Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

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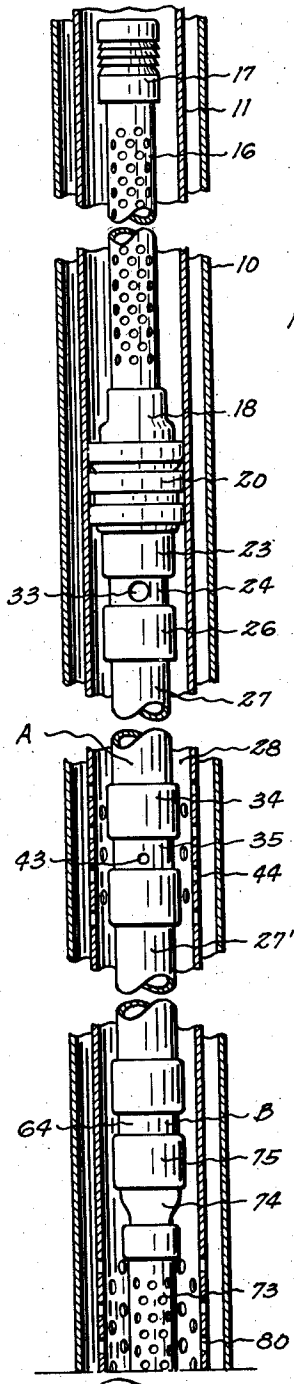


Fig. 1.

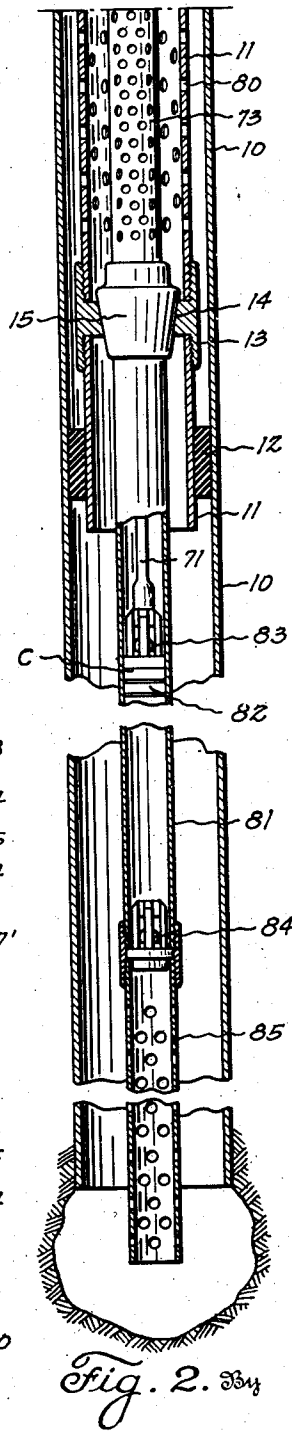


Fig. 2.

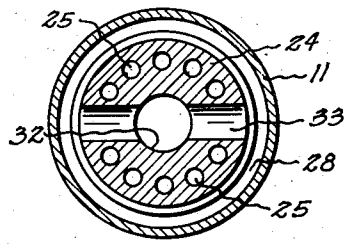


Fig. 9.

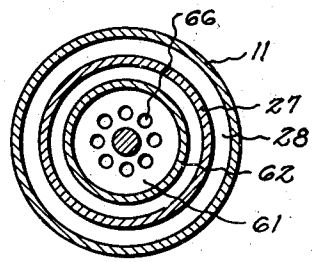


Fig. 10.

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PUMPING APPARATUS

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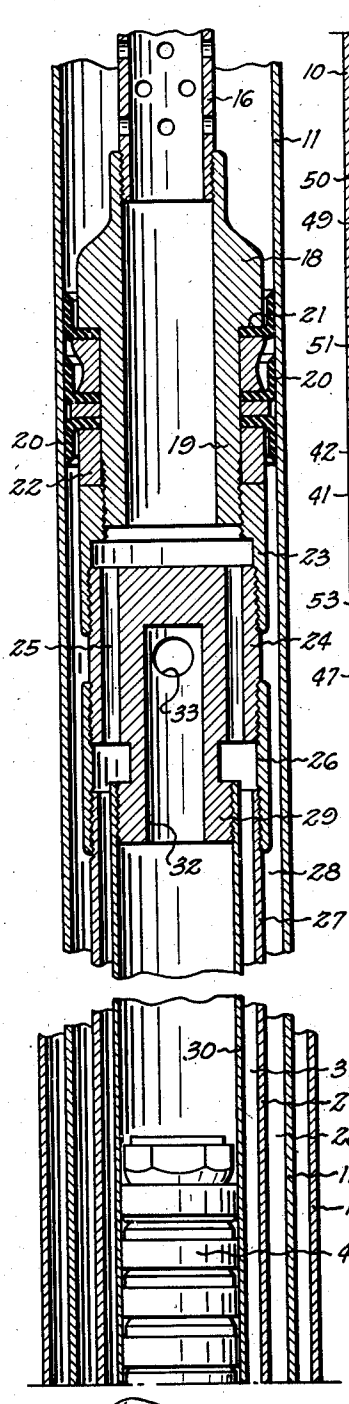


Fig. 3.

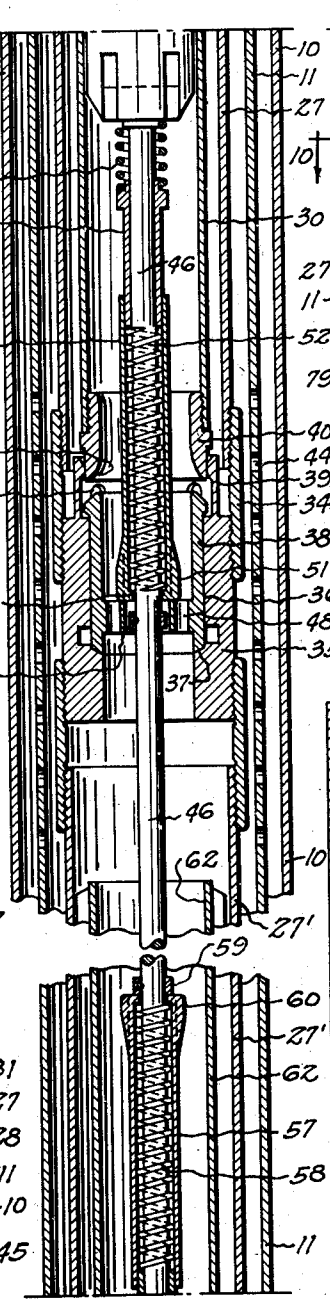


Fig. 4.

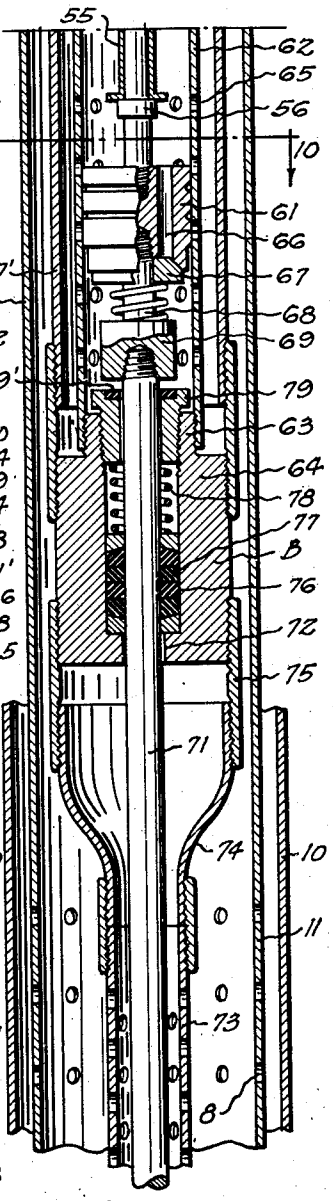


Fig. 5.

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Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 3

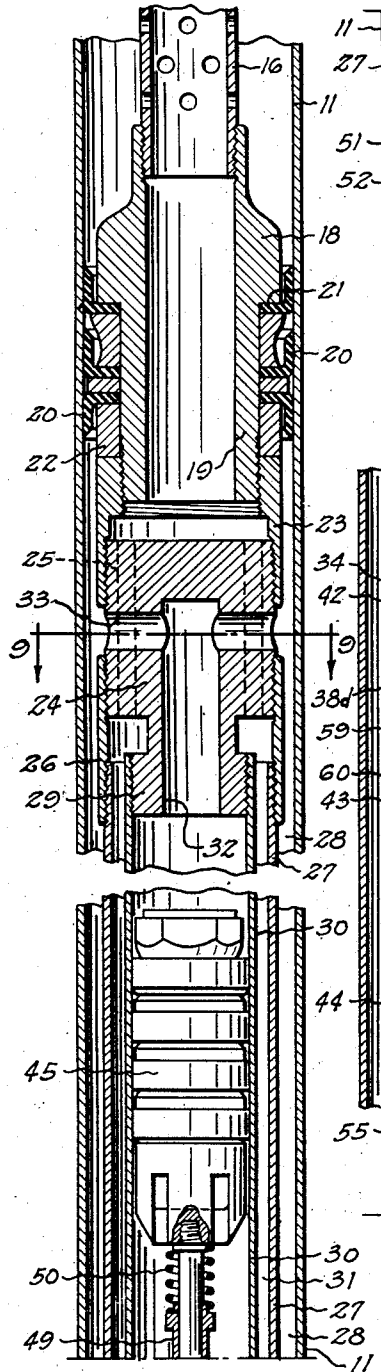


Fig. 6.

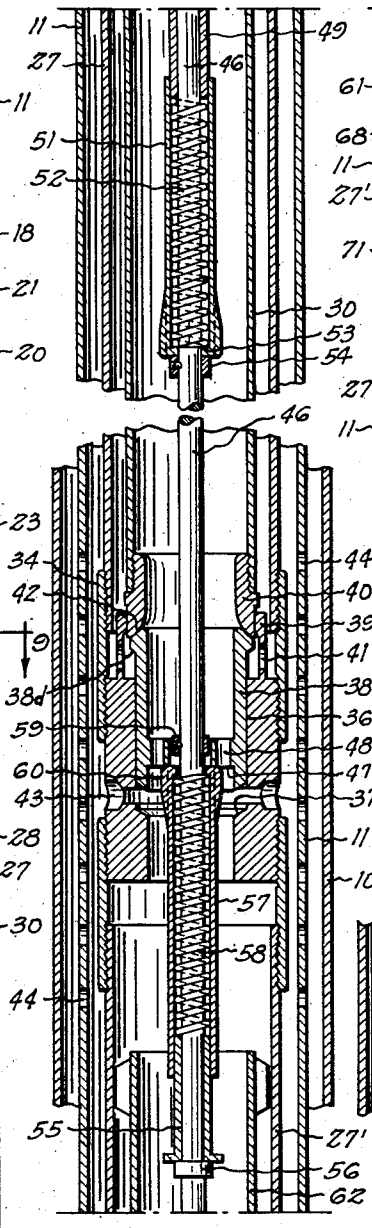


Fig. 7.

