

July 23, 1946.

J. R. NORTON

2,404,524

PUMPING MECHANISM

Filed April 12, 1945

4 Sheets-Sheet 1

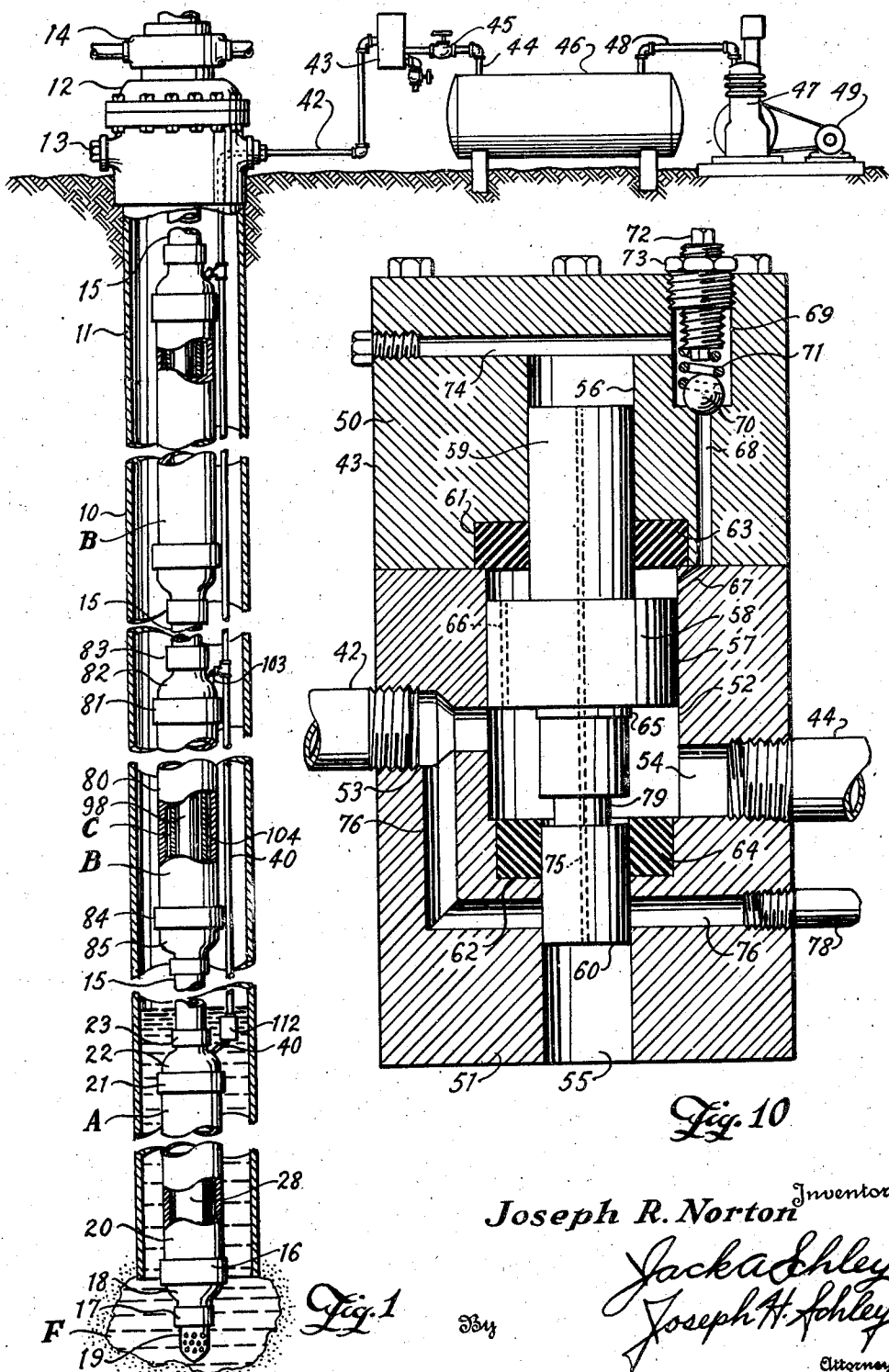


Fig. 10

Joseph R. Norton *Inventor*

Jack Achley
Joseph H. Achley
Attorneys

July 23, 1946.

