts shown as single elements in Figs. 1 to 4.

The outer tubing assembly

That portion of the outer tubing 2 immediately above the pump is joined by a nipple 52 (Fig. 5) to a coupling 53. As shown in the drawings, the nipple 52 is expanded at its lower end and interiorly threaded to screw onto an exteriorly threaded portion of the coupling 53. The exterior diameter of the lower portion of the nipple 52 and of coupling 53 is slightly greater than the body of the tubing 2 (not shown in Fig. 5) and the upper end of nipple 52, but is of sub-

stantially the same outside diameter as the couplings which are used to join successive lengths of the outer tubing 2 so that the entire device can be lowered through any casing large enough to accommodate the outer tubing itself. The coupling 53 projects inwardly beyond the inner surface of the lower enlarged portion of the nipple 52 and constitutes a guide for the member 70 to be described later. The upper edge 53a of the coupling 53 constitutes a shoulder for supporting a skirt 73 to be described later.

Threaded onto the lower end of coupling 53 is a sleeve 54 which extends downwardly (Figs. 5, 6, 7, 8, 9 and 10) to a point immediately above the pump portion of the unit where it is threaded onto a pump supporting coupling 55. Attached to the lower end of the pump supporting coupling 55 and extending downwardly therebelow is another sleeve 56 (Figs. 10, 11 and 12) extending substantially to the lower end of the unit, where it is threaded onto a gas anchor coupling 57. The anchor coupling 57 is adapted to have screwed thereinto an upper end of any standard gas anchor for separating gas from the oil before it enters the pump barrel.

The stationary motor plunger and pump barrel assembly

Referring first to Fig. 10, the stationary motor plunger and pump barrel assembly, which is directly supported from the pump supporting coupling 55, comprises a hollow stem 58 having a beveled face 59 which rests against and seals with a complementary face on the upper end of coupling 55. The hollow stem 58 together with the coupling 55 constitute the elements defining a partition in the outer tubing to permit the portion of the outer tubing thereabove to be used as a discharge passage for oil to the surface while the portion of the outer tubing therebelow contains well-oil at relatively low pressure.

Threaded onto the upper end of the hollow stem 58 is a supporting column 60, which is of tubular construction but provided with diametrically opposite longitudinal slots 60a serving as guides for the cross head to which the traveling barrel is attached. The supporting column 60 extends upwardly (Figs. 10 and 9) and is connected at its upper end by screw threads to the lower end of a nipple 61, which constitutes the housing for the auxiliary valve motion reversing mechanism. The nipple 61 is attached at its upper end by screw threads to a block 62 constituting the lower end closure wall of the valve chest 6. Block 62 is connected at its upper end to the lower end of a sleeve 63 defining the lower portion of the valve chest and also the lower shoulder of the motor plunger that seals with the traveling barrel and closes the lower end of the working chamber. To this end packing rings 64 are provided on the exterior of sleeve 63 to effectively seal with the traveling barrel. The passages 46 for communicating the valve chest with the exterior of the plunger rod below the working chamber and the passages 37 for communicating the valve chest with the lower end of the working chamber are formed in the sleeve 63.

At its upper end the sleeve 63 is joined by screw threads to a sleeve 65, which constitutes that portion of the plunger rod of the motor which defines the inner wall of the annular working chamber and also the mid portion of the valve chest.

Sleeve 65 is attached by screw threads at its upper end to the lower end of a sleeve 66 which

defines the upper portion of the valve chest and also the upper shoulder of the motor plunger that seals with the traveling barrel and closes the upper end of the working chamber. Sleeve 66 is provided with packing rings 67 (Figs. 7 and 6) for sealing with the traveling barrel and contains the passages 38 for communicating the valve chest with the upper end of the working chamber, and exhaust passages 39 for communicating the upper pocket 27 of the valve with the outer tubing.

Sleeve 66 is connected at its upper end by screw threads to a block 68 constituting the upper end closure wall of the valve chest. Sleeve 66 and block 68 contain the longitudinal passages 36 for connecting the valve chest to the upper end of the stationary plunger rod which is exposed to the pressure fluid delivered through the inner tubing. These passages terminate, at the upper end of sleeve 66 and the lower end of block 68, in annular passageways 36a to provide free fluid connection between those portions of the passages 36 in the two blocks regardless of whether or not they are aligned with each other.

The block 68 constitutes a guide for the upper end of the auxiliary valve 8 and is therefore provided with vent ports 68a for connecting the upper end of the auxiliary valve guide channel to the space within the outer tubing sleeve 54 which is filled with exhaust and pumped fluid.

The upper end of block 68 is threaded into the lower end of a sleeve 69, which in turn is threaded at its upper end into the lower end of a coupling 70 which has attached thereto at its upper end a deflecting cone 71 for spreading the skirt 73 in a manner to be described later.

As shown in the schematic diagrams of Figs. 1 to 4, the inner tubing 3 is solidly attached to and supported from the stationary plunger assembly 4 of the pump. Such construction would be undesirable in practice as the relatively enormous weight of the inner tubing might produce severe stresses in the pump plunger which would distort it and prevent satisfactory operation. For this reason the expansible skirt 73 (Fig. 5) is provided for directly supporting the weight of the inner tubing from the coupling 53 in the outer tubing and a sliding but fluid-tight connection is provided between the coupling 70 on the lower end of the inner tubing 3 and the upper end of the stationary plunger assembly, which upper end is constituted by the coupling 72 and deflecting cone 71 in Fig. 5. The coupling member 72 on the lower end of the inner tubing 3 is therefore provided with an inner downwardly extending sleeve 74 which passes downwardly through the deflecting cone 71 and is sealed therewith by packing members 71a. The sleeve 74 is provided with a shoulder 74b thereon for limiting upward movement of the sleeve 74 with respect to the cone 71 constituting the upper end of the stationary motor plunger assembly. However, downward movement of the sleeve 74 is limited only by engagement of the skirt 73 on the coupling 72 with the shoulder 53a on coupling 53 in the outer tubing so that the entire weight of the inner tubing 3 is borne by the coupling 53 whereas the entire weight of the stationary motor plunger and pump barrel assembly is borne by the outer tubing through the lower coupling 44 (Fig. 10).