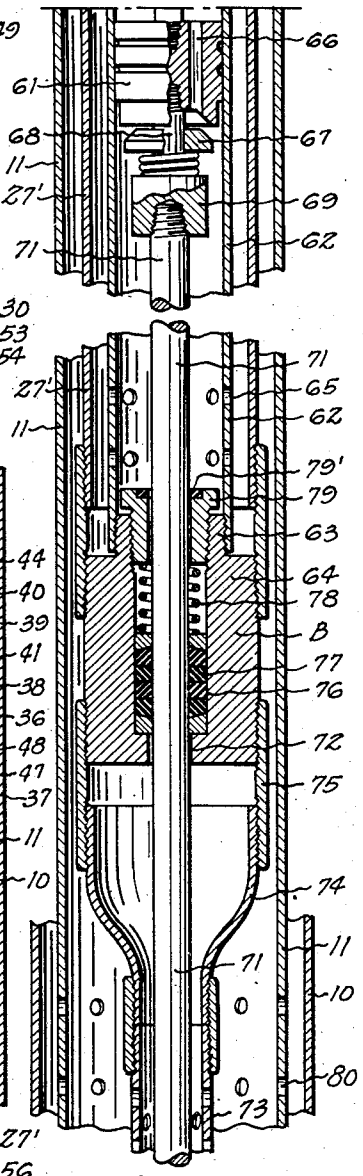


Fig. 8.

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Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 4

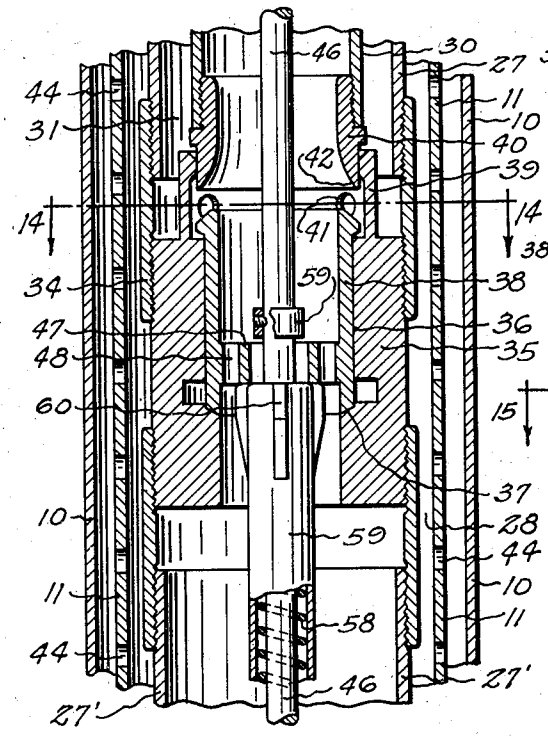


Fig. 11.

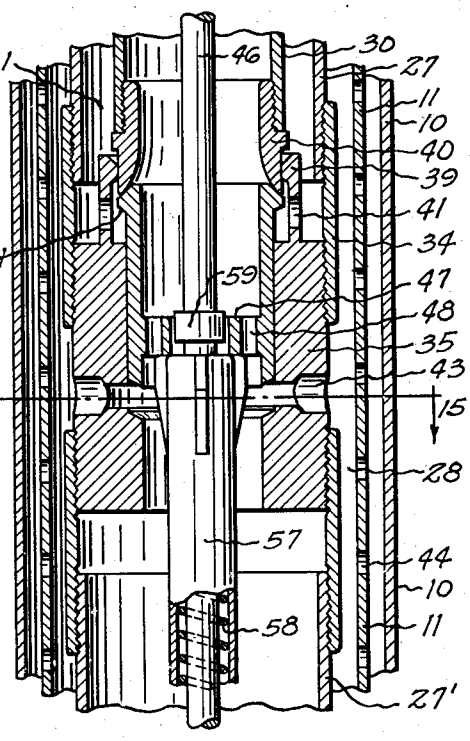


Fig. 12.

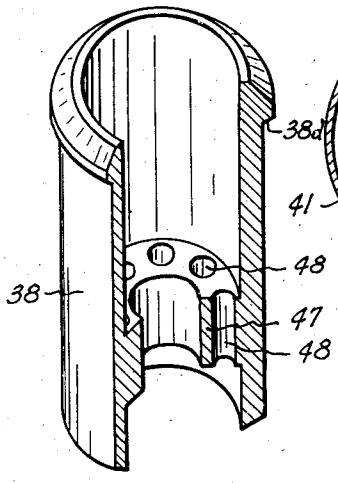


Fig. 13.

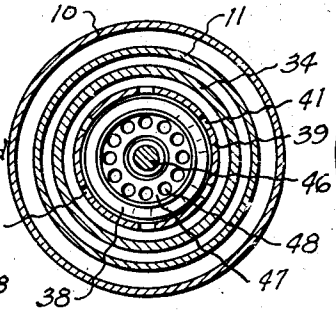


Fig. 14.

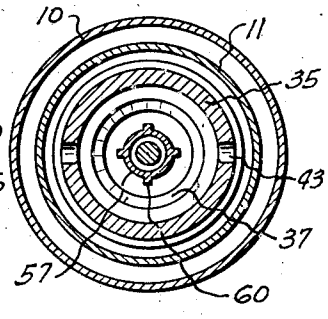


Fig. 15.

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Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 5

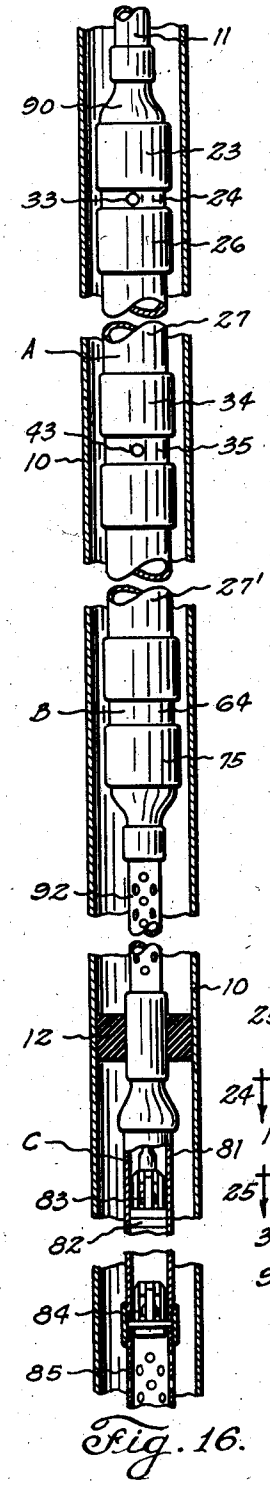


Fig. 16.

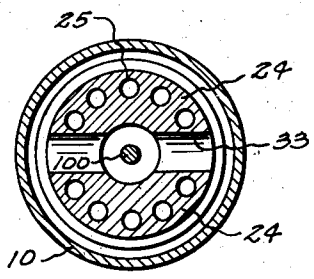


Fig. 24.

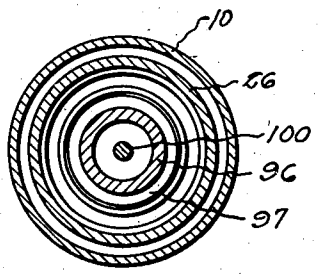


Fig. 25.

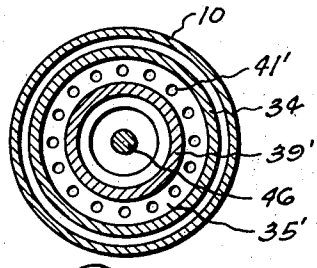


Fig. 20.

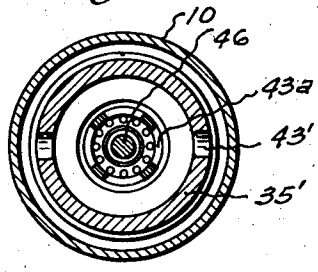


Fig. 22.

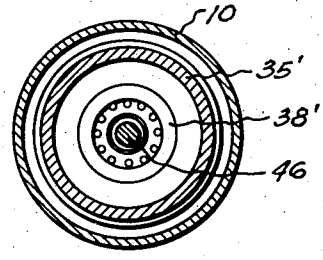


Fig. 21.

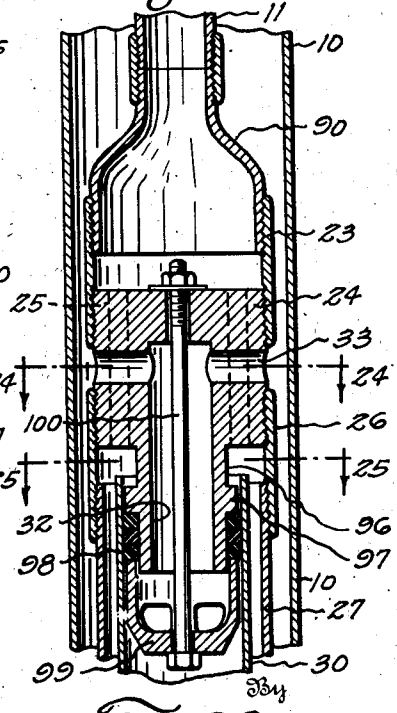


Fig. 23.

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Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

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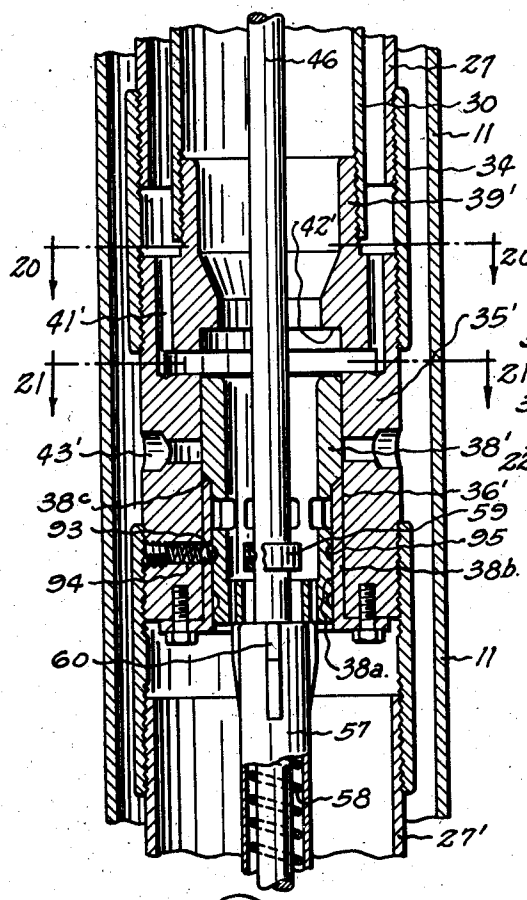


Fig. 17.