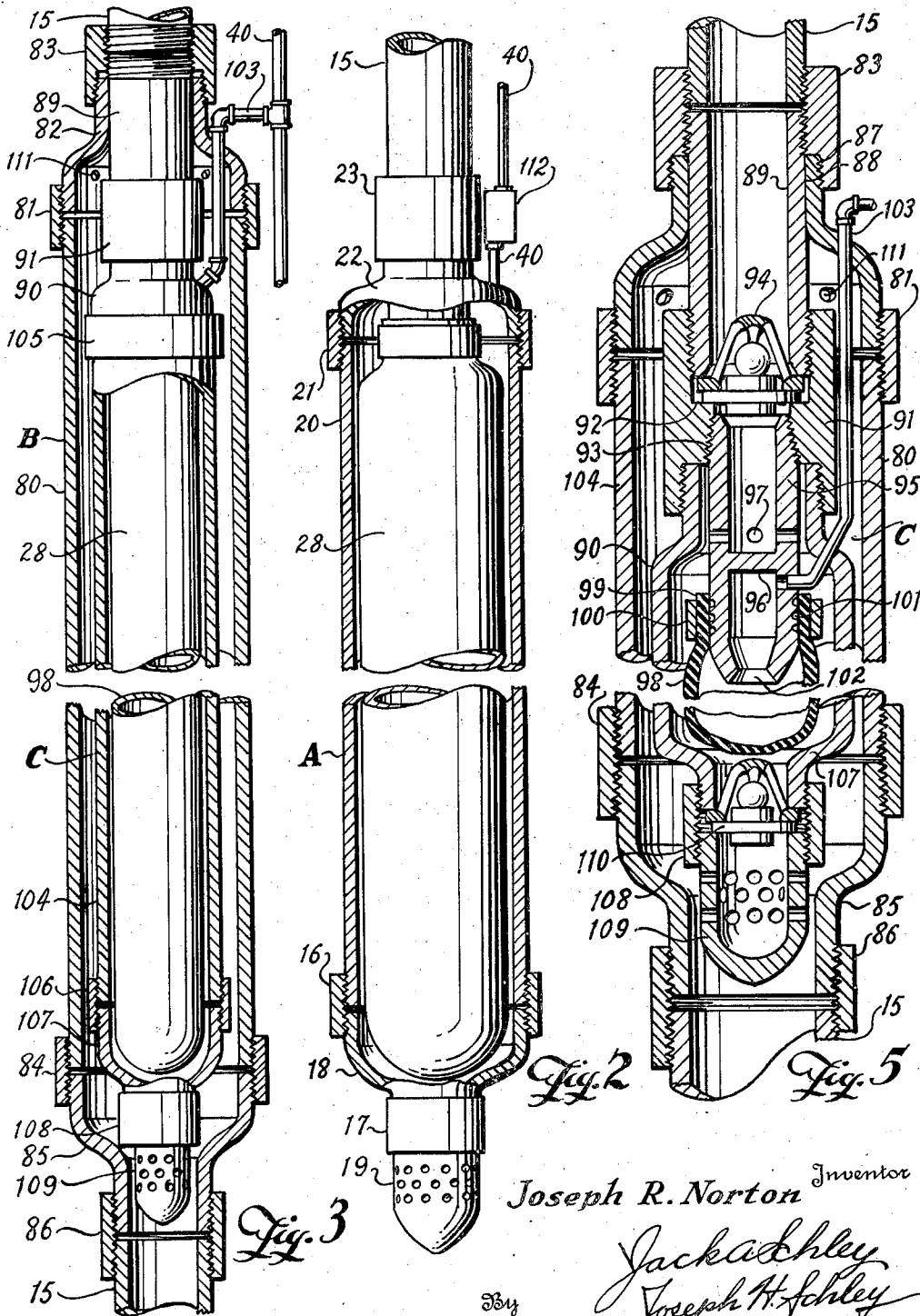
J. R. NORTON

2,404,524

PUMPING MECHANISM

Filed April 12, 1945

4 Sheets-Sheet 2



Joseph R. Norton Inventor

Jack Achley
Joseph H. Achley
Attorneys

July 23, 1946.