The lower end of the sleeve 74 is provided with perforations 74c therein, permitting high pressure fluid to pass from sleeve 74 into the surrounding space within the coupling 70 and the sleeve 69, from which point it is free to pass down

into the hollow upper end of block 68 and thence through the passages 36 to the valve chest.

The lower end of sleeve 74 is closed by a bushing 75, which snugly engages a plug rod 76 having an enlarged head 76a on the lower end thereof which seals a vent 68b provided in the upper end of block 68. The rod 76 is provided on its upper end with a nut 76b so that when the sleeve 74 is elevated by lifting the inner tubing string 3, in the process of removing the pump from the well, the bushing 75 engages the nut 76b on the plug rod 76 and lifts the head 76a clear of the aperture 68b, thereby permitting fluid standing in the inner tubing 3 to drain out through the ports 68a into the outer tubing.

Auxiliary valve

The auxiliary valve 8, which is shown constructed in one piece in the schematic diagrams of Figs. 1 to 4, is in the practicable pump illustrated in Figs. 5 to 18 made in several parts. Thus the upper end of the auxiliary valve is shown in Figs. 6 and 7 as comprising a rod 80 having the grooves 43 and the central passage 49 therein. This rod 80 is joined at its lower end by screw threads to a rod 81 (Figs. 7 and 8) constituting the central portion of the auxiliary valve and which in turn is joined by screw threads at its lower end to the upper end of a rod 82 having the passage 42 and the grooves 50 therein.

The lower end of the rod 82 projects through the block 62 defining the lower end of the valve chest (Fig. 9) and is provided with an annular groove 82a in its projecting lower end, which interlocks with a shoulder 83 on the upper end of the rack 30, which engages with the pinion 31. The pinion 31, as previously mentioned, is rotatably supported in the nipple 61 and also meshes with the rack 32. The latter is provided with a shoulder 84 on its lower end which engages with an annular groove 85 in the upper end of the auxiliary valve actuating rod 10. The racks 30 and 32 are supported for free longitudinal movement within the nipple 61 by providing grooves in the nipple for receiving the racks, as shown clearly in the cross section of Fig. 15.

The stroke of the auxiliary valve and of the auxiliary valve actuating rod 10 is much less than the stroke of the traveling barrel, the auxiliary valve being shifted during only the last portion of each stroke of the traveling barrel. In order to maintain the auxiliary valve in each end stroke position until it is positively displaced therefrom by the next movement of the traveling barrel in the opposite direction, the rod 10 is provided with grooves 10a containing expansible rings 10b which expand into recesses 10c and 10d in the upper end of the supporting column 60 when the rod 10 is in its lowermost and its uppermost positions, respectively. The force of the rings 10b is sufficient to retain the rod 10 in the end stroke position into which it was last moved but is not sufficient to prevent the rod being moved when positively shifted by the traveling barrel.

The cross head 33 on the lower end of the actuating rod 10 is constituted by a metal block extending crosswise through an aperture provided therefor in the lower end of rod 10, the ends of this block 33 fitting in guideways provided therefor in the traveling barrel to be described later. Thus the adjacent portion 100 of the traveling barrel is provided with grooves for receiving the ends of the cross head 33, the length of the grooves being equal to the difference between the stroke of the traveling barrel and the stroke of the aux-

iliary valve so that the auxiliary valve will be shifted into a new end position only during the latter portion of each stroke of the traveling barrel. In the drawings both the traveling barrel and the auxiliary valve are shown in lowermost position in which the ends of the cross head 33 have been engaged by the shoulders at the upper ends of the guide channels or grooves 100. On the next upward stroke of the traveling barrel the auxiliary valve will remain stationary until the traveling barrel has ascended to a point where the inner edge of the coupling 99 on the lower end of the tubular member 100 constituting the lower section of the traveling barrel, encounters the lower edge of the cross head 33, thereby carrying the latter and the entire auxiliary valve assembly upwardly with it.

Construction of the piston valve

The piston valve 7 is constructed in three parts. Thus it comprises an upper member 86 which seals about the rod 80 and is provided with an upper shoulder 87 (Fig. 6) and a lower shoulder 88 (Fig. 7) which seal with the wall of the valve chest and define therebetween the upper valve pocket 27. The member 87 is joined at its lower end to the upper end of a sleeve member 89 which contacts neither with the adjacent portion 81 of the auxiliary valve nor the walls of the valve chest, and is provided with perforations 89a to permit free passage of fluid therethrough. The sleeve member 89 is provided with a shoulder 89b immediately below the perforations 89a and detent rings 89c are preferably provided on the shoulder 89b to provide a yieldable mechanical locking mechanism tending to retain the piston valve in its uppermost position after having once been moved into that position. As shown in Fig. 7, the piston valve is in its lowermost position, in which the detent rings 89c are substantially completely pressed within the shoulder 89b. However, when the valve is moved into its uppermost position the detent rings 89c rise slightly above a shoulder 65a in the sleeve 65 constituting the adjacent portion of the valve chest wall. The detent rings thereupon expand and, when the valve tends to return, the rings bear against the shoulder 65a and tend to resist such return. However, when pressure fluid is applied to the end of the piston valve the force applied to the valve is relatively great as compared to the resistance to motion produced by the detent rings 89c and the latter compress and permit the valve to move downwardly. For a substantial distance below the shoulder 89b the member 89 is imperforate and cylindrical in shape and of such dimensions that it contacts neither the auxiliary valve nor the walls of the valve chest. At the lower end of this portion there is provided another shoulder 90 (Fig. 8) having detent rings 90a thereon for engaging below a shoulder 65b in the sleeve 65 when the valve is in lowermost position. These detent rings 90a function to yieldably retain the valve in lowermost position in exactly the same manner as the detent rings 89c tend to maintain it in its upper position. A small section of member 89 below the shoulder 90 is provided with perforations 91 to permit free passage of fluid therethrough. The lower end of the sleeve member 89 is attached by screw threads to a member 92 corresponding to the upper valve member 86 having upper and lower shoulders 93 and 94, respectively, which seal with the walls of the valve chest and define the valve pocket 29.