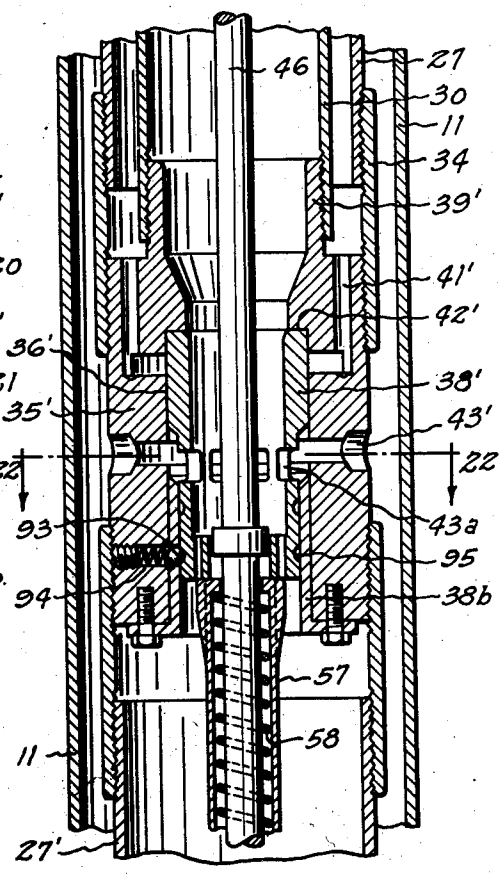


Fig. 18.

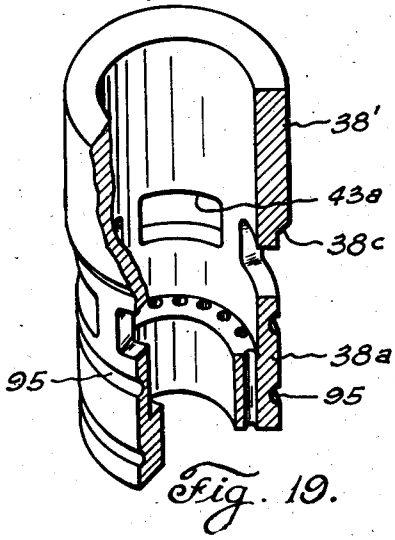


Fig. 19.

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Feb. 17, 1942. R. C. FARLEY ET AL 2,273,349

PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 7

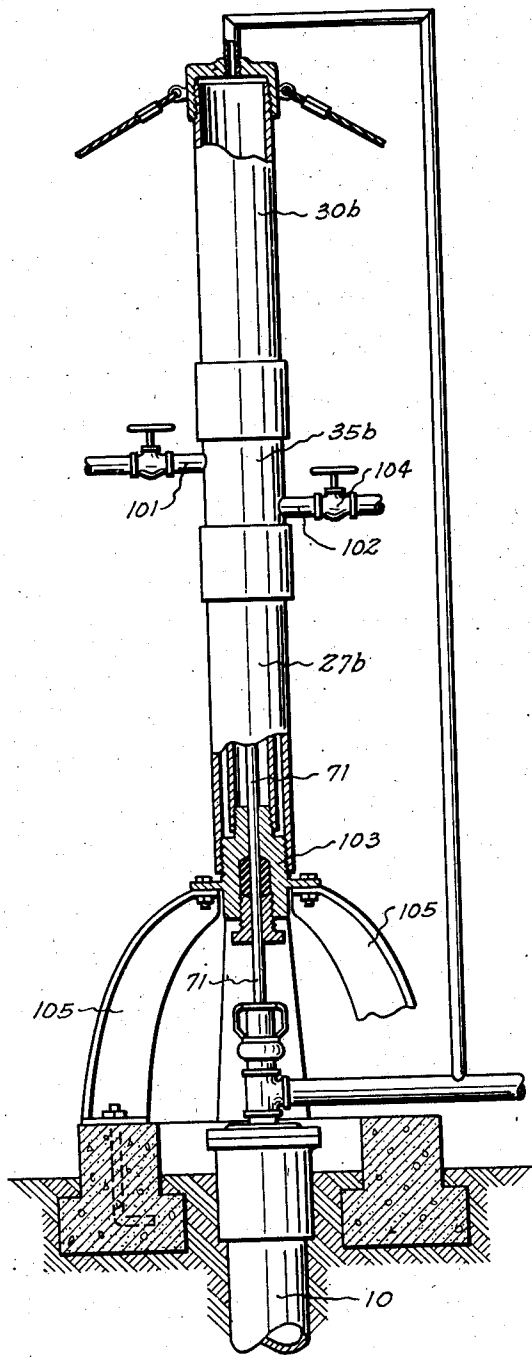


Fig. 26.

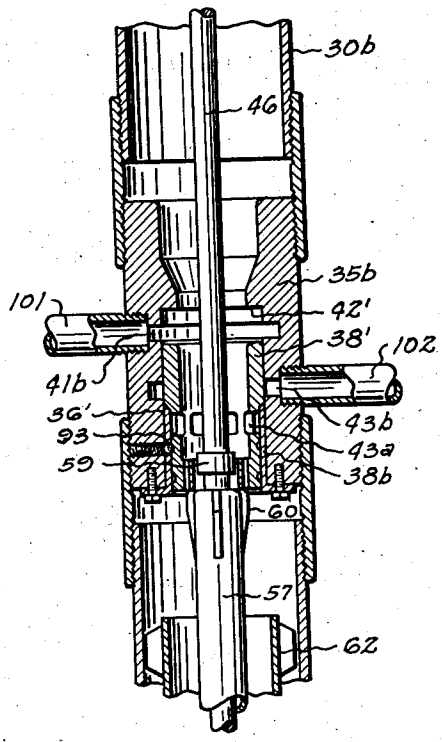


Fig. 27.

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PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 8

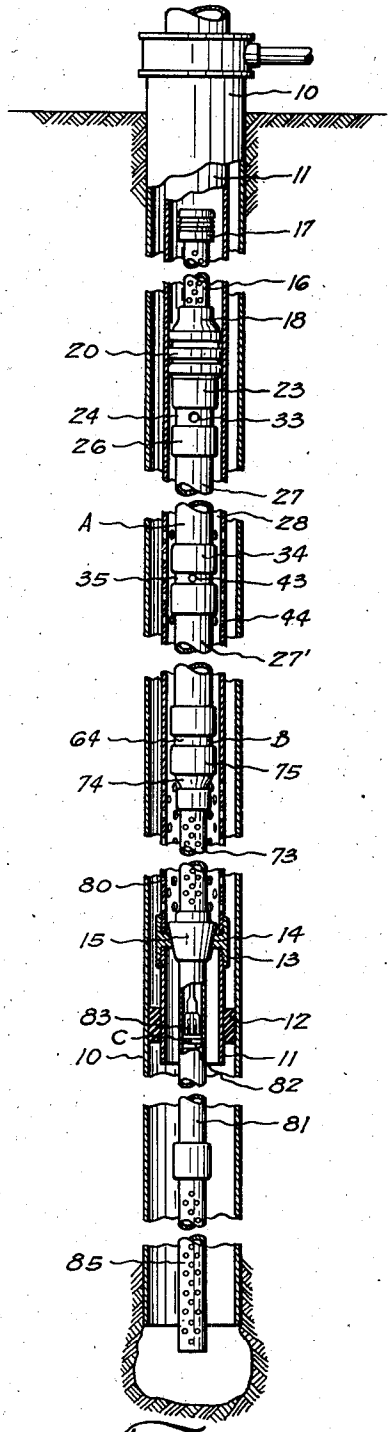


Fig. 28.

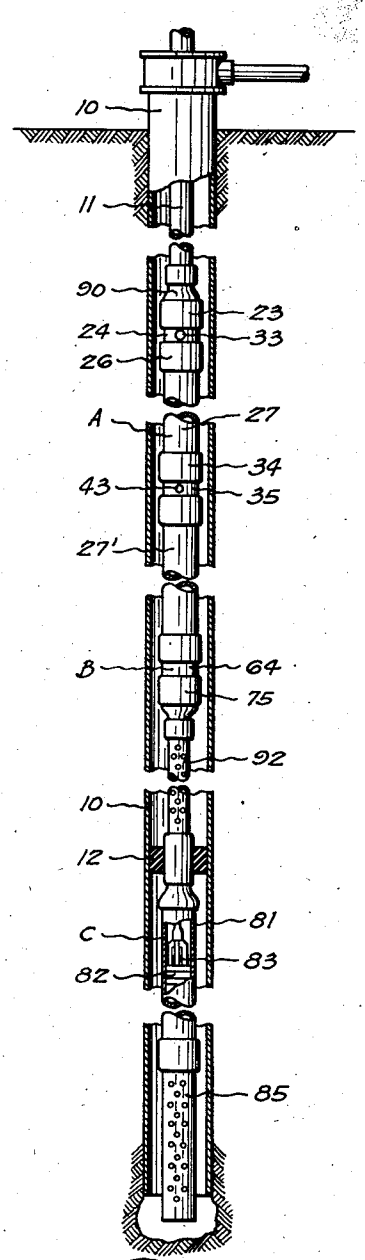


Fig. 29.

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PUMPING APPARATUS

Filed Aug. 18, 1938 9 Sheets-Sheet 9

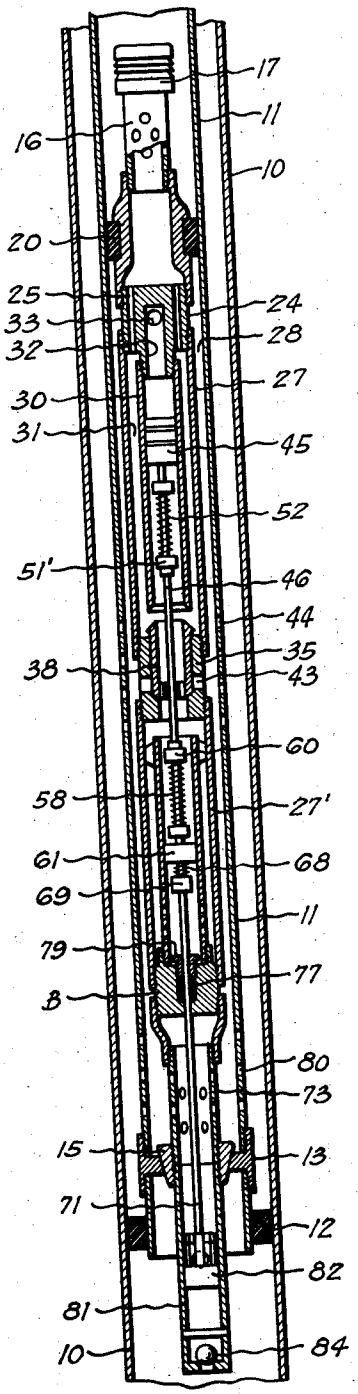


Fig. 30.