J. R. NORTON

2,404,524

PUMPING MECHANISM

Filed April 12, 1945

4 Sheets-Sheet 3

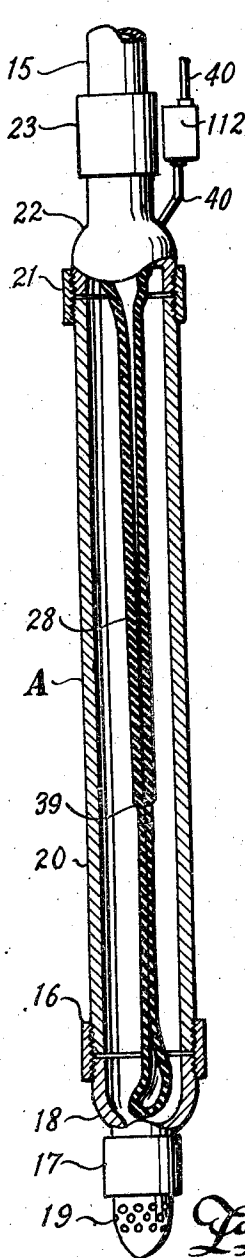


Fig. 6

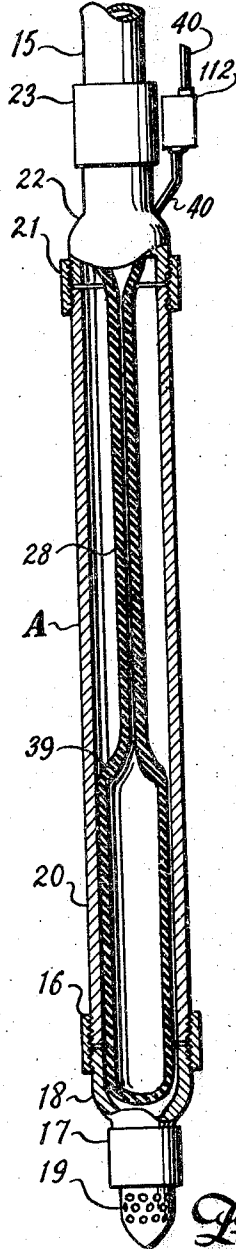


Fig. 7

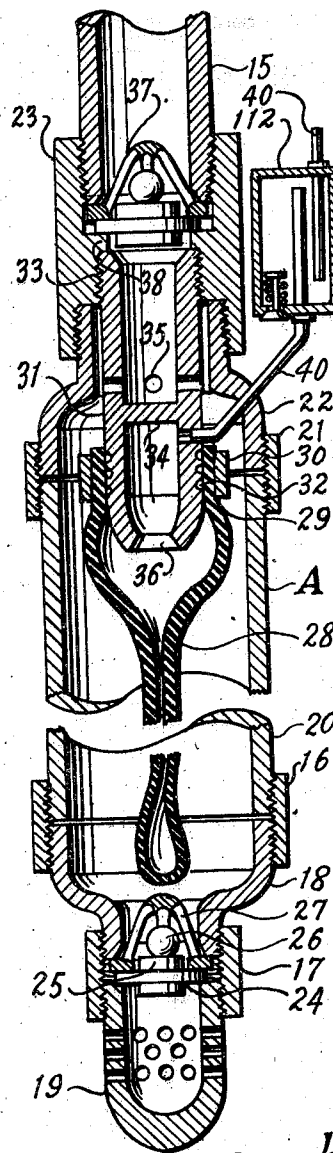


Fig. 4

Joseph R. Norton *Inventor*

Jack A. Schley
Joseph H. Schley
Attorneys

384

July 23, 1946.