It will be observed from comparison of the valve structures shown in the schematic diagram of Fig. 1 and the practicable construction shown in Figs. 6, 7 and 8 that the essential difference between the two resides in the fact that the valve has been greatly elongated in the practical modification by, in effect, breaking it at the middle and interconnecting the two parts with the sleeve member 89.

The traveling motor barrel

As has been previously explained, the traveling barrel of the motor is rigidly connected to and reciprocates the pump plunger. Referring first to Fig. 10, the upper end of the pump plunger rod 95 is screwed onto a downwardly depending stub shaft 96 on a cylindrical member 97 which is solidly attached to a cross head 98, which extends through an orifice provided therefor in the member 97. The outer ends of cross head 98 extend through and are flush with the outer surface of a collar 99, which is screwed into the lower end of a tubular member 100, constituting the lower section of the traveling barrel. At its upper end the tubular member 100 (Fig. 8) is threaded onto a coupling 101, which coupling is ground to seal with the adjacent portion 65 of the stationary plunger rod. The coupling member 101 therefore constitutes the piston element of the motor which divides the working chamber into two parts. It will be observed that the tubular member 100 seals with the packing rings 64 on the sleeve 63 which defines the lower end of the working chamber of the motor.

The coupling member 101 is joined at its upper end by screw threads to a tubular member 102 constituting the upper portion of the traveling barrel, this portion sealing with packing rings 67 on the sleeve 66 defining the upper end of the working chamber, and extending upwardly therebeyond a substantial distance, as shown in Fig. 6. This upper section of member 102 is provided with apertures 102a to provide free flow of fluid from the exhaust passages 39 and the passages 68a. A collar 103 is provided on the upper end of the tubular member 102 which slides along the sleeve 69 and acts as a guide for the upper end of the traveling barrel.

Pump unit

Referring to Figs. 10 and 11, the upper end of the pump barrel comprises a tubular member 105 threaded into the lower end of the hollow stem 58, which seats within the pump supporting coupling 55. Packing rings 105a are preferably provided to form a seal between the barrel member 105 and the upper end of the pump plunger rod 95.

The barrel proper of the pump is constituted by a sleeve 106 screwed onto the lower end of the tubular member 105. The sleeve 106 is provided with ports 106a therethrough to permit fluid from the well to surge in and out of the upper end of the barrel as the plunger reciprocates. The lower end of the sleeve 106, constituting the pump barrel, terminates (Fig. 12) in a coupling 107 which serves to secure in position in the lower end of the sleeve 106 a standing valve seat 108 and valve cage 109, within which the ball valve 23 is positioned. The lower end of the coupling 107 is threaded to receive an oil inlet pipe (not shown) extending downwardly into the well.

The pump plunger assembly comprises the hollow plunger rod 95 (Fig. 10) previously men-

tioned, which extends through and seals with the hollow stem 58 and the tubular member 105 and is joined at its lower end by coupling members 110, 111 and 112 to a hollow plunger core member 113, upon which are supported a pair of cylindrical members 114 and 115 constituting the plunger proper which seals with the pump barrel 106. Thus the cylindrical member 114 is supported between a shoulder 113a on member 113 and the lower end of the coupling member 112. The cylindrical member 115 is similarly supported between a shoulder 113b on member 113 and a coupling member 116 screwed onto the lower end of member 113. The coupling members 111 and 112 serve to support therebetween a valve seat 117 cooperating with a ball valve 118, and a member 119 positioned below the coupling member 116 and a bushing 120 (the latter constituting the extreme lower end of the pump plunger) serve to retain a second valve seat 121 which cooperates with a ball valve 122. The two valves, including balls 118 and 122, together function the same as the single valve ball 23 shown in the schematic drawings of Figs. 1 to 4 to permit entry of fluid compressed below the pump plunger up through the hollow plunger rod, but prevent its return. The fluid flowing up through the hollow plunger rod escapes to the outer tubing through ports 24 (Fig. 10) in the upper end of the hollow pump plunger rod.

Traveling barrel locking mechanism

Pumps of the general type to which this invention relates depend for their proper operation on definite sequential movements of the different parts. Should the different parts, such as the traveling barrel assembly, the piston valve and the auxiliary valve, be accidentally initially placed in certain relative positions, they might fail to operate in response to the application of pressure fluid thereto. I therefore provide a special locking mechanism for maintaining the traveling barrel assembly in lowermost position while the device is in transit and is being lowered into the well with means for automatically unlocking the traveling barrel assembly after installation in the well.