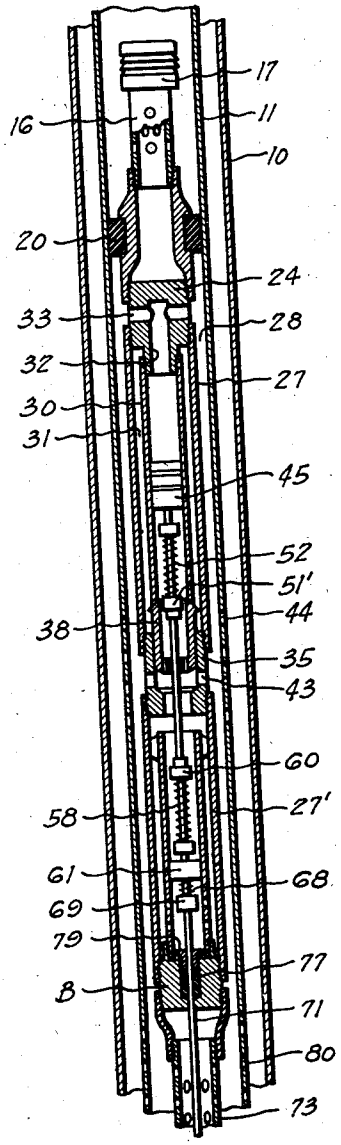


Fig. 31.

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Patented Feb. 17, 1942 2,273,349

UNITED STATES PATENT OFFICE

2,273,349

PUMPING APPARATUS

Ralph C. Farley and J. W. Gillespie,
Henderson, Tex.

Application August 18, 1938, Serial No. 225,504

31 Claims. (Cl. 103—46)

The invention relates to new and useful improvements in pumping apparatus.

One object of the invention is to provide an improved apparatus for operating the usual reciprocating well pump, which apparatus is actuated by a pressure fluid, whereby the use of a pump jack, or other mechanical pumping unit, together with the cost of operation and maintenance thereof, is eliminated.

An important object of the invention is to provide an improved pumping apparatus which is arranged to be lowered into a well in close proximity to the well pump and which is adapted to be operated from the surface by a pressure fluid, whereby the usual elongate pump rods and pumping units at the surface, are eliminated.

Another object of the invention is to provide an improved pumping apparatus, wherein a reciprocating piston is attached to the usual well pump, with means for applying a fluid pressure to the piston to raise the same and thereby impart an upstroke to the well pump; the downstroke of said pump occurring by gravity, when the pressure below said piston is released, whereby operating costs are minimized and efficient pumping is accomplished.

A particular object of the invention is to provide an improved apparatus, of the character described, wherein the admittance and release of pressure to the operating piston is controlled by a single sliding valve, which is actuated with a snap action, whereby the direction of movement or stroke of the piston and the well pump connected thereto is positively and abruptly changed to eliminate inertia interfering with the operation of the apparatus.

A further object of the invention is to provide an improved pumping apparatus, wherein the stroke of the well pump is fixed and also wherein means for absorbing the shock on the downstroke of the pump plunger is provided so as to insure smooth operation with minimum wear.

Still another object of the invention is to provide an improved pumping apparatus which is so constructed that it may be run into or removed from a well bore on a wire line, whereby the time and labor necessary to position the device within said well bore is minimized.

A still further object of the invention is to provide an improved well pumping apparatus which is so arranged that it may be lowered into the well bore and operated by a fluid pressure from the surface; or, if desired, it may be located at the surface and connected with the well pump within the bore, thereby making the apparatus adaptable to various types of wells.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, and showing the upper portion of an apparatus, constructed in accordance with the invention, and mounted within a well tubing,

Figure 2 is a continuation of Figure 1 showing the lower portion of the device,

Figure 3 is a transverse, vertical, sectional view on an enlarged scale of the upper portion of the device,

Figure 4 is a continuation of Figure 3 showing the central portion of said device,

Figure 5 is a continuation of Figure 4 and showing the lower portion of the device,

Figures 6, 7 and 8 are views similar to Figures 3, 4 and 5 and showing the valve in its other position,

Figure 9 is a horizontal, cross-sectional view taken on the line 9—9 of Figure 6,

Figure 10 is a horizontal, cross-sectional view taken on the line 10—10 of Figure 5,

Figure 11 is an enlarged, transverse, vertical, sectional view of the control valve and showing the same in a lowered position during the upstroke of the piston,

Figure 12 is a similar view with the valve member raised during the downstroke of the piston,

Figure 13 is a partial isometric view of the valve member,

Figure 14 is a horizontal, cross-sectional view taken on the line 14—14 of Figure 11,

Figure 15 is a horizontal, cross-sectional view taken on the line 15—15 of Figure 12,

Figure 16 is a view, partly in elevation and partly in section, and showing the apparatus as connected directly in the tubing string,

Figure 17 is a view similar to Figure 11 and showing a modified form of control valve, with the valve member in a lowered position,

Figure 18 is a view similar to Figure 17 with the valve member in a raised position,

Figure 19 is a partial isometric view of the valve member shown in Figures 17 and 18,

Figure 20 is a horizontal, cross-sectional view taken on the line 20—20 of Figure 17,

Figure 21 is a horizontal, cross-sectional view taken on the line 21—21 of Figure 17,

Figure 22 is a horizontal, cross-sectional view taken on the line 22—22 of Figure 18,

Figure 23 is a transverse, vertical, sectional view showing a modified method of connecting the upper end of the cylinder wherein the operating piston reciprocates,

Figure 24 is a horizontal, cross-sectional view taken on the line 24—24 of Figure 23,

Figure 25 is a horizontal, cross-sectional view taken on the line 25—25 of Figure 23,

Figure 26 is a view, partly in elevation and partly in section, and showing a modified form of apparatus particularly adapted for use at the surface of the well,

Figure 27 is a transverse, vertical, sectional view of a modified form of valve for use in the form shown in Figure 26.

Figure 28 is a view, partly in elevation and partly in section, showing an apparatus, constructed in accordance with the invention, and mounted within a well tubing,

Figure 29 is a view, partly in elevation and partly in section, showing the apparatus as connected directly in the tubing string, and mounted within a well casing.

Figure 30 is a schematic, transverse, vertical, sectional view of the apparatus with certain details of construction omitted and showing the position of the valve on the upward travel of the piston, and

Figure 31 is a view similar to Figure 30, showing the position of the valve on the downward travel of the piston.

In the drawings (Figures 1 and 2), the numeral 10 designates the usual well casing which extends substantially throughout the well bore. The lower end of the casing is open, whereby the well fluids may enter said casing and flow upwardly therein. The well tubing 11 extends axially through the well casing, being suspended from a tubing hanger, or other support (not shown) at the surface and the lower end of said tubing terminates at a point above the lower end of the casing. A suitable packer 12 surrounds the lower end of the tubing (Figure 2) and engages the wall of the well casing so as to pack off the annular space between the tubing and casing. Above the packer, a seating collar 13 is connected in the tubing 11 and is provided with an internal, annular, beveled seat 14.

The improved pumping apparatus A is arranged to be lowered into the well tubing, as will be hereinafter explained, and includes a seating nipple 15. This nipple has its outer surface beveled complementary to the inclination of the seat 14, whereby when the apparatus A is lowered into the tubing, the nipple is arranged to engage the seat to support said apparatus in the tubing.

The apparatus includes an elongate perforated pipe section 16 which is located at the upper portion of the same (Figure 3) and this pipe section has a fishing neck 17 of the usual construction at its upper end, whereby a suitable tool (not shown) may be utilized to raise and lower the apparatus in the tubing. The lower end of the pipe section 16 is threaded into the upper end of a swaged coupling collar 18, which collar has a depending tubular shank 19 preferably made integral therewith. Pressure actuated packing cups 20 surround the shank and engage the wall of the tubing, being confined on said shank between an external shoulder 21 on the collar and a nut 22 screwed onto the lower portion of the shank. Three cups have been shown but any desired number may be employed and, as illustrated, the lowermost cup is inverted, whereby a seal in both directions between the shank and the well tubing is had.

The lower end of the shank is connected by a coupling 23 with the upper end of a cylindrical head or block 24 which head has a plurality of vertical passages 25 extending therethrough. A coupling collar 26 is threaded onto the exterior of the head and has its lower end receiving an elongate sleeve 27 which extends axially within the tubing 11. The outer diameter of the sleeve is less than the inner diameter of the tubing, whereby an annular space 28 is formed therebetween. The bottom of the head has a reduced collar 29 depending therefrom and preferably made integral therewith and, as clearly shown in Figure 3, the collar is of a smaller diameter than the sleeve 27 and is disposed within the upper end of said sleeve. The collar 29 has external screw threads thereon whereby the upper end of a cylinder 30 may be connected thereto. The cylinder extends axially substantially throughout the length of the sleeve and is of a smaller diameter to provide an annular space 31 therebetween. An axial bore 32 extends upwardly through the collar 29 and also partially through the head or block 24 and the lower end of said bore communicates with the interior of the cylinder 30. Radial ports 33 extend through the head, being located between the vertical passages 25 and establish a communication between the upper end of the bore 32 and the annular space 28 between the sleeve 27 and well tubing 11, whereby fluid may flow from the cylinder 30 through the bore 32 and ports 33 and into the well tubing.

When the apparatus is in position within the well tubing 11, it is manifest that fluid introduced under pressure from the surface may flow downwardly through said tubing and will enter the perforated section of pipe 16. The fluid cannot by-pass the pipe because of the packing cups 20 immediately therebelow and, thus, the pressure fluid is directed into the pipe and flows downwardly through the collar 18 and bore of the shank 19, after which it passes into the coupling 23 above the head 24. The fluid then flows through the vertical passages 25 in said head and enters the upper end of the sleeve 27, flowing downwardly through said sleeve in the annular space 31 between said sleeve and the cylinder 30. In this manner, a pressure fluid introduced into the upper end of the tubing is conducted to the sleeve 27 so as to flow downwardly therethrough.

The lower end of the sleeve 27 is connected by a coupling 34 with the upper end of an annular valve body 35, which body has its lower end connected to the upper end of an elongate tubular sleeve 27'. The sleeve 27' extends axially through the well tubing and has its lower end connected to a stuffing box B, as will be explained. The valve body has an axial bore 36 which is formed with an internal, annular, beveled seat 37 therein and a tubular valve member 38 is slidable in the bore above the seat. The lower end of the valve member is beveled complementary to the inclination of the seat so as to engage the same and prevent a flow thereby. An upstanding collar 39 is preferably formed integral with the valve body and the diameter of this collar is less than the internal diameter of

the sleeve 27 to which the valve body is connected, whereby said collar projects upwardly into the lower end of the sleeve. The bore of the collar 39 receives the lower end of a complementary collar 40 which is threaded onto the lower end of the cylinder 30 and, with this arrangement, the cylinder is suspended from its upper end through attachment with the collar 29 on the head 24, its lower end being held in axial alinement with the sleeve by the collar 40 engaging within the upstanding collar 39 on the valve body 35.

