Nov. 20, 1934. S. E. ROSS 1,981,288

WELL PUMPING APPARATUS

Original Filed April 19, 1932 2 Sheets-Sheet 1

Fig. 2

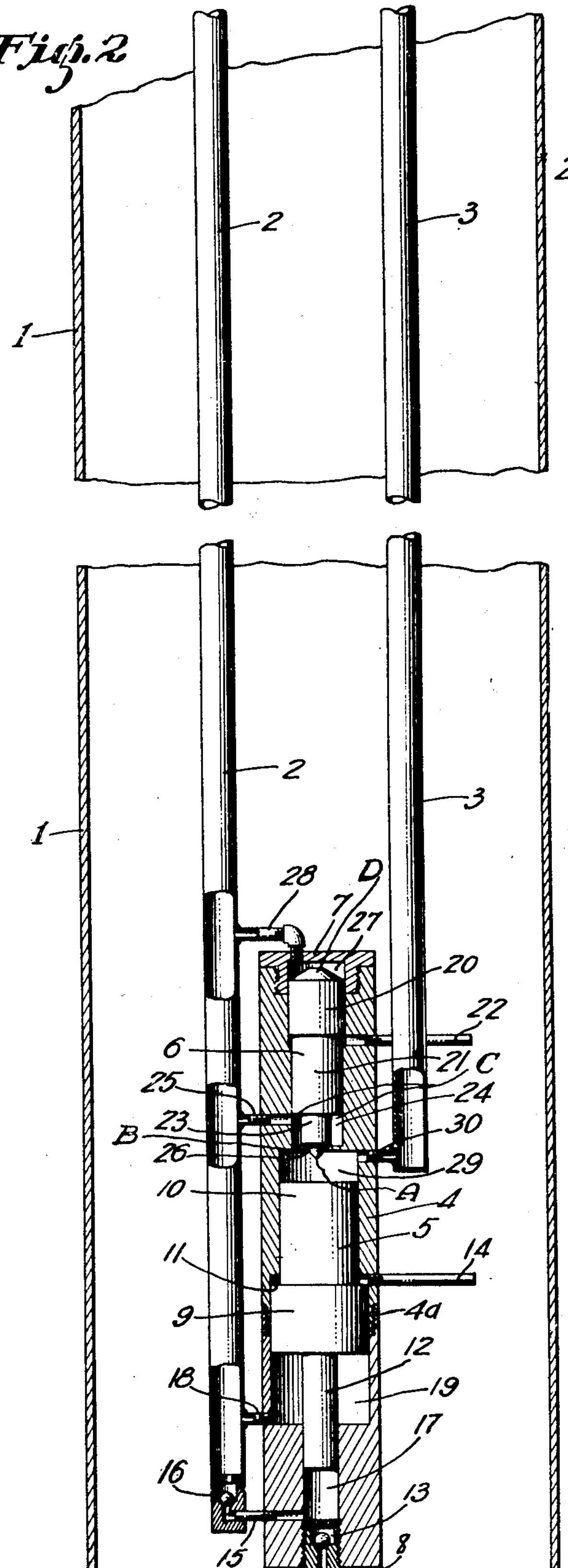
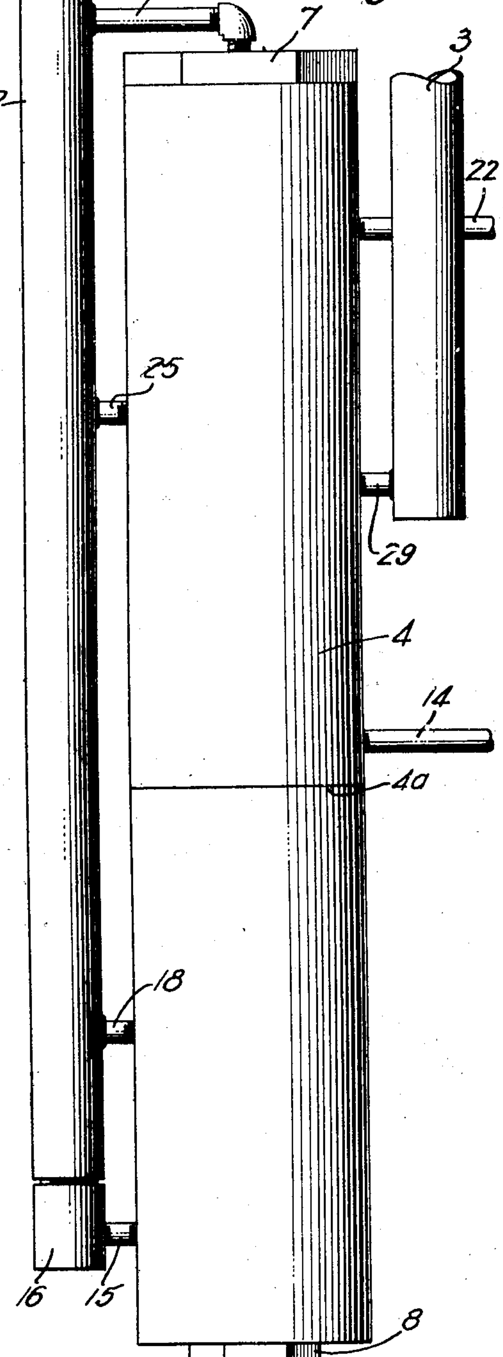