Referring to Fig. 10, the locking mechanism therein disclosed comprises a detent ball 123 positioned in a passageway 124 in the block 58, the length of the passageway 124 being slightly less than the diameter of the detent ball 123 and the outer edge of the passageway being normally closed by a plunger 125 fitted in a vertical cylindrical passage 126 in the block 58. The upper end of passage 126 opens into the outer tubing above the sealing surface 59 on block 58 and the lower end of the passage opens to the exterior below the sealing surface 59. The plunger 125 is normally retained in uppermost position by a helical spring 127 positioned therebelow, in which position the detent ball 123 is forced inwardly beyond the inner surface of the block 58 and into engagement with a portion 128 of the pump plunger 95, which is of reduced diameter. It will be apparent that so long as plunger 125 is in the uppermost position shown in Fig. 10, any upward movement of the pump plunger 95 and the traveling barrel assembly connected thereto will be prevented by engagement of the detent ball 123 with the shoulder formed at the lower edge of the reduced section 95a, and the plunger 125 remains in its upper position, as shown, at all times until a differential pressure is applied to opposite ends of the plunger 125 sufficient to overcome the

force of the helical spring 127 and move the plunger downwardly until a recess 128 therein is juxtaposed to the detent ball 123, permitting the latter to move outwardly away from the pump plunger rod 95.

The differential pressure necessary to move the plunger 125 is produced when the pump, after being seated in the well with the beveled face 59 resting against and sealing with the cooperating face on the pump supporting coupling 55, is conditioned for service by filling the outer tubing 2 with oil. As soon as any appreciable head of oil has been built up within the outer tubing, the pressure of the oil on the upper end of plunger 125 is sufficient to depress the latter to release the detent ball 123 and permit the reciprocation of the traveling motor barrel and pump plunger assembly.

A modified form of lock is shown in Fig. 10A, which shows a section of a completed pump corresponding in general to that disclosed in Fig. 10 and corresponding parts of which bear corresponding reference numerals with the prime mark suffixed. The essential difference between the locking mechanism disclosed in Fig. 10A over that disclosed in Fig. 10 is that whereas the ball detent is released in Fig. 10 by the application of fluid pressure, the detents in Fig. 10A are automatically released in response to the seating of the pump. Thus the detent balls 123' positioned in passages 124' in the block 58' are, before the pump is installed, forced into engagement with the reduced portion 128' of the pump plunger rod 95' by a skirt member 129 which is forced downwardly by a helical spring 130 positioned thereabove to bring the upper reduced portion 131 of the skirt juxtaposed to the outer ends of the passages 124'. The skirt member 129 in this modification constitutes the member which seats against the pump supporting coupling 55' and is provided with a beveled face 59' for this purpose. The skirt member is also slidable vertically along the hollow stem 58' but has its vertical movement limited by a shoulder 132 through which, when the pump has been seated, the entire weight and all downward force exerted on the pump are transmitted to the skirt member 129 and thence to the pump supporting coupling 55'. It will be observed that as soon as the pump has been seated, as shown in Fig. 10A, the skirt member 129 is forced upwardly into engagement with the shoulder 132 and the detent balls 123' are released from locking engagement with the reduced portion 128' of the stem 95, thereby permitting free reciprocation of the traveling motor valve and motor plunger assembly.

Construction of joints between sections

As described, my practical pump is made up of many different tubular or cylindrical parts joined together by screw threads. In many instances, adjacent parts have bearing surfaces that must be concentric with respect to each other. Thus, for example, consider the joint between the tubular block 62 (Fig. 8) and the sleeve 63 thereabove, in which the bore of the block must be very accurately aligned with the bore of the sleeve if the auxiliary valve and main valve are to move freely and also seal with each other and with the bores of the block 62 and sleeve 63, respectively. Heretofore, in order to closely fit such parts, it has been considered necessary either to cut the threads exactly concentric with the bores, or to drill or ream the bores of the parts after they have been screwed together.

Both methods are expensive and I avoid them by using square threads, to join the parts instead of the conventional V-threads, and aligning the parts with a mandrel while they are being screwed together. This method, as applied to the joint between block 62 and sleeve 63 is illustrated in Fig. 19, in which the square threads on the sleeve 63 are indicated at 63a, the square threads on the block 62 are indicated at 62a, and the aligning mandrel indicated in dotted lines at 140. The square threads 62a and 63a are so deep that they permit substantial lateral movement between the two parts and do not determine their alignment, merely serving to clamp the parts firmly together while they are maintained in alignment by the mandrel 140. After the joint is made and the mandrel 140 is removed, the parts remain in alignment because of the friction between the threads and between the abutting shoulders of the parts, and because the square threads exert no lateral force tending to produce a lateral shift. It is to be noted that this method of joining parts with their cylindrical bearing surfaces in alignment cannot be used with V-threads because the latter are inherently self-centering, whereas square threads are not.

The method, although illustrated in detail only with reference to the joint between block 62 and sleeve 63, is applicable to all the screw joints in the pump between parts having cylindrical surfaces that must be accurately aligned, the shape and dimensions of the mandrel employed with each joint depending, of course, on the shapes and dimensions of the surfaces to be aligned. Thus where the surfaces to be aligned are outer surfaces instead of inner surfaces, the mandrel must surround the parts and in some such instances the mandrel may be split to facilitate its removal.

Installation and removal of the pump

At the time of the original installation of a pump as described, the outer tubing 2 before being lowered into the well has attached thereto on its lower end the nipple 52, coupling 53, sleeve 54, pump supporting coupling 55, sleeve 56, and the anchor coupling 57, as disclosed in Figs. 5 to 12, inclusive. Thereafter the pump unit is attached to the lower end of the inner tubing string 3 and is later lowered down through the outer tubing 2.

While supported from the lower end of the inner tubing string 3, all portions of the pump unit are sufficiently small to pass freely through the outer tubing. Thus at this time the sleeve 74 attached to the coupling 72 (Fig. 5) instead of being in the position shown in the drawings, would be withdrawn until the shoulders 74b rested against the lower end of the packing members 71a, the weight of the entire unit being supported by the shoulder 74b. In this position the expansible split skirt 73 on the coupling 72 is in its normal position in which it is substantially cylindrical in shape and of the same outside diameter as the main portion of the coupling 72.