The upstanding collar 39 is provided with a plurality of inlet ports 41 which establish a communication between the interior of the sleeve 27 and the interior of the collar. Since the collar communicates with the bore of the cylinder 30, it is manifest that fluid from the annular space 31 between the exterior of the cylinder and the sleeve, may flow through the ports 41 and thereby enter the interior of the cylinder.

The lower edge of the collar 40 which is attached to the cylinder 30 is inclined to form a seat 42 which seat is adapted to be engaged by the upper beveled end of the slidable valve member 38. When the member is in engagement with the seat 42 (Figure 7), its lower end is raised from the seat 37 formed within the bore of the valve body 35. In such position, a flow of fluid from the annular space 31 between the cylinder 30 and sleeve 27 to the interior of the cylinder 30 is prevented. As the valve member moves upwardly from the seat 37 to engage the seat 42, its lower end uncovers radial ports 43 which extend through the valve body from the bore thereof. The ports are located immediately above the seat 37 and when uncovered, establish a communication between the bore of the valve body and the exterior of said body. As clearly shown in Figure 7, the well tubing 11 extends downwardly past the valve body and thus fluid from within the bore of said valve body may flow through the ports 43 and into the annular space 28 between the tubing and body. From the tubing, this fluid may escape into the casing through perforations 44 provided for the purpose in the well tubing. When the valve member 38 is in its lowered position engaging the seat 37, the ports 43 are closed to prevent a flow therethrough (Figure 3). Such lowering of the valve, however, disengages its upper end from the upper seat 42, whereby flow from the sleeve 27 to the cylinder 30 is permitted through the ports 41.

From the foregoing, it will be manifest that the valve member 38 controls the admittance to and escape of fluid from the interior of the cylinder 30 and, as explained, this fluid is under pressure, having been introduced from the surface through the well tubing 11. A piston 45 mounted to reciprocate within the cylinder 30 and the pressure fluid introduced from the surface is utilized to reciprocate this piston. A piston rod 46 has its upper end connected to the piston and extends axially through the cylinder 30, tubular valve member 38, sleeve 27' and stuffing box B, and has its lower end connected with the well pump, as will be explained. For guiding the piston rod axially through the valve member 38, said member has a transverse web or partition 47 therein, which web has a central opening through which the rod extends. The web also has additional openings 48 therein, whereby an uninterrupted flow through the member may occur.

When the valve member 38 is in a lowered position, the pressure fluid in the annular space 31 between the sleeve 27 and cylinder 30 may enter the lower end of the cylinder through the ports 41 so as to act against the underside of the piston 45. Such pressure acts to raise the piston in the cylinder and thus lift the piston rod therewith. Any fluid above the piston is forced upwardly through the bore 32 in the collar 29 and then outwardly through the radial ports 33 and into the annular space 28 between the sleeve 27 and well tubing 11. This fluid passes downwardly through the space 28 and escapes therefrom into the well casing 10 through the perforations 44 in said tubing.

When the piston 45 has reached the top of its stroke, the valve member 38 is raised so as to engage the seat 42 and thereby cut off the communication between the space 31 and the interior of the cylinder. As the valve member is raised to engage the seat 42, its lower end disengages the seat 37 within the bore of the valve body 35 and the radial bleeder ports 43 are uncovered. The fluid below the piston 45 may then drain from the cylinder 30 through these ports and into the annular space 28, from where it may flow into the casing 10 through the perforations 44. As the fluid flows from the cylinder 30, the piston 45 falls by gravity until it has completed its downstroke. During such downstroke, fluid may be drawn into the upper end of the cylinder 30 through the radial ports 33 and bore 32. Upon completion of the downstroke, the valve member 38 is again lowered to engage the seat 37 to again cover the ports 43 and also to disengage the seat 42, whereby the pressure fluid from the annular space 31 is again admitted to the cylinder to raise the piston and repeat the operation.

For sliding the valve member 38 from one position to another to reciprocate the piston 45, as described, an elongate sleeve 49 is slidable on the upper end of the piston rod 46 below the piston. The upper end of the sleeve is spaced from the piston by a coiled spring 50 which surrounds the rod and which is confined between the flanged upper end of the sleeve and the underside of the piston. A second elongate sleeve 51 surrounds the rod and has its upper end telescoping the lower end of the sleeve 49. A coiled spring 52 surrounds the rod and is located within the bore of the lower sleeve 51, with its upper end engaging the lower edge of the upper sleeve 49. The lower end of the spring 52 rests on an internal shoulder 53 formed at the lower end of the lower sleeve and exerts its pressure to constantly urge the telescoping sleeves apart. Separation of the sleeves 49 and 51 is prevented by a collar 54 secured on the rod and, manifestly, the spring 52 normally holds the lower sleeve 51 in engagement with the collar 54, as shown in Figure 7. The extreme lower end of the sleeve 51 is formed with radial lugs or projections 51'. The telescoping sleeves 49 and 51 are utilized to lower the valve member 38 at the completion of the downstroke of the piston 45.

For raising the valve member 38 at the completion of the upstroke of the piston, an elongate sleeve 55, similar to the sleeve 49, is slidable on the lower end of the piston rod 46 (Figures 4 and 5), being supported on a collar 56 which is secured to said rod. The upper end of the sleeve telescopes the lower end of a second elongate sleeve 57, which is similar to the sleeve 51, and a coiled spring 58 is confined with the bore of this sleeve. The spring urges the upper end of the

sleeve 57 into engagement with a collar 59 on the piston rod. The upper end of said sleeve is formed with radial lugs 60.

With the piston 45 at the lower end of its downstroke, the parts are in the position shown in Figures 3 to 5 and, in such position, the lugs 51' on the sleeve 51 are engaging the top of the web 47 within the valve member. The collar 54 is within the axial opening in said web and is spaced from the sleeve, having been moved to this position on the lowering of the valve member 38, which lowering has just previously occurred. The pressure fluid which is introduced into the tubing at the surface is within the annular space 31 and may flow into the cylinder 30 to raise the piston 45, as has been explained. As the piston moves upwardly, the piston rod 46 travels therewith, thereby raising the sleeve 51 from the web of the valve member 38. As the sleeve 51 moves away from the web, the spring 52 immediately moves the sleeve into contact with the collar 54 and the sleeve remains in this position until the completion of the downstroke.

As the upstroke continues, the sleeve 51 is moved upwardly away from the valve member 38, while the sleeves 57 and 55 below said member are moved toward the same. During the upstroke, the pressure of the fluid is acting against the effective cross-sectional area of the valve member, this area being the upper edge thereof, and thus, the member is held in its lowered position engaging the seat 37. As the piston nears the upper end of its upstroke, the collar 59 above the sleeve 57 enters the axial opening in the web 47 of the valve member and the lugs 60 on the upper end of said sleeve contact the web. When this occurs, further movement of the sleeve 57 is resisted by the pressure holding the valve member 38 lowered, and continued upward movement of the piston 45 and rod 46 causes upward movement or telescoping of the lower sleeve 55 relative to the upper sleeve 57, thereby resulting in a compression of the coiled spring 58 confined between the sleeves' This spring is acting to urge the sleeve 57 upwardly and as soon as the spring has been compressed sufficiently to overcome the pressure holding the valve member 38 lowered, said valve member is moved upwardly to engage the seat 42. This movement is rapid for, obviously, the spring tension must reach a critical point sufficient to overcome the pressure acting downwardly on the valve member and, therefore, a snap action is imparted to the member.

As soon as the member 38 moves upwardly (Figure 7), the relief ports 43 in the valve body are uncovered to permit the fluid to drain from the cylinder 30 and allow the piston 45 and rod to move downwardly by gravity. During this downstroke, the valve member is held in a raised position by the pressure therebelow, as well as by the pressure within the annular space 28 outside the cylinder, which latter pressure acts against the underside of an external, overhanging flange 38d which is formed on the upper end of the valve member 38.

The downstroke of the piston 45 and rod continues until the lower end of the sleeve 51 strikes the web and the coiled spring 52 is compressed sufficiently to overcome the pressure holding the valve member raised. When this occurs, the member is returned to a lowered position to again close the relief ports 43 and to again admit the pressure fluid to the cylinder 30 and raise the piston 45. The provision of the telescoping sleeves above and below the valve member 38 makes it possible to operate the valve with a snap action to abruptly change the direction of movement of the piston 45. By varying the position of the sleeves on the piston rod and also by varying the tension of the springs 52 and 58, the length of the piston stroke may be changed.

For absorbing the shock and for assuring a smooth downstroke of the piston 45 and rod 46, a shock absorber is connected to the lower end of the piston rod. This shock absorber (Figure 5) includes a piston 61 which has the lower end of the rod 46 threaded axially therein. The piston is movable in a cylinder 62 which extends axially through the sleeve 27' depending from the valve body 35. The lower end of the cylinder 62 is threaded onto an upstanding collar 63 which is preferably formed integral with the upper end of the body 64 of the stuffing box. The cylinder has perforations 65 in its lower portion and has a length greater than the stroke of the piston 45 and rod 46, the open upper end of said cylinder terminating short of the valve body 35 (Figure 4). Vertical passages 66 extend through the piston 61 and their lower ends are normally closed by a slidable valve disk 67 which seats on the underside of the piston. The valve disk is mounted on a stem 68 which has an enlarged head 69 at its lower end and a coiled spring surrounding the stem is confined between the head and disk and constantly urges the disk to a seated position.

Upon the upstroke of the piston 45 and rod 46, the shock absorber piston 61 moves upwardly in its cylinder and fluid from within the sleeve 27' enters the cylinder 62 below the piston through the perforations 65. If there is a fluid head above the piston 61 which might interfere with the upward movement thereof, the valve disk 67 is unseated to allow a by-pass of fluid past said piston and, thus, it is assured that when the upstroke is completed, fluid is within the cylinder 62 below the piston 61.

As the downstroke begins, the piston 61 moves downwardly in its cylinder and forces the fluid therebelow from the cylinder through the perforations 65. At the start of the downstroke, all of the perforations are below the piston 61 but as said piston moves downwardly some of the openings are closed as fluid outlet. Manifestly, the piston 61 and rod 46 cannot fall any faster than the fluid can escape from the cylinder and, therefore, the rod 46 is lowered gradually. Since the outlets 65 are restricted as the piston 61 moves through the cylinder, the lowering of the rod 46 and operating piston 45 attached thereto is gradually slowed until said rod and piston finally stop at the end of the downstroke. In this manner, smooth operation is assured.

From the foregoing, it will be seen that the piston 45 is reciprocated in the cylinder 30 by the auxiliary pressure fluid which is introduced into the tubing 11 at the surface, the valve member 38 controlling the admittance of the pressure fluid to the cylinder. For connecting the piston rod 46 to a well pump C (Figure 2) so as to operate the same as said rod reciprocates, a connecting rod 71 (Figures 5 and 8) has its upper end threaded into the head 69 which is secured to the shock absorbing piston 61. Since the lower end of the piston rod 46 is fastened to the piston, said piston forms a coupling between the rod 46 and connecting rod 71. The connecting rod extends downwardly through the axial bore 72 of the body 64 of the stuffing box B

and through a perforated section of pipe 73, which has its upper end secured to the stuffing box body by a swaged nipple 74 and coupling 75. The interior of the body 64 is provided with a packing chamber 76 wherein suitable packing 77, which surrounds the rod 71, is confined. A coiled spring 78 engages the packing 77 and is held within the packing chamber by a gland or nut 79 which is threaded into the upper end of said chamber.