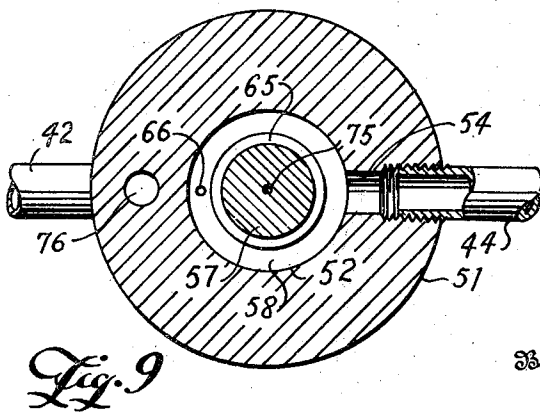
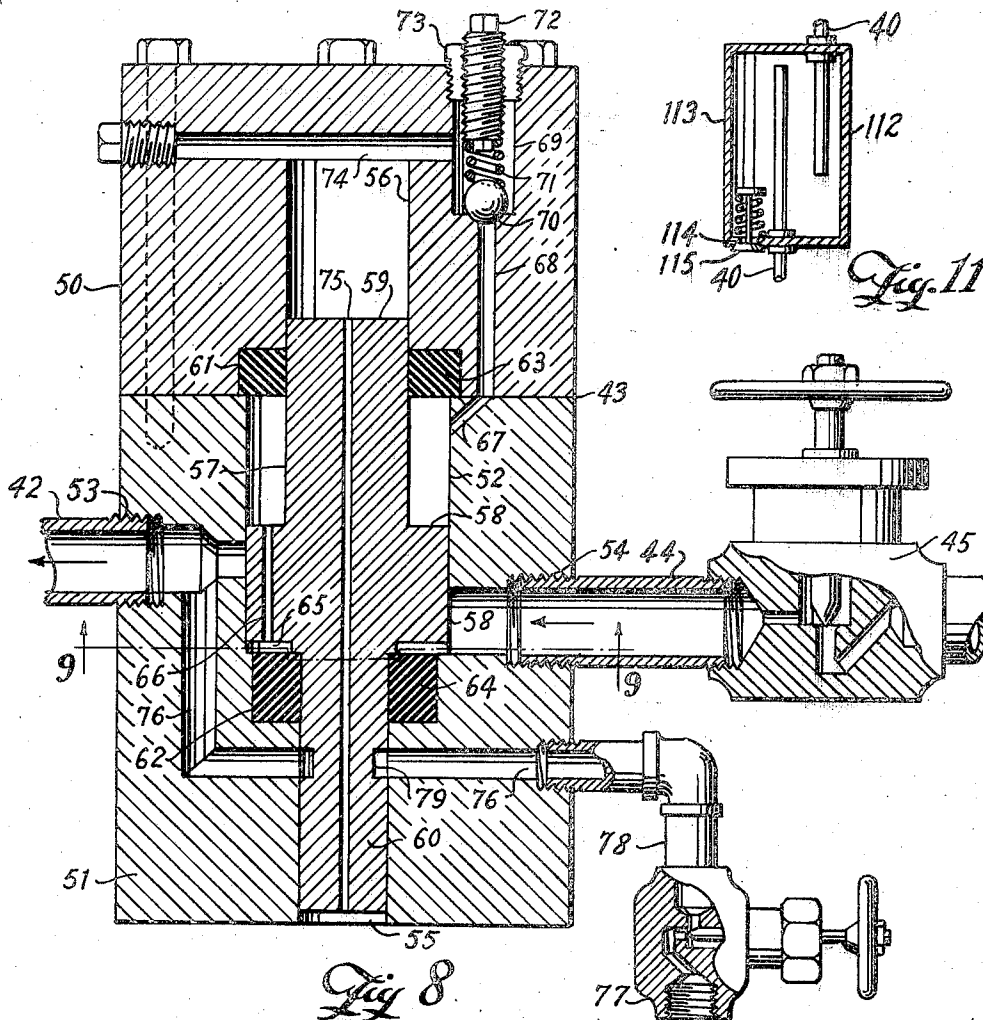
J. R. NORTON