As the assembly supported on the inner tubing string 3 approaches the lower end of the outer tubing 2, the tubular member 105 defining the pump barrel enters the pump supporting coupling 55 and passes downwardly therethrough until the beveled face 59 seats against the upper end of coupling 55 (Fig. 10). Thereafter continued downward movement of the inner tubing string

causes the sleeve 74 to telescope within the deflecting cone 71, thereby expanding the split skirt 73 until the lower edge of the latter rests against the shoulder 53a on the coupling 53 (Fig. 5). Thereupon the weight of the inner tubing is supported through the skirt 73 by the coupling 53.

The pump parts are so dimensioned that shortly after the beveled face 59 of the hollow stem 58 (Fig. 10) seats against the pump supporting coupling 55, the enlarged head 76a (Fig. 6) seats in the port 68b which communicates the ports 68a with the outer tubing.

The pump is then set in operation by filling the outer tubing with oil to create sufficient pressure to actuate the plunger 125 (Fig. 10) and release the detent ball 123 to permit reciprocation of the traveling motor barrel and pump plunger assembly. Thereafter the inner tubing string 3 is filled with pressure fluid and a continuous stream of pressure fluid is forced therethrough to operate the pump in the manner described with reference to the schematic drawings of Figs. 1 to 4. It will be observed that when the inner tubing string is filled with liquid under pressure the enlarged plunger head 76a (Fig. 6) is maintained tightly seated by the pressure of the fluid thereabove.

The installation and operation of a pump having a locking mechanism as disclosed in Fig. 10A is identical with that described except that it is unnecessary to fill the outer tubing with oil preliminary to starting the pump since the detent balls 123' are automatically released when the pump is seated.

If for any reason it becomes necessary to remove the pump from the well after it has been in operation, such removal is accomplished by simply disconnecting the supply of pressure fluid from the inner tubing string 3 at the surface of the well and pulling the inner string. Initial upward movement of the inner tubing string 3 elevates the coupling 72 (Fig. 5), lifting the split skirt 73 away from the deflecting cone 71 and the shoulder 53a, permitting the latter to contract to the diameter of the upper or main portion of the coupling 72. Thereafter continued upward movement first causes the bushing 75 (Fig. 2) in the lower end of the sleeve 74 to engage the nut 76b on the upper end of the plug rod 76 and lift the enlarged head 76a clear of the opening 68b which it normally closes. This permits the oil standing in the inner tubing string to drain out through the opening 68b and the ports 68a into the outer tubing as the inner tubing and the pump are withdrawn, thereby permitting what is termed a "dry job" of pulling. Of course, further upward movement of the inner tubing string causes the shoulder 74b on the sleeve 74 to engage with the under edge of the packing member 71a following which further upward movement of the inner tubing string carries the pump up through the outer tubing string 2 to the surface.

After the pump has been removed from the well, it will be observed from Fig. 10 that the motor end of the pump may be completely detached from the pump end by breaking the threaded connection between the hollow stem 58 and the supporting column 60 and the threaded connection between the upper end of the pump plunger rod 95 and the stud shaft 96 on the cylindrical member 97. This feature, whereby the pump unit may be readily removed from the motor unit, is very important for the reason

that a pump unit is apt to wear much more rapidly than the motor unit by reason of the fact that the pump must handle oil from the well containing sand and other abrasive material whereas the motor unit can be supplied with clean filtered oil from the surface.

The ready separation of the pump and motor units is also desirable in that it permits ready substitution of pump units of different capacities, thereby permitting the use of the same motor in wells of different depths without increasing the pressure of the operating fluid supplied to the motor in the deeper well by merely employing a pumping unit of smaller capacity in the deep well than in the shallow well.

It should also be noted that, by virtue of the fact that the motor end of the pump is fully enclosed and constantly flooded with filtered oil from the inner tubing 3, no bearing surface of the mechanism in the motor unit comes in contact with the pumped fluid.

Of course, as previously mentioned, probably the greatest single advantage of my construction is that the use of the traveling motor barrel and stationary plunger assembly with the valve mechanism positioned within the plunger rod eliminates many restricted passages and irregular passages having right angle turns therein, thereby decreasing fluid friction and adding to the mechanical efficiency of the unit. This advantage can best be emphasized by comparison. Thus I am able to obtain an equal or greater pumping capacity with an assembly of the type described having an over all diameter of only 2 and 3/4ths inches than was formerly obtained with a pump having an over all diameter of 4 inches.

A substantial advantage results in my construction from the fact that both the traveling motor barrel and stationary motor plunger are supported from their lower ends and the inner tubing string is supported independently of the stationary plunger assembly, thereby eliminating unnecessary compression or tension strains in the plunger and barrel assemblies which might cause them to warp and freeze when installed in the well. The free-end barrel is less rigid and will flex enough to align itself with the enclosed piston or plunger even though the bore of the barrel may be off center a few thousandths of an inch or may not be absolutely straight.

The use of the automatic lock for the traveling barrel is a very desirable feature in that it makes the pump substantially fool-proof even when installed and operated by unskilled labor. The use of the expansible skirt for supporting the weight of the inner tubing from the outer tubing independently of the pump mechanism also tends to make the device more fool-proof as it prevents any possible damage to the mechanism resulting from too rapid landing of the pump in the bottom of the tubing by a careless well crew.

Although, as previously stated, the motor unit is preferably supplied with clean filtered oil through the inner tubing string 3, the tubing itself often contains a certain amount of dirt, scale, sediment, etc., which it is desirable to keep out of the motor parts. Such deposits are prevented in large measure from reaching the working parts of the motor by the sleeve 74 (Figs. 5 and 6) having the perforations 74c therein. These perforations filter the oil to a certain extent and the tube also acts as a sort of a trap, heavy foreign particles in the oil therein tend-

ing to settle to the bottom of the sleeve 74 about the plunger rod 76 instead of passing out through the perforations 74c.