The lower end of the perforated pipe section 73 (Figure 2) is threaded into the seating nipple 15 which, as has been explained, is supported on the seat 14 of the collar 13 connected in the tubing 11. The pipe 73 extends axially through the tubing and that portion of said tubing surrounding said pipe is provided with perforations 80, whereby communication between the well tubing 11 and casing 10 is established at this point.

A tubular working barrel 81 of the usual construction has its upper end threaded into the seating nipple 15 and extends downwardly from the lower end of the well tubing and axially through the lower portion of the well casing. The usual pump plunger 82 having a traveling valve 83 mounted thereon is connected to the lower end of the connecting rod 71 and, manifestly, when the operating piston 45 and piston rod 46 are reciprocated, as has been explained, to reciprocate the rod 71, the pump plunger is reciprocated therewith. A standing valve 84 is mounted in the lower end of the working barrel 81 and the usual well screen 85 extends downwardly from said working barrel, said screen terminating near the bottom of the well bore.

When the pump plunger 82 is reciprocated, the well fluid is drawn into the working barrel from the well through the screen 85 and standing valve 84 and is lifted upwardly through the working barrel and nipple 15 into the perforated section of pipe 73. The fluid passes outwardly through the perforations in this pipe and into the well tubing 11, from where it flows through the perforations 80 into the well casing 10 above the packer 12. The well fluid is then lifted upwardly in the casing through the annular space between the casing and the well tubing to the surface. The pump plunger 82 and working barrel 81 may be of any standard type and their particular construction is subject to variation.

In operation, the well tubing 11 has the collar 13 connected therein and is run into the well casing 10 in the usual manner. The well packer 12 is set so as to seal off between the lower end of the tubing and the well casing. A suitable lowering tool (not shown) is then connected to the fishing neck 17 of the apparatus, whereby said apparatus may be lowered through the well tubing. The lowering of the apparatus continues until the seating nipple 15 engages the beveled seat 14 within the collar 13, at which time further lowering of said apparatus is prevented. As the device is being lowered through the tubing, the piston 45 is in its lowermost position, whereby the rod 46 attached to said piston has moved the shock absorber piston 61 downwardly to its lowermost position. In such lowermost position, the head 69 on the stem 68 which depends from the piston 61, is resting on a resilient ring 79' which is mounted in the upper end of the packing gland or nut 79 (Figure 5). With this arrangement, the weight of the piston 45 and its associate parts is carried by the head 69. It is noted that the head 69 engages the ring 79' and nut 79 only when the device is being lowered through the tubing or is being raised therefrom. During normal operation, the stroke of the piston 45 is such that the head 69 stops short of the nut 79, as indicated by the space in Figure 5.

After the apparatus has been positioned within the well tubing 11, a pressure fluid is introduced into the upper end of the well tubing at the surface and this fluid passes downwardly through the well tubing until it strikes the packing cups 20 which are mounted below the perforated section of pipe 16. The provision of the cups force the fluid to pass through the perforations in the section 16, whereby said fluid flows downwardly through the collar 18 and the shank 19. From this point, the fluid passes downwardly through the passages 25 in the head or block 24 and enters the annular space 31 between the sleeve 27 and the cylinder 30. With the parts in the position shown in Figures 3 to 5, it will be seen that the control valve member 38 is in its lowered position and, therefore, the fluid from the space 31 may pass through the ports 41 and into the lower end of the cylinder 30, whereby said pressure may act against the underside of the piston 45.

When this occurs, the piston 45 is moved upwardly in the cylinder 30 with the result that the piston rod 46 secured to said piston as well as the connecting rod 71 secured to the rod 46, are raised. The raising or lifting of the connecting rod 71 causes the pump plunger 82 of the well pump C, which plunger is secured to the rod 71, to be moved upwardly in the working barrel 81. Thus, so long as the piston 45 continues its upward movement, the pump plunger is moving through its upstroke.

Upward movement of the piston 45 continues until the sleeve 57 which is carried by the rod 46 strikes the underside of the web 47 within the valve member 38. As has been explained, the engagement of the sleeve 57 with the web 47, with continued upward movement of the piston 45 and rod 46, causes the spring 58 to be compressed. When this spring has been compressed sufficiently to overcome the pressure acting downwardly on the upper end of the valve member 38, said valve member is moved to its upper or raised position, as shown in Figure 7. When this occurs, the admittance of the pressure fluid from the space 31 through the ports 41 and to the cylinder 30, is shut off. At the same time, the upward movement of the valve member 38 uncovers the relief ports 43, whereby the fluid within the cylinder may drain outwardly through these ports and into the well tubing 11. From the well tubing, this fluid may escape into the well casing through the perforations 44 in said tubing.

As the fluid drains from the cylinder 30, the weight of the piston 45 and its associate parts, causes said piston to move downwardly by gravity. It is pointed out that since the upper end of the cylinder is at all times in communication with the casing through the bore 32 and ports 33, the establishment of communication between the lower end of the cylinder and said casing through the perforations 44, causes an equalization of pressures across the piston to permit downward movement thereof by gravity. This downward movement is gradual due to the provision of the shock absorber piston 61 moving through its cylinder 62. As the piston 45 moves downwardly in its cylinder 30, it is manifest that

a downward movement will be imparted to the pump plunger 82 of the well pump C, due to the connection between the piston rod 46, connecting rod 71 and said plunger. Thus, the downstroke of the pump plunger 82 is accomplished by means of gravity.

The valve member 38 remains in its raised or upper position (Figure 7) until such time as the sleeve 51 on said piston rod 46 strikes the upper end of the web 47 within said valve member. When this sleeve strikes the web and the piston rod continues its downward movement, the spring 52 confined within the sleeve 51 is compressed. When this spring is compressed sufficiently, the spring tension is sufficient to overcome the pressure holding the valve member in its raised position and as soon as this occurs the valve member is again lowered to re-engage the seat 37 and close the relief ports 43. At the same time, the downward movement of the valve member 38 opens the ports 41 to the interior of the cylinder 30, whereby the pressure fluid from the space 31 may again enter the lower end of the cylinder 30. This results in the piston 45 again moving upwardly and the operation is thus repeated.

When it is desired to remove the device from the well tubing, it is only necessary to relieve the pressure from the well tubing 11 above the apparatus. After this is done, a suitable lowering tool (not shown) may be engaged with the fishing neck 17 and the entire device removed as a unit. It is noted that the provision of the fishing neck makes it possible to run the apparatus into the well tubing or remove the same therefrom by means of a wire line or cable.

In some instances, it might be desirable to connect the apparatus directly in the tubing string instead of making the same removable as described. In such case, the well tubing is connected to the head or block 24 by means of a swaged coupling 90, as is clearly shown in Figure 16. A perforated section or length of tubing 92 is substituted for the perforated pipe 73 shown in Figure 5 and the working barrel 31 is connected to the lower end of this tubing section. The well packer 12 is mounted between the working barrel and the perforated section of tubing 92 and serves to pack off the annular space between the tubing and the well casing 10. In this construction, the packing cups 20 are eliminated and the pressure fluid which actuates the device is introduced through the tubing 11. It passes downwardly through the swaged nipple 90 and through the head 24, from where it flows to the cylinder 30, as has been described. As the piston 45 is reciprocated, the pump plunger 82 of the well pump C is also reciprocated. Reciprocation of the pump plunger draws the well fluid through the working barrel and lifts the same into the perforated section 92 of the tubing. From the section, the fluid flows outwardly through the perforations and then upwardly through the well casing 10. The operation of this form is substantially the same as the first form with the exception that the apparatus is mounted in the well tubing string and is lowered therewith. In the first form, the device is insertable within and removable from the well tubing.

In Figures 17 to 25, a modified form of control valve is shown. This valve is connected in the apparatus at the same point as has been described and includes a valve body 35', similar to the valve body 35. The body 35' is connected by the coupling with the sleeves 27 and 27' and is formed with a bore 36' which extends vertically therethrough. The upper end of the valve body is formed with an upstanding collar 39' which is externally screw-threaded, whereby the lower end of the cylinder 30 may be screwed thereon. It is noted that in the first form where the valve body 35 is employed, the lower end of the cylinder 30 is connected to the body 35 by means of the coacting collars 39 and 40, whereas in the present form the cylinder is screw-threaded to the body 35'. Angular ports 41' extend from the top of the body 35' and communicate with the upper end of the bore 36' thereof, whereby a pressure fluid in the sleeve 27 may flow downwardly into said bore.

Above the ports 41', an internal, annular seat 42' is provided and this seat is adapted to be engaged by the upper end of a sliding valve member 38'. When the upper end of said valve member is engaging the seat, as shown in Figure 18, the ports 41' are closed and the fluid pressure from within the sleeve 27 cannot flow into the bore of the valve body 35'. When the valve member is lowered, the ports are opened and the fluid pressure may enter the lower end of the cylinder 30 and act on the piston 45 movable therein.

The lower end of the valve member 38' is reduced at 38a and is slidable within a flanged sleeve 38b which is inserted within the lower portion of the bore 36' of the body 35'. The upper end of the sleeve 38b is beveled and is adapted to be engaged by an external beveled shoulder 38c which is formed on the member 38'. When the valve member 38' is in its lowermost position (Figure 17), the ports 41' in the upper end of the body 35' are open. At this time, radial ports 43' which are provided in the valve body below the ports 41', are closed by the member 38'. A frictional resistance to the upward movement of the member 38' is set up by a spring-pressed ball 93 which is mounted in an opening 94 formed in the lower end of the body 35'. The ball is arranged to engage an annular groove 95 formed in the exterior surface of the member 38' near the lower end thereof. Obviously, before the valve member 38' may move upwardly, the frictional resistance occasioned by the engagement of the ball 93 in the groove 95 must be overcome and, thus, this frictional resistance is added to the pressure acting downwardly on the member 38', before said member can be moved to a raised position.

When the member is moved to a raised position, the ports 41' are closed, as has been explained, and the ports 43' are open. The opening of the ports 43' is accomplished by the registration of radial openings 43a which are provided in the valve member 38' below the external shoulder 38c with the ports 43'. Such registration of the openings 43a and the ports 43' permits the fluid from the cylinder to escape outwardly into the well tubing 11 which surrounds the sleeves 27 and 27', as well as the valve body 35'. The movement of the valve member 38' and its operation is exactly the same as the movement of the valve member 38, hereinbefore described in the first form.