Fig. 1



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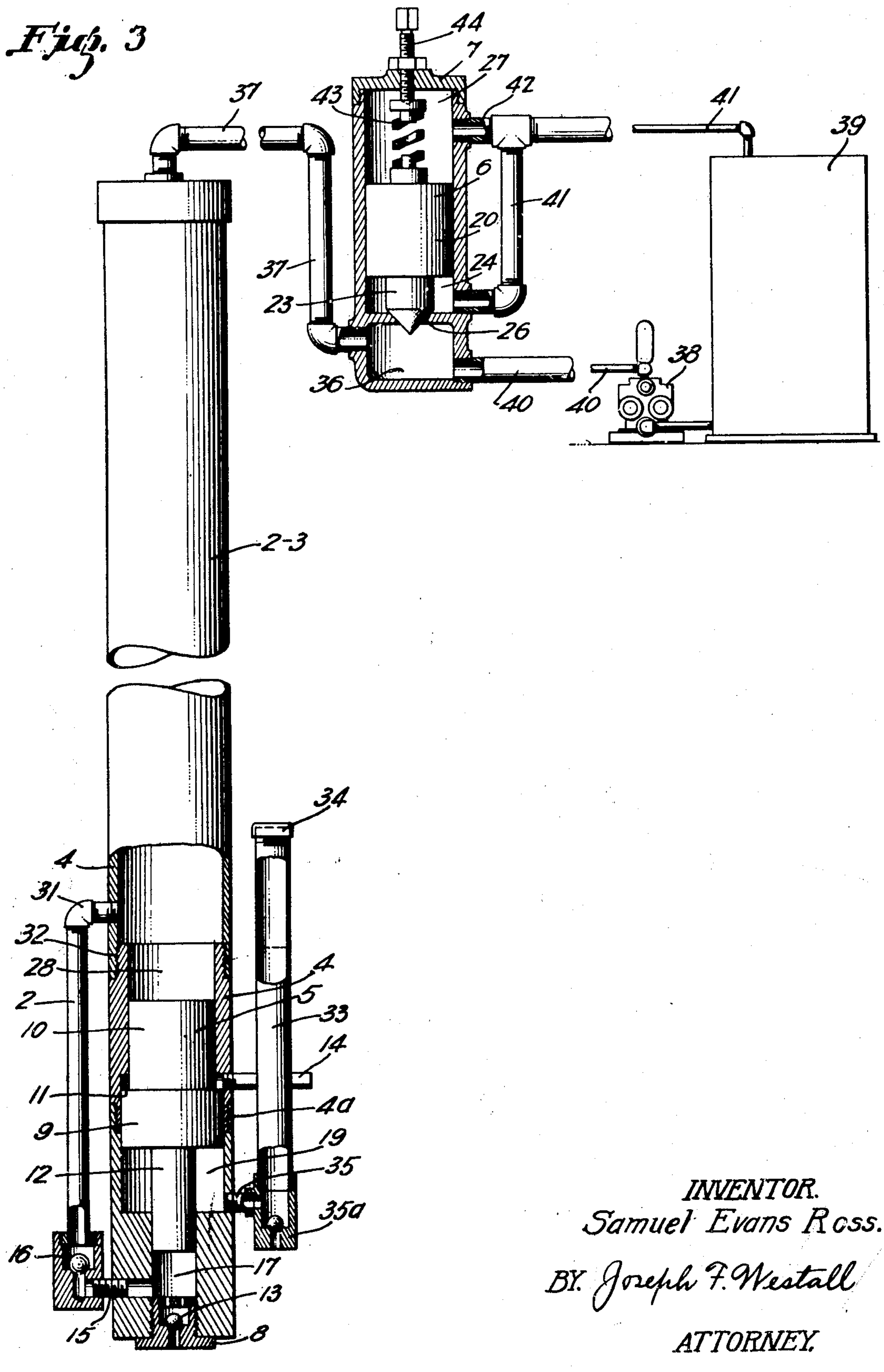