Although the invention has been described with reference to a particular embodiment thereof to simplify the conveying of a full understanding of the essential principles involved, it is to be understood that the invention is not limited to the specific structures shown but instead is to be limited only as set forth in the appended claims.

1. In a fluid-actuated well pump adapted to be positioned in a well and having pressure fluid and exhaust fluid connection with the surface through separate conduits, a reciprocating pump unit having a stationary element and a reciprocating element, a motor unit comprising a stationary plunger assembly adapted to be connected to the stationary element of the reciprocating pump unit, and a cooperating reciprocable cylinder assembly adapted to be coupled to the reciprocating element of the pump unit and defining together with said plunger assembly a working chamber having a reciprocable piston element therein, valve means for said motor unit incorporated within said stationary plunger assembly for controlling the admission of pressure fluid to and the discharge of exhaust fluid from opposite ends of said working chamber, said plunger assembly also defining fluid passages extending directly from said valve means to said working chamber and from said valve means to said pressure fluid and exhaust fluid conduits, respectively, and means for actuating said valve means in response to predetermined movements of said cylinder assembly.

2. In a fluid-actuated well pump adapted to be positioned in a well and having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid and separate fluid connection with the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit comprising a stationary plunger assembly and a cooperating reciprocable cylinder assembly adapted to be submerged in exhaust and pumped fluid within said outer tubing and defining between them a working chamber, a reciprocable piston element in said chamber, valve means incorporated within said stationary plunger assembly for controlling the admission of pressure fluid to and the discharge of exhaust fluid from the opposite ends of said working chamber, said plunger assembly also defining fluid passages extending directly there-through from said valve means to said working chamber and from said valve means to the fluid surrounding said unit within said outer tubing, and to said inner tubing, respectively, means for actuating said valve means in response to predetermined movements of said cylinder assembly, a pump unit, and means for actuating said pump unit in response to reciprocation of said cylinder assembly.

3. In a fluid-actuated well pump adapted to be positioned in a well and having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid, and separate fluid connection with the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit comprising a reciprocable cylinder member and a cooperating stationary plunger member within said cylinder member and defining therewith a working chamber, a piston element reciprocable in

said chamber, said unit being adapted to be submerged in fluid in said outer tubing and positioned below the lower end of said inner tubing, said plunger member having a cavity therein constituting a valve chest, a reciprocable valve in said valve chest, means forming a fluid connection between said inner tubing and the upper end of said plunger member, an operating fluid inlet port in said valve chest and a passage in said plunger member connecting said inlet port with said end of said plunger member, exhaust ports in said valve chest and passages extending through said plunger member for connecting said exhaust ports with the exterior of said member in communication with the fluid in which said unit is submerged within said outer tubing, other ports in said valve chest and passages in said plunger member communicating said other ports with the opposite ends of said working chamber, said reciprocable valve having chambers therein for selectively interconnecting said inlet and exhaust ports with said other ports to supply operating fluid to either end of and to exhaust fluid from the other end of said working chamber depending upon the position of said valve, and means for shifting said valve in response to predetermined movement of said traveling cylinder, a pump unit, and means for actuating said pump unit in response to reciprocation of said cylinder assembly.

4. In a fluid-actuated well pump adapted to be positioned within a well and having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid and separate fluid connection with the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit adapted to be submerged in fluid within said outer tubing and comprising a stationary plunger assembly and a cooperating reciprocable cylinder assembly, the two defining therebetween a working chamber, a piston element reciprocable in said chamber, said plunger assembly comprising an elongated plunger member having a cavity therein constituting a valve chest, valve means incorporated within said valve chest comprising a reciprocable valve rod extending through said chest and projecting therebelow and a fluid operated piston valve positioned concentrically about said valve rod and having a sliding sealing fit within said valve chest and about said valve rod, an inlet port in said chest and a passage in said plunger member communicating said inlet port with the upper end of said plunger member, means communicating the upper end of said plunger member with said inner tubing, an exhaust port in said chest and a passage through said plunger member communicating said exhaust port with the surface of the plunger member at a point therein positioned beyond said working chamber and exposed to the fluid in which said unit is submerged, other ports in said valve chest and other passages in said plunger member communicating said other ports with the surface of said plunger member at points positioned within and adjacent opposite ends of said working chamber, said piston valve having chambers therein for selectively communicating said inlet and exhaust ports with said other ports to supply operating fluid to either end of said working chamber and to exhaust fluid from the opposite end of said working chamber when said valve is in predetermined positions in said valve chest, said valve rod having passages therein terminating in ports registering, respectively, with said valve chambers

and with opposite ends of said piston valve when said rod is in predetermined positions for admitting pressure fluid to one end and exhausting fluid from the opposite end of said piston valve to shift the latter, and means for reciprocating said valve rod in response to predetermined movement of said traveling cylinder assembly, a pump unit, and means for actuating said pump unit in response to reciprocation of said cylinder assembly.

5. In a fluid-actuated well pump adapted to be positioned within a well and having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid and separate fluid connection with the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit comprising a reciprocable cylinder and a cooperating stationary plunger member positioned within said cylinder, said plunger member having longitudinally spaced shoulders sealing with said cylinder and constituting the end walls of the working chamber of the motor and said cylinder having a shoulder thereon sealing with said plunger member and constituting the reciprocable piston within said working chamber, said plunger member having a cavity therein approximately coextensive with said working chamber constituting a valve chest, exhaust ports in said valve chest adjacent opposite ends thereof and exhaust passages in said plunger member extending directly therethrough from said exhaust ports to the exterior of said plunger member at points beyond said shoulders thereon for discharging exhaust fluid from said chest, an inlet port in said chest adjacent the center thereof and a passage extending longitudinally through said plunger member from said inlet port to the upper end of said plunger member, means for applying pressure fluid from said inner tubing to the upper end of said plunger member, other ports in said valve chest positioned between and adjacent to said respective exhaust ports, passages extending directly through said plunger member from said other ports to the exterior of said plunger member at points between and adjacent said shoulders thereon for communicating said valve chest with opposite ends of said working chamber, a valve reciprocable in said valve chest and sealing with the walls of said chest and having pockets therein for communicating one of said passages extending to one end of said working chamber with either said inlet port or the adjacent exhaust port and communicating the passage extending to the opposite end of the working chamber either with the exhaust port adjacent thereto or said inlet port, depending upon the position of said valve in said chest, and means for reciprocating said valve in response to predetermined movements of said reciprocable cylinder assembly, a pump unit, and means for actuating said pump unit in response to reciprocation of said cylinder assembly.