When the valve body 35' is employed and the cylinder 30 is directly connected to the upstanding collar 39', it is necessary that the upper end of the cylinder be connected to the head 24 by means other than screw threads. Such a means is clearly shown in Figure 23 and includes a depending sleeve 96 which is provided with

an external flange 97. This sleeve and flange are substituted for the screw-threaded collar 29 shown in Figure 3. The external diameter of the flange 97 is substantially equal to the internal diameter of the cylinder 30, whereby the upper end of said cylinder may receive said flange. A plurality of packing rings 98 surround the lower end of the sleeve or shank 96 and are confined between the flange 97 and a spider 99. The spider is secured by means of an elongate bolt 100 to the head 24. Manifestly, when the spider is tightened against the packing rings 98, said rings pack off between the cylinder 30 and the sleeve 96 so as to prevent a leakage of pressure at this point. The connection shown in Figure 23, in no way affects the operation of the apparatus, as has been described, such connection merely being a substitute for the screw-threaded collar 29.

Although it is desirable that the apparatus be lowered into the well bore in close proximity to the well pump, whereby the usual pump rods may be eliminated, it is not essential that this be done. The apparatus could be mounted at the surface of the well and could be connected to the well pump within the well bore by means of the usual connecting rod, in which event the apparatus would take the place of the usual mechanical pumping unit. This application of the invention is shown in Figures 26 and 27, wherein a cylinder 30b has its upper end closed by a suitable cap. The piston 45 operates in this cylinder. A valve 35b, similar in construction to the valve 35', is connected to the lower end of the cylinder and controls the application and release of pressure below the piston operating in the cylinder 30b. As clearly shown in Figure 27, this valve includes an inlet port 41b which has an inlet pipe 101 connected thereto. The port 41b takes the place of the inlet ports 41' in the valve 35'. An outlet port 43b which is adapted to register with the openings 43a in the valve member 38' is mounted in the opposite side of the valve body 35b and has an outlet pipe 102 connected therein. The piston rod 46 which is secured to the piston 45 operating in the cylinder 30b is provided with the telescoping sleeve, whereby the valve member 38' is operated in the same manner as has been hereinbefore described. Thus, the reciprocation of the piston within the cylinder 30b is controlled. An elongate section of pipe 27b is connected to the lower end of the valve body 35b and has a stuffing box 103 at its lower end. The shock absorber, disclosed in Figure 5, may be mounted above the stuffing box 103 if desired. The connecting rod 71 may connect the piston rod 46 with the usual pump rods which extend axially through the well casing 10. It is pointed out that the shock absorber may be eliminated in this form and the release or escape of pressure from the cylinder 30b controlled by a hand valve 104 connected in the outlet line 102. The entire device may be supported on suitable brackets 105 secured to the derrick floor.

The operation of this form is exactly the same as the operation of the other forms and, manifestly, the valve 38' slidably mounted within the body 35b controls the reciprocation of the piston 45 within the cylinder 30b. As the piston reciprocates within the cylinder, the rod 71 is reciprocated and a vertical movement is imparted to the well pump located in the well bore by means of the usual pump rods.

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

1. The combination with a well tubing and a well casing of a pumping apparatus arranged to be lowered into and removed from the well tubing on a flexible line and including, a cylinder having a pressure actuated member movable therein, a well pump having its plunger connected with said pressure actuated plunger so as to be actuated thereby, and means for introducing a pressure fluid into the tubing whereby said tubing is utilized as a conductor for conducting the pressure fluid to the cylinder to actuate the pressure actuated plunger.

2. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a vertically-movable valve controlling the inlet to and exhaust from the lower end of said cylinder, a working barrel below said device having a well fluid inlet at its lower end and a well fluid outlet at its upper end, a pump plunger reciprocable in the barrel, a vertically-movable actuating member extending from the piston to the pump plunger, and means for equalizing the pressures across said piston when the valve is in exhausting position so that the piston may move downwardly by gravity.

3. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, vertically-movable valve means for controlling the admittance of a pressure fluid to the lower end of said cylinder below the piston and for releasing the fluid from the cylinder when said piston has completed its upstroke to permit downward movement of the same by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, and a vertically-movable actuating member extending from the piston to the pump plunger through the valve means so as to actuate the same.

4. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, annular valve means mounted at the lower end of said cylinder for controlling the flow of pressure fluid to and from the cylinder, whereby the piston may be moved upwardly by pressure and downwardly by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, and a vertically-movable actuating member extending from the piston to the pump plunger and having means for actuating the annular valve means.

5. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a vertically-movable valve for con-

trolling the admittance and release of pressure fluid from the lower end of said cylinder to raise and lower the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, a vertically-movable actuating member extending from the piston to the plunger, and means carried by the member for actuating the valve to control the movement of said piston.

6. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a vertically-movable valve for controlling the admittance and release of pressure fluid from the lower end of said cylinder to raise and lower the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, a vertically-movable actuating member extending from the piston to the plunger, and means mounted on the member for engaging and actuating the valve to control the movement of said piston.

7. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a single valve means for controlling the admittance to and release of pressure fluid from the lower end of said cylinder, whereby the valve means controls the reciprocation of the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, and a rod extending from the piston to the plunger and movable through said valve means so as to actuate the same.

8. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a single valve means for controlling the admittance to and release of pressure fluid from the lower end of said cylinder, whereby the valve means controls the reciprocation of the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, and a rod extending from the piston to the plunger, the rod being movable through the valve means and having means mounted thereon for actuating said valve means.

9. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a single valve means for controlling the admittance to and release of pressure fluid from the lower end of said cylinder, whereby the valve means controls the reciprocation of the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, a rod extending from the piston to the plunger and movable through said valve means so as to actuate the same, and means associated with the rod intermediate said piston and plunger for cushioning the downstroke thereof.

10. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a single valve means for controlling the admittance to and release of pressure fluid from the lower end of said cylinder, whereby the valve means controls the reciprocation of the piston, a working barrel below the device, a pump plunger reciprocable in the barrel, a rod extending from the piston to the plunger, the rod being movable through the valve means and having means mounted thereon for actuating said valve means, and means associated with said rod intermediate said piston and plunger for cushioning the downstroke thereof.

11. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a valve body at the lower end of said cylinder having a pressure fluid inlet port and an outlet port, an annular slidable valve within the body for closing the outlet port when the inlet port is open to admit pressure fluid to the lower end of the cylinder to raise the piston, the valve being movable when said piston completes its upstroke to a position closing the inlet port and opening the outlet port to permit escape of pressure fluid from the cylinder and to prevent the admittance of pressure fluid thereto, thereby allowing the piston to move downwardly by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, and a vertically-movable actuating member extending from the piston to the pump plunger through the valve and having means mounted thereon for actuating said valve.

12. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a valve body at the lower end of said cylinder having a pressure fluid inlet port and an outlet port, an annular slidable valve within the body for closing the outlet port when the inlet port is open to admit pressure fluid to the lower end of the cylinder to raise the piston, the valve being movable when said piston completes its upstroke to a position closing the inlet port and opening the outlet port to permit escape of pressure fluid from the cylinder and to prevent the admittance of pressure fluid thereto, thereby allowing the piston to move downwardly by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, a vertically-movable actuating member extending from the piston to the pump plunger through the valve and having means mounted thereon for actuating said valve, and means associated with the member intermediate said piston and plunger for cushioning the downstroke thereof.

13. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylin-

der having a pressure fluid inlet at its lower end, a piston reciprocable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a valve body at the lower end of said cylinder having a pressure fluid inlet port and an outlet port, a valve within the body for closing the outlet port when the inlet port is open to admit pressure fluid to the lower end of the cylinder to raise the piston, the valve being movable when said piston completes its upstroke to a position closing the inlet port and opening the outlet port to permit escape of pressure fluid from the cylinder and to prevent the admittance of pressure fluid thereto, thereby allowing the piston to move downwardly by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, a piston rod extending from the piston to the pump plunger, and means mounted on the piston rod and disposed within the cylinder for engaging the valve at the termination of each stroke of the piston, whereby said valve is shifted from one position to the other to change the direction of travel of the piston.

14. In a well pumping apparatus, the combination with a well tubing and a well casing, of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing, a piston movable in the cylinder, said cylinder having an inlet port for establishing a communication between the tubing and the lower end of the cylinder whereby a pressure fluid may be introduced into the tubing and conducted downwardly therethrough to the cylinder to raise the piston, the cylinder also having an outlet port for draining the fluid from said cylinder to permit the piston to move downwardly in the cylinder, a single annular valve member coacting with the ports and movable to two positions, each position of said valve opening one of the ports and closing the other to allow either raising or lowering of the piston, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

15. In a well pumping apparatus, the combination with a well tubing and a well casing of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing, a piston movable in the cylinder, the cylinder having an inlet port for establishing a communication between the tubing and the lower end of the cylinder whereby a pressure fluid may be introduced into the tubing and conducted downwardly therethrough to the cylinder to raise the piston, the cylinder also having an outlet port for draining the fluid from said cylinder to permit the piston to move downwardly in the cylinder, a single annular valve, a member coacting with the ports and movable to two positions, each position of said valve opening one of the ports and closing the other to allow either raising or lowering of the piston, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

16. In a well pumping apparatus, the combination with a well tubing and a well casing, of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing, a piston movable in the cylinder, the cylinder having an inlet port for establishing a communication between the tubing and the lower end of the cylinder whereby a pressure fluid may be introduced into the tubing and conducted downwardly therethrough to the cylinder to raise the piston, the cylinder also having an outlet port for draining the fluid from said cylinder to permit the piston to move downwardly in the cylinder, a single annular valve member coacting with the ports and movable to two positions, each position of said valve opening one of the ports and closing the other to allow either raising or lowering of the piston, means carried by the piston for moving the valve member upon completion of each stroke of the piston, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

17. In a well pumping apparatus, the combination with a well tubing and a well casing of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing and having a pressure fluid inlet at its lower end, a piston movable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, means for moving the piston upwardly in the cylinder by pressure and for moving the same downwardly by gravity, a valve means wholly within the cylinder and actuated by the piston for controlling the admittance and release of pressure to and from the lower end of said cylinder, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

18. In a well pumping apparatus, the combination with a well tubing and a well casing of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing and having a pressure fluid inlet at its lower end, a piston movable in the cylinder, means for conducting a pressure fluid to the lower end of the cylinder, means for moving the piston upwardly in the cylinder by pressure and for moving the same downwardly by gravity, annular valve means actuated by the piston and connected to the lower end of the cylinder and having a diameter substantially equal to the diameter of the cylinder for controlling the admittance and release of pressure to and from the lower end of said cylinder, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

19. In a well pumping apparatus, the combination with a well tubing and a well casing of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing and having a pressure fluid inlet at its lower end, a piston movable in said cylinder, means for conducting a pressure fluid to the lower end of the cylinder, means for moving the piston upwardly in the cylinder by pressure and for moving the same downwardly by gravity, a valve means wholly within the cylinder for controlling the admittance and release of pressure to and from the lower end of said cylinder, means carried by said piston and disposed within the cylinder so as to co-act with the valve means so as to actuate the same, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

20. In a well pumping apparatus, the combination with a well tubing and a well casing of a pumping device adapted to be lowered into the tubing including, a cylinder disposed in the tubing and having a pressure fluid inlet at its lower end, a piston movable in said cylinder, means for conducting a pressure fluid to the lower end of the cylinder to raise the piston, means for permitting the escape of said pressure fluid from said cylinder to allow the piston to move downwardly by gravity, a single valve for controlling the admittance to and release of the fluid from the cylinder, whereby the valve controls the reciprocation of the piston, means mounted on said piston and disposed within the cylinder for actuating the valve, means for actuating the valve with a snap action to provide a change in the movement of the piston, a working barrel below said device, a pump plunger reciprocable in the barrel, and a piston rod extending from said piston to the pump plunger through the valve so as to actuate the same.

21. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough of a pumping device adapted to be lowered into the tubing including, a cylinder, a piston movable in the cylinder, a valve body at the lower end of the cylinder having a pressure fluid inlet port and a fluid outlet port, means for conducting a pressure fluid to the lower end of the cylinder, a valve member within the body arranged to close the outlet port when the inlet port is open to admit pressure fluid to the cylinder to raise the piston, said member being movable when the piston completes its upstroke to a position closing the inlet and opening the outlet to permit escape of pressure fluid from the cylinder, thereby allowing the piston to move downwardly by gravity, a working barrel below said device, a pump plunger reciprocable in the barrel, a piston rod extending from said piston to the pump plunger, means on the piston rod and disposed within the cylinder adapted to engage the valve member at the termination of each stroke of the piston, whereby the valve is shifted from one position to the other to shift the direction of travel of the piston, and means for actuating the valve with a snap action to provide a change in the movement of the piston.

22. A well pumping apparatus including, a conduit for conducting a pressure fluid, a well casing, a cylinder having its lower end communicating with the fluid conduit and also communicating with the casing, a valve member at the lower end of said cylinder movable to control the communication of the interior of the cylinder with either the fluid conduit or the casing, whereby the position of the valve controls the admission and exhaust of pressure fluid to and from the lower end of the cylinder, a pressure responsive element movable within the cylinder and arranged to be moved upwardly by the pressure fluid when the valve member is in a position admitting pressure fluid to the interior of the cylinder, said element moving downwardly by gravity when the valve is in its other position to permit an exhaust of fluid from the cylinder into the casing, a working barrel disposed within said casing below said cylinder, a pump plunger reciprocable in the barrel, and means depending from the element for connecting the same to the plunger.

23. A well pumping apparatus including, a conduit for conducting a pressure fluid, a well casing, a cylinder having its lower end communicating with the fluid conduit and also communicating with the casing, a valve member at the lower end of said cylinder movable to control the communication of the interior of the cylinder with either the fluid conduit or the casing, whereby the position of the valve controls the admission and exhaust of pressure fluid to and from the lower end of the cylinder, a pressure responsive element movable within the cylinder and arranged to be moved upwardly by the pressure fluid when the valve member is in a position admitting pressure fluid to the interior of the cylinder, said element moving downwardly by gravity when the valve is in its other position to permit an exhaust of fluid from the cylinder into the casing, means carried by the pressure responsive element for engaging and actuating the valve to move it from one position to the other upon the completion of each stroke, a working barrel disposed within said casing below said cylinder, and a pump plunger reciprocable in the barrel and being connected to said element, whereby the plunger is actuated by the element.

24. A well pumping apparatus including, a pressure fluid conduit, a well casing, a nipple connected in the fluid conduit and having vertical passages therein for permitting a flow of pressure fluid therethrough, a cylinder depending from the nipple and disposed within the fluid conduit, whereby the pressure fluid may flow downwardly around the cylinder, the nipple having a passage establishing communication between the upper end of the cylinder and the well casing, the lower end of the cylinder having communication with both the fluid conduit and the casing, a piston movable in the cylinder, valve means at the lower end of the cylinder and movable to two positions to control the communication of the cylinder with either the fluid conduit or the casing, whereby when the valve is in a position establishing communication between the fluid conduit and the cylinder the piston is raised by the pressure fluid and when the valve is in its other position establishing communication between the cylinder and the casing the pressures across the piston are equalized and said piston may move downwardly by gravity, and means for actuating said valve means.

25. A well pumping apparatus including, a pressure fluid conduit, a well casing, a nipple connected in the fluid conduit and having vertical passages therein for permitting a flow of pressure fluid therethrough, a cylinder depending from the nipple and disposed within the fluid conduit, whereby the pressure fluid may flow downwardly around the cylinder, the nipple having a passage establishing communication between the upper end of the cylinder and the well casing, the lower end of the cylinder having communication with both the fluid conduit and the liquid casing, a piston movable in the cylinder, valve means at the lower end of the cylinder and movable to two positions to control the communication of the cylinder with either the fluid conduit or the casing, whereby when the valve is in a position establishing communication between the fluid conduit and the cylinder the piston is raised by the pressure fluid and when the valve is in its other position establishing communication between the cylinder and the casing the pressures across the piston are equalized and said piston may move downwardly by gravity, and means carried by the pressure responsive

element for actuating the valve to move it from one position to the other upon the completion of each stroke, a working barrel disposed within said casing below said cylinder, and a pump plunger reciprocable in the barrel and being connected to said element, whereby the plunger is actuated by the element.

26. A well pumping apparatus including, a pressure fluid conduit, a well casing, a nipple connected in the fluid conduit and having vertical passages therein for permitting a flow of pressure fluid therethrough, a cylinder depending from the nipple and disposed within the fluid conduit, whereby the pressure fluid may flow downwardly around the cylinder, the nipple having a passage establishing communication between the upper end of the cylinder and the well casing, the lower end of the cylinder having communication with both the fluid conduit and the casing, a piston movable in the cylinder, valve means at the lower end of the cylinder and movable to two positions to control the communication of the cylinder with either the fluid conduit or the casing, whereby when the valve is in a position establishing communication between the fluid conduit and the cylinder the piston is raised by the pressure fluid, and when the valve is in its other position establishing communication between the cylinder and the casing the pressures across the piston are equalized and said piston may move downwardly by gravity, a piston rod secured to the piston and extending through the valve means, means on the piston rod disposed within the cylinder and adapted to engage the valve means at the termination of each stroke of the piston, whereby the valve is shifted from one position to the other to change the direction of travel of the piston, a working barrel disposed within the casing beneath said valve means, and a plunger reciprocable in the barrel and connected to said piston by the piston rod, whereby the plunger is actuated by the piston.

27. A well pumping apparatus including, a pressure fluid conduit, a well casing, a nipple connected in the fluid conduit and having vertical passages therein for permitting a flow of pressure fluid therethrough, a cylinder depending from the nipple and disposed within the fluid conduit, whereby the pressure fluid may flow downwardly around the cylinder, the nipple having a passage establishing communication between the upper end of the cylinder and the well casing, the lower end of the cylinder having communication with both the fluid conduit and the casing, a piston movable in the cylinder, valve means at the lower end of the cylinder and movable to two positions to control the communication of the cylinder with either the fluid conduit or the casing, whereby when the valve is in a position establishing communication between the fluid conduit and the cylinder the piston is raised by the pressure fluid, and when the valve is in its other position establishing communication between the cylinder and the casing the pressures across the piston are equalized and said piston may move downwardly by gravity, a piston rod secured to the piston and extending through the valve member, means on the piston rod disposed within the cylinder and adapted to engage the valve member at the termination of each stroke of the piston, whereby the valve is shifted from one position to the other to change the direction of travel of the piston, means for actuating the valve with a snap action to provide a substantially abrupt change in the movement of the piston, a working barrel disposed within said casing below said cylinder, and a pump plunger reciprocable in the barrel and being connected to said element, whereby the plunger is actuated by the element.

28. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough, of a pumping device adapted to be lowered into the tubing including, a cylindrical casing having a pressure fluid inlet at its upper end, an upright cylinder disposed in said casing having a pressure fluid inlet at its lower end, a piston reciprocable in said cylinder, means for conducting a pressure fluid to the lower end of the cylinder, a vertically-movable valve controlling the inlet and exhaust from the lower end of said cylinder, a working barrel below said device having a well fluid inlet at its lower end and a well fluid outlet at its upper end, a pump plunger reciprocable in said barrel, and a vertically-movable actuating member extending from the piston to the pump plunger and having resilient means for shifting said valve.

29. In a well pumping apparatus, the combination with a well casing having a tubing extending therethrough, of a pumping device adapted to be lowered into the tubing including, a cylinder, a piston having a piston rod arranged to reciprocate within said cylinder, means for conducting a pressure fluid to the lower end of the cylinder, valve means through which the rod is movable for admitting a pressure fluid to the cylinder below the piston to raise the same, means for releasing the fluid from the cylinder when the piston has completed its upstroke to permit said piston to move downwardly by gravity, and means for equalizing the pressures across said piston when the valve has been shifted to exhausting position so that the piston may move downwardly by gravity.

30. A well pumping apparatus including, a conduit for conducting a pressure fluid, a well casing, a cylinder having its lower end communicating with the fluid conduit and also communicating with the casing, a valve member at the lower end of said cylinder movable to control the communication of the interior of the cylinder with either the fluid conduit or the casing, whereby the position of the valve controls the admission and exhaust of pressure fluid to and from the lower end of the cylinder, means for actuating said valve member, a pressure responsive element movable within the cylinder and arranged to be moved upwardly by the pressure fluid when the valve member is in a position admitting pressure fluid to the interior of the cylinder, the upper end of the cylinder being in constant communication with the casing so that when the valve member moves to a position establishing communication between the lower end of the cylinder and the casing the pressure fluid within said cylinder is permitted to escape into said casing, whereby the pressures across the pressure responsive element are equalized and said element may move downwardly by gravity, a working barrel disposed within said casing below said cylinder, and a pump plunger reciprocable in the barrel and being connected to said element, whereby the pump plunger is actuated by the element.

31. A well pumping apparatus including, a conduit for conducting a pressure fluid, a well casing, a cylinder having its lower end communicating with the fluid conduit and also communi-

cating with the casing, a valve member at the lower end of said cylinder movable to control the communication of the interior of the cylinder with either the fluid conduit or the casing, whereby the position of the valve controls the admission and exhaust of pressure fluid to and from the lower end of the cylinder, means for actuating said valve member, a pressure responsive element movable within the cylinder and arranged to be moved upwardly by the pressure fluid when the valve member is in a position admitting pressure fluid to the interior of the cylinder, the upper end of the cylinder being in constant communication with the casing so that when the valve member moves to a position establishing communication between the lower end of the cylinder and the casing the pressure fluid within said cylinder is permitted to escape into said casing, whereby the pressures across the pressure responsive element are equalized and said element may move downwardly by gravity, means carried by the pressure responsive element for actuating the valve to move it from one position to the other upon the completion of each stroke, a working barrel disposed within said casing below said cylinder, and a pump plunger reciprocable in the barrel and being connected to said element, whereby the plunger is actuated by the element.

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