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WELL PUMPING APPARATUS

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8 Claims. (Cl. 103—46)

This invention relates to means for pumping wells, and may be described broadly and generally as a device whereby hydraulic pressure from the top of the well is used to actuate mechanism to perform a pumping stroke, and hydrostatic pressure within the well is, in the main, utilized (supplemented by spring pressure in certain forms of the device) to return the parts to a position for the next pumping stroke. Its principal object is an increase in economy and efficiency over devices intended for similar purposes heretofore known in the art.

In the accompanying drawings (illustrating two preferred forms of the device respectively adaptable to different conditions) parts, principles, and modes of operation, for the sake of greater clarity, have been illustrated principally in diagrammatic form, and are not to be understood as even approximately representing relative sizes, areas, or proportions of the various parts of an actual working installation, as such are, where material to the present invention, sufficiently disclosed in the detailed description following. In these drawings Fig. 1 is an elevation of the principal parts of the device, all except the hydraulic pumping apparatus at the surface of the ground showing, exteriorly, the pump barrel and its connections with pressure conduit and well tubing; Fig. 2 is a view partly in elevation and partly in longitudinal section, with immaterial additions, of Fig. 1; and Fig. 3 is a view, partly in section and partly in elevation, of a modification of that shown in Fig. 2, where part of the valve system is placed above the ground.

Referring in detail to the drawings, the numerals of which are intended to designate similar parts throughout the several views, 1 indicates a well casing; 2 pump tubing; 3 a pipe conduit for liquid under pressure from the top of the well; 4 a pump barrel or cylinder in which reciprocates the pump plunger 5, and in which also reciprocates the cylindrical valve plunger 6.

The pump barrel 4, for purposes of convenient assembly, may be made in two pieces screwed together (just below the middle of its length) as indicated at 4*a*; and is closed at its upper end (except for pipe conduits to be later described) by a plug 7 screw-threaded into it as indicated in Fig. 2. The bottom of the pump-barrel 4 has screw-threaded into it plug 8 (containing conduit and valve means to be later described). Said pump-barrel 4 is centrally and cylindrically bored throughout its length to different diameters (Fig. 2) to accommodate, provide differential areas, and limit the movement of the reciprocating parts about to be specifically described.

The pump plunger 5 is cylindrical throughout its length, but of three different diameters. Its middle portion 9 is made of greater diameter than its upper portion 10 in order to provide an annular shoulder 11 to limit its upward reciprocating movement. The lower portion 12 of said pump-plunger 5 is of still smaller diameter, among other purposes hereinafter made apparent, to permit it (when the pump-plunger is in its lowermost position) to close the ball check valve 13 and its adjoining passages. 14 is a breather pipe in open communication with the interior of the well casing. A pipe conduit 15, controlled by a ball check valve 16 connects the cylindrical chamber 17 with the well tubing 2, and a like conduit 18 similarly connects the annular chamber 19 with the well tubing 2.