6. In a fluid-actuated well pump adapted to be positioned in a well and having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid and separate fluid connection to the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit comprising a reciprocable cylinder member and a cooperating stationary plunger member positioned within the cylinder member and defining with said cylinder member an annular working chamber having an annular piston element

reciprocable between opposite ends of said working cylinder, said plunger member having a cavity therein constituting a valve chest, passages extending from ports in said valve chest through

5 said plunger member to opposite ends of said working chamber for supplying pressure fluid to either end of said working chamber and exhaust fluid from the opposite end of said working chamber, an inlet port in said valve chest and a passage extending through said plunger member from said inlet port to the upper end thereof for communicating said port with said inner tubing, exhaust ports in said valve chest and passages extending therefrom through said plunger member to the exterior thereof and into communication with fluid within said outer tubing, an annular piston valve in said valve chest reciprocable in said chest and having pockets therein for communicating said ports connected to opposite ends of said working chamber with said inlet and exhaust ports, respectively, said pockets and ports being so positioned that when said piston valve is in its lowermost position pressure fluid is applied to said working chamber to move said reciprocable cylinder upwardly, and when said valve is in its uppermost position fluid is applied to said working chamber to move said reciprocable cylinder assembly downwardly, an auxiliary valve rod extending vertically through said valve chest and through said annular piston valve and sealing therewith, motion reversing mechanism coupling said auxiliary valve to said cylinder assembly whereby movement of said cylinder upwardly shifts said auxiliary valve downwardly and downward movement of said cylinder assembly shifts said auxiliary valve upwardly, said auxiliary valve having passages therein terminating in ports communicating the lower end of said piston valve with said inlet port and the upper end of said piston valve with said exhaust port when the auxiliary valve is in up position, and for communicating the upper end of said valve chest with said inlet port and the lower end of said valve chest with one of said exhaust ports when said auxiliary valve is in down position, a pump unit, and means for actuating said pump unit in response to reciprocation of said cylinder assembly.

50 7. In a fluid-actuated well pump, having fluid connection with the surface through an outer tubing for the discharge of exhaust fluid and pumped fluid and separate fluid connection with the surface through a smaller inner tubing positioned within the outer tubing for the reception of operating fluid under high pressure, a motor unit adapted to be submerged in exhaust and pumped fluid within said outer tubing and positioned below the lower end of the inner tubing and having fluid connection therewith, said unit comprising a stationary plunger member, means for supporting the lower end of said plunger member from said outer tubing, said unit also comprising a traveling cylinder assembly reciprocable with respect to said stationary plunger assembly and defining therewith a working chamber, a piston element reciprocable in said chamber, valve means within said stationary plunger for supplying pressure fluid to and exhausting fluid from opposite ends of said working chamber, means for shifting said valve in response to predetermined movement of said traveling cylinder assembly, means communicating said valve means within said stationary plunger with said inner tubing, and a pumping

unit having two relatively reciprocable members, one of which is attached to said stationary motor plunger assembly adjacent the point of support of the latter from said outer tubing and the other of which pump members is connected to said traveling cylinder assembly.

8. In a fluid-actuated well pump adapted to be lowered into a well through an outer tubing string while supported on an inner tubing string, and having fluid connection with both the inner and outer tubing strings when positioned in said well, a stationary motor plunger member having a supporting base on its lower end, a cooperating seat on said outer tubing for engaging said base and supporting said plunger member when the latter has been lowered into working position within said outer tubing, telescoping sleeve means on the upper end of said stationary plunger member for communicating said plunger member with said inner tubing and supporting the plunger member from the inner tubing while permitting a substantial amount of relative movement therebetween, an expansible skirt member on the lower end of said inner tubing, a skirt-expanding cone on the upper end of said plunger member and shoulder means in said outer tubing so spaced above said seat that when said plunger base reaches said seat further downward movement of said inner tubing forces said expansible skirt down over said cone and expands the skirt to engage with and rest upon said shoulder, whereby the weight of said inner tubing is supported from said outer tubing substantially independently of said plunger member, a traveling motor barrel surrounding said plunger member and cooperating therewith to define a working chamber, and valve means and fluid passages in said plunger member for supplying pressure fluid to said working chamber from said inner tubing and exhausting fluid from said working chamber to said outer tubing.

9. A device as described in claim 8 in which said telescoping sleeve means comprises a sleeve depending from and in communication with said inner tubing, said sleeve extending down into a recess provided therefor in the upper end of said plunger member, packing means on said plunger member sealing with said sleeve and constituting with said sleeve a fluid-tight closure for said recess, a shoulder on said sleeve below said packing means for engaging therewith and limiting upward movement of said sleeve with respect to said plunger member, said sleeve having perforations therein below said shoulder for the passage of pressure fluid into said plunger recess and longitudinal passages in said plunger member communicating said recess with said valve means.