The cylindrical portions of the valve plunger 6 are also of three different diameters. The difference in diameter between the upper portion 20 and the intermediate portion 21 of said valve plunger 6 is provided to create differential areas of pressure opposing faces as hereinafter described, locking by suction being prevented by breather pipe 22 which is in open communication with the interior of the well-casing. The lower portion 23 of the valve plunger 6 being of still lesser diameter than the intermediate portion 21 of said valve plunger, provides an annular chamber 24 which communicates with the well tubing 2 by the pipe conduit 25. The lower end of the portion 23 of the valve plunger 6 is conical in form, and, when in its lowermost position, seats as indicated at 26. The chamber 27 (above the valve plunger 6) is in open communication with the well-tubing 2 through the conduit pipe 28. The pipe conduit 3 is connected by nipple 30 to cylindrical chamber 29 (above the upper portion 10 of the pump plunger 5).

The modified form of the device illustrated in Fig. 3 of the drawings differs principally from the apparatus of Figs. 1 and 2 above described in that the valve plunger 6 with its immediately associated parts is placed above the ground instead of being submerged in the bottom of the well casing. Such arrangement requires the substitution of spring means, in place of the hydrostatic pressure in the well, to return the valve plunger 6 to its seat.

In this modified form (Fig. 3) 2—3 represents a combined pressure pipe and well tubing, the pipe 2 being connected to the pipe 2—3 by an elbow and nipple connection 31. Still referring to Fig. 3, the pipe 2—3 is screw threaded to pump barrel 4 at 32. 33 is a surging chamber closed at its upper end by a cap 34 and connected adjacent to the bottom of the chamber 19 by a T and nipple screw-threaded connection 35 to said chamber. The purpose of this chamber 33 is to avoid the installation of a second string of pipe where it is considered advantageous to do so. The chamber affords a fluid reservoir to apply pressure for the return of pump plunger 5 to its upper position while the hydraulic pressure is being dissipated at the surface through the relief valve there located. 35A indicates a ball-check valve at the bottom of surging chamber 33. The upper portion of the pressure and well tube-conduit pipe 2—3 communicates with the chamber 36 through pipe connections 37. 38 diagrammatically represents the pumping apparatus by which hydraulic pressure is obtained to actuate the pump plunger in its pumping stroke; and 39 is a like representation of a storage tank for liquid being pumped and used as pressure-fluid. Pipe connections 40 from the pump 38 are conduits for the liquid under pressure from the pump. Pipe 41 is a conduit for oil being pumped into the storage tank 39, which pipe 41, is connected by a bleeder nipple 42 to the chamber 27 (above the valve plunger 6). 43 indicates a helical spring (including spring-holding and positioning elements which are obvious) tending by its expansion to normally impel the valve element 6 to its lowermost position and upon its seat 26. Screw tension adjusting means, well known in the art, are indicated at 44.

It will be seen from the foregoing description that I have provided a device in which there are two sliding members, each having faces opposed to hydraulic pump-pressure communicated from the top of the well, and each, also, having other faces opposed to the hydrostatic pressure within the well. The principle of operation of the device is to utilize pump-pressure, concentrated (during its power stroke) on top of the pump-plunger 5, to force the oil in the chamber beneath it into the oil tubing 2 and out of the well, at the end of which stroke such concentrated pressure is dissipated or minimized by the opening of an outlet valve (the raising of valve 6 from its seat) whereupon hydrostatic pressure operating against opposing faces of the pump-plunger 5 returns it to the initial position for another stroke. In order to effectuate the desired result (above described), the areas of the ends and intermediate annular shoulders of pump-plunger 5 and valve-plunger 6 are made to differ in a definite ratio, the computation of which (the principle of operation being understood) being a matter of engineering skill of the designer, there being considerable latitude in deciding upon such relative areas to produce the results desired and to meet diverse conditions found in different wells.

The operation of the device (referring particularly for the present to the form illustrated in Figs. 1 and 2) is as follows: Starting with the mechanism in the position shown in Fig. 2, that is to say, the pump-plunger 5 being in its uppermost position and the valve-plunger 6 in its lowermost position (upon its seat 26), hydraulic pressure is communicated from the pump 38 (Fig. 3) at the top of the well through the pressure-pipe conduit 3 and its nipple connection 30 to the chamber 29. Areas on the bottom of the valve-plunger 6 (in its closed position) are much less than the area on the upper surface of the pump-plunger 5, so that the effect of the hydraulic pressure is to force the pump-plunger 5 downwardly to the bottom of its stroke, during which movement the valve plunger 6 remains seated. When, however, the pump-plunger 5 has reached the limit of its movement (at which time the lower face of its lower portion 12 seats upon and closes off the check valve 13), owing, partially to a reduction of the hydrostatic pressure through the pipe 28 in the chamber 27 (on the top of the valve-plunger 6) caused by the closing of the valve 13 (communicating with the oil casing) but, principally, owing to the building up of hydraulic pressure in the chamber 29 (top of pump-plunger 5), the valve-plunger 6 is lifted from its seat 26 and the pressure in the chamber 29 (theretofore concentrated upon the top of pump-plunger 5) is partially dissipated, at which time hydrostatic pressure in the chamber 12 beneath the lower surface of the pump-plunger 5 (area being so proportioned as to secure such effect) impels said pump-plunger upwardly toward the initial position simultaneously causing a low pressure area to exist in chamber 17 (under lower portion 12 of pump-plunger 5), the effect being the entrainment of fluid from the well bore into chamber 17. When the pump-plunger 5 reaches its uppermost position, hydrostatic pressure is built up and communicated, principally, through the pipe 28 to the chamber 27 (top of the valve-plunger 6), causing it to move downwardly to its seat 26, thus again closing the chamber 29, when the mechanism is in position for a repetition of the cycle just described.

Let diameter of "A" equal $\frac{3}{4}$'', its area being .44179 square inches.

Let diameter of "B" equal $\frac{13}{16}$'', its area being .51849 square inches.

Let the diameter of "C" equal $1\frac{7}{16}$''; and being an annular face, it has an area of 1.6230—.51849 which equals 1.10451 square inches.

Let the diameter of "D" equal $1\frac{9}{16}$'', its area being 1.9175 square inches.

Assuming that the device is installed in a well bore at a depth of 5,000 feet, we have the following opposing weights:

Hydrostatic pressure (2170 pounds)×1.9175 equals 4,171 pounds exerted downwardly upon "D" to retain the valve against the seat; and, 2170×1.10451 equaling 2,396.8 pounds exerted upwardly against "C", plus 2170×.44179 equaling 958.7 pounds exerted upwardly against "A", which represents total hydrostatic weight of 3,355.5 pounds opposing the weight exerted against "D", thus the differential in weights retaining the valve in a seated position is: 4,171—3,355.5 or 815.5 pounds. Therefore, before the valve can be raised off the valve seat, hydraulic pressure amounting to 815.5 divided by .44179, equaling 1,845 pounds per square inch, must be applied.

As the relative ratios of the faces on the pump plunger are such that the necessary operating pressure is appreciably less than this poundage, the valve plunger 6 will remain seated until the pump plunger terminates its downward stroke, and, as downward movement ceases and a deadlock occurs, the pressure will build up to the required poundage to cause valve plunger 6 to become unseated. Immediately upon valve plunger 6 being raised above the seat, the pressure differentials change, as the entire cross-sectional area of the diameter of which "C" forms the annular face, namely, $1\frac{7}{16}$'', with an area of 1.6230 square inches, is subjected to both the hydrostatic pressure and the hydraulic pressure applied to raise the valve. Thus, the initial weight applied to retain valve plunger 6 in its upward position is: 2170×1.6230 plus 1845×1.6230 or 6516.3 pounds, while the opposing weight exerted downwardly against "D" is 4,171 pounds, therefore, the differential in weights retaining the plunger 6 in its uppermost position is: $6516.3 - 4171$ or 2345.3 pounds. It will readily be seen that the valve will be retained in its uppermost position until the greater amount of the hydraulic pressure has been dissipated, during which interval the pump plunger 5 is being returned to its uppermost position. When hydraulic pressure has been lowered to the point where the weight exerted against "D" is greater than that exerted against "B" and "C", valve plunger will again become seated, and hydraulic pressure will build up for the commencement of the next cycle.

Supplementing the foregoing description of operation by particular reference to the form shown in Fig. 3; pump-pressure is communicated through the pipe 40, chamber 36, pipe 37, and pipe 2—3 to the top of the pump-plunger 5, which forces it downwardly to the end of its stroke, which (as in the case of the device of Figs. 1 and 2) seats the lower face of the lower portion 12 of the pump-plunger 5 over the check-valve 13, thus cutting off pressure (in the casing outside) from the pipe 2 and its connections upwardly. During this downward movement of pump-plunger 5, the valve-plunger 6 is maintained by the expansion of the spring 43 at its lowermost position, seated at 26. Continuing the pump-pressure after the pump-plunger 5 has reached the end of its stroke forces upwardly the valve-plunger 6 against the expansion of its spring 43. As soon as pressure on the upper surface of pump-plunger 5 is thus lessened, said pump-plunger will, responding to hydrostatic pressure in the surging chamber communicated to the chamber 19, (and, perhaps to some extent in the chamber 17 communicated from the well casing), raise to its initial uppermost position, at which time the valve-plunger 6, acted upon by the expansion of its spring, will return to its seat 26, the parts being then in position to repeat the cycle.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is,—

1. In a device of the character described, the combination of means to create hydraulic pressure, conduits for such pressure to a hydraulic pressure chamber; conduits for hydrostatic pressure, and a plurality of hydrostatic pressure chambers served by said conduits; a pump barrel enclosing said hydraulic pressure chamber and having extensions at each end enclosing said hydrostatic pressure chambers, a pump-plunger operatively mounted in said pump-barrel and having a surface opposed to the pressure within the hydraulic pressure chamber and another surface opposed to pressure within one of the hydrostatic pressure chambers; a valve plunger operatively mounted in an extension of said pump barrel and having a surface opposed to pressure within said hydraulic pressure chamber and other surfaces opposed to pressure within a hydrostatic pressure chamber, the relative areas of the respective surfaces opposed to pressure being such as to permit hydraulic pressure to actuate the pump plunger in its power stroke and hydrostatic pressure to return it to initial position after having completed its power stroke.

2. In a device of the character described, means to create hydraulic pressure, a hydraulic pressure chamber positioned within a region of hydrostatic pressure within a well, a conduit for said hydraulic pressure to said hydraulic pressure chamber; a pump barrel; a pump-plunger operatively mounted in said barrel having a surface opposed to said hydraulic pressure within said hydraulic pressure chamber; valvular means controlling a port from said hydraulic pressure chamber adapted to be maintained by said hydrostatic pressure outside of said hydraulic pressure chamber in closed position during a pumping stroke and to open to relieve hydraulic pressure in said hydraulic pressure chamber at the conclusion of a pumping stroke, means utilizing said hydrostatic pressure within the well to return the pump plunger to the position it occupied before being acted upon by the hydraulic pressure within said pressure chamber.

3. In a device of the character described, a hydraulic pressure chamber positioned in a region of hydrostatic pressure within a well; a pump barrel; a pump plunger operatively slidable in said barrel, having a surface opposed to hydraulic pressure within said hydraulic pressure chamber and other surfaces opposed to said hydrostatic pressure outside of said chamber and within said well, a valve plunger operatively slidable in an extension of said pump barrel having a surface opposed to hydraulic pressure within said hydraulic pressure chamber, and other surfaces outside of said hydraulic pressure chamber opposed to hydrostatic pressure within said well, hydraulic pressure supplied to said hydraulic pressure chamber to actuate said pump-plunger in its pumping stroke and to raise said valve plunger to open its valve against opposing hydrostatic pressure at the conclusion of said pumping stroke, thus to relieve hydraulic pressure within said chamber and to permit hydrostatic pressure to restore said pump plunger to position for its next pumping stroke.

4. In a device of the character described, hydraulic pressure means above the ground, a conduit for said hydraulic pressure to a pressure chamber positioned in a region of hydrostatic pressure within a well; a pump barrel; a pump plunger slidably mounted in said pump barrel and adapted for actuation to perform a pumping stroke by hydraulic pressure supplied to said chamber by said pressure means, a port from said pressure chamber, valvular means controlling said port and normally maintaining closure of said port by hydrostatic pressure within the well outside of said hydraulic pressure chamber, said valvular means being adapted to be actuated to open said port by the excess over said hydrostatic pressure tending to maintain it in closed position of the hydraulic pressure within said chamber at the conclusion of each pumping stroke.

5. In a device of the character described, means to create hydraulic pressure, a hydraulic pressure chamber positioned in a well in a region of hydrostatic pressure, a conduit for said hydraulic pressure to said hydraulic pressure chamber, a pump barrel, a pump plunger operatively mounted in said pump barrel and having a surface opposed to said hydraulic pressure within said hydraulic pressure chamber, valvular means communicating with said hydraulic pressure chamber and adapted to open

to relieve hydraulic pressure in said hydraulic pressure chamber, said valvular means being normally maintained in closed position during the pumping stroke and adapted to open to relieve hydraulic pressure at the end of the pumping stroke by the excess of said hydraulic pressure over the force of its normally closing means, means utilizing said hydrostatic pressure within the well to return the pump plunger to the position it occupied before being actuated by the hydraulic pressure within said pressure chamber.

6. In a device of the character described, a hydraulic pressure chamber positioned in a well in a region of hydrostatic pressure; means to supply hydraulic pressure to said hydraulic pressure chamber; a pump barrel, a pump plunger slidably mounted in said pump barrel and having a surface opposed to hydraulic pressure within said hydraulic pressure chamber and another surface opposed to hydrostatic pressure within said well, a valve plunger mounted in an extension of said pump barrel controlling a port controlled by said valve plunger adapted to be opened to relieve hydraulic pressure within said hydraulic pressure chamber, and means normally tending to maintain said valve plunger in a position closing said port, means to supply hydraulic pressure to said pressure chamber to actuate said pump plunger in its pumping stroke and at the end of said pumping stroke to raise said valve plunger against its opposing closure means to open said port, thus to relieve hydraulic pressure within said chamber and to permit hydrostatic pressure to restore said pump plunger to position for its next pumping stroke.

7. In a device of the character described, means to create hydraulic pressure, a hydraulic pressure chamber, a conduit for said hydraulic pressure to said pressure chamber, a pump barrel, a pump plunger operatively mounted in said barrel and adapted for actuation to perform a pumping stroke by said hydraulic pressure supplied to said chamber, valvular means controlling a port from said pressure chamber, hydrostatic means for normally maintaining closure of said port during a pumping stroke, said valvular means being adapted to be actuated by an excess of hydraulic pressure over said hydrostatic pressure to open said port against its opposing closure means at the conclusion of a pumping stroke.

8. In a device of the character described, a pump, comprising a pump barrel having slidably contained therein a pump plunger, said pump being mounted within a region subject to hydrostatic pressure within a well, said pump plunger having lower surfaces exposed to said hydrostatic pressure; means to create hydraulic pressure; a conduit for said hydraulic pressure, a hydraulic pressure chamber in said pump barrel above said pump plunger; a port for the release of hydraulic pressure within said hydraulic pressure chamber; a valve controlling said last-mentioned port, said valve comprising a plunger slidable in a barrel forming an extension of said pump barrel, said valve plunger having surfaces subject to hydrostatic pressure within a plurality of hydrostatic pressure chambers; conduits for said hydrostatic pressure to said respective hydrostatic pressure chambers, the areas of said respective surfaces of pump plunger and valve plunger being so proportioned as to permit said pump plunger to be actuated by hydraulic pressure to perform a pumping stroke, and to be returned to initial position for the next pumping stroke.

SAMUEL EVANS ROSS.