10. In a fluid-actuated well pump adapted to be lowered into a well through an outer tubing string while supported on an inner tubing string, and having fluid connection with both the inner and outer tubing strings when positioned in said well, a stationary motor plunger member having a supporting base adapted to seat on a cooperating seat on the outer tubing and be supported thereby when the pump has been lowered into working position within said outer tubing, a sleeve depending from and in communication with said inner tubing, said sleeve extending down into a recess provided therefor in the upper end of said plunger member, packing means on said plunger member sealing with said sleeve, a shoulder on said sleeve below said packing means for engaging therewith and limiting upward movement of said sleeve with respect to said

plunger member, said sleeve having perforations therein below said shoulder for the passage of pressure fluid into said plunger recess, a traveling motor barrel surrounding said plunger member and cooperating therewith to define a working chamber, a valve within said plunger member, longitudinal passages in said plunger member communicating said recess with said valve, another passage in said plunger member communicating said recess with the exterior of said plunger member and terminating in an orifice in the bottom of said recess, a rod having a plug on the lower end thereof for closing said orifice, said rod extending up into said sleeve, a bushing in the lower end of said sleeve for guiding said rod and sealing the lower end of said sleeve, and shoulder means on the upper end of said rod for engagement by said bushing when said plunger member is supported by said inner tubing to lift said plug from said orifice and thereby establish direct fluid communication between said inner and outer tubings.

11. In a fluid-actuated well pump adapted to be positioned within and supported by an outer tubing extending to the surface and in which the pump seals off the outer tubing, whereby oil may be inducted from the well into the pump through the lower portion of the outer tubing and pumped oil and exhaust fluid discharged from the pump may be transmitted to the surface through that portion of the outer tubing extending thereabove, and in which the pump includes a fluid-actuated driving motor supplied with pressure fluid through an inner tubing which also functions as a supporting string to lower and withdraw the pump through the outer tubing; a pump body incorporating a reciprocating pump and motor mechanism and comprising a base member adapted to seat on and seal with a pump supporting seat in said outer tubing, said mechanism including a rod reciprocable in said pump body, latch means in said base member movable into engagement with said rod when the latter is in a predetermined position for preventing movement of said rod from said position, spring actuating means for moving said latch means into engagement with said rod, and means rendered operative in response to seating of said base member in said seat in the outer tubing for releasing said latch means from engagement with said rod.

12. In a fluid-actuated well pump adapted to be positioned within and supported by an outer tubing extending to the surface and in which the pump seals off the outer tubing, whereby oil may be inducted from the well into the pump through the lower portion of the outer tubing and pumped oil and exhaust fluid discharged from the pump may be transmitted to the surface through that portion of the outer tubing extending thereabove, and in which the pump includes a fluid-actuated driving motor supplied with pressure fluid through an inner tubing which also functions as a supporting string to lower and withdraw the pump through the outer tubing; a pump body incorporating a reciprocating pump and motor mechanism and having a base member adapted to seat on and seal with a pump supporting seat in said outer tubing, said base member comprising a sleeve slidably mounted on said pump body for limited vertical movement with respect thereto, spring means for normally maintaining said sleeve in lowermost position on said pump body while permitting upward movement thereof in response to seating of the pump, said

mechanism including a rod reciprocable in said pump body, a detent in said pump body movable into and out of engagement with said rod, and means on said sleeve for forcing said detent into engagement with the rod when the sleeve is in lowermost position and releasing the detent when the sleeve is in uppermost position.

13. A device as described in claim 11, in which said latch means comprises a plunger reciprocable in a passage in said base member, one end of which passage is ported above the seating surface of said base member and the other end of which is ported below said seating surface, a detent movable into and out of engagement with said rod, means on said plunger cooperating with said detent to maintain the latter in engagement with said rod when the plunger is in one end position and release the detent from engagement with the rod when the plunger is in the other end position, spring means for normally urging said plunger in said one end position but yielding in response to differential pressure applied to the opposite ends of said passage to permit movement of said plunger into said other end position, whereby said mechanism may be maintained locked in a predetermined position during lowering of said pump in said well and released following seating of the pump in the outer tubing by establishing a column of liquid in said outer tubing above said pump.

14. In a fluid-actuated well pump adapted to be positioned in a well and having exhaust fluid connection with the surface through an outer tubing string, and pressure fluid connection with the surface through an inner tubing string positioned within the outer tubing, a motor unit comprising a stationary plunger assembly having a base member thereon adapted to seat on a supporting flange provided therefor in the outer tubing string, a cooperating reciprocable cylinder assembly comprising a cylinder of substantial length surrounding the major portion of said plunger assembly and defining therewith a working chamber adjacent the central portion of said cylinder, said cylinder projecting substantially above and below said working chamber and defining with said plunger annular passages above and below said working chamber, valve means within said stationary plunger, means connecting said stationary plunger to the lower end of said inner tubing, a passage in said plunger communicating said inner tubing with said valve, passages in said valve communicating said valve with said working chamber, exhaust passages extending from said valve to said annular passages defined by said cylinder and plunger assemblies above and below said working chamber, a pump positioned below said motor unit and connected thereto and adapted to discharge pumped fluid up through said outer tubing past said motor cylinder, whereby exhaust oil from said valve discharged into said outer tubing through the annular passages defined between the ends of said cylinder above and below said working chamber displaces any pumped fluid tending to approach the cooperating sliding contact surfaces of said motor mechanism.

15. In a fluid-actuated pump, an inner member having a cylindrical outer surface, an outer member reciprocable with respect to said inner member and having a cylindrical inner surface spaced from and surrounding said outer surface on said inner member, and constituting therewith the inner and outer walls of an annular working chamber, a pair of spaced apart flanges

on one of said members that seal with the cylindrical surface on the other member and constitute the end walls of the working chamber, a flange on the other of said members sealing with the cylindrical surface on the said one member and constituting a working piston within said working chamber, valve means positioned within said inner member and connected with said working chamber by passages in said inner member for controlling the flow of fluid to and from said working chamber, means for supplying pressure fluid to and exhausting fluid from said valve, and means for actuating said valve in response to predetermined relative movements of said inner and outer members.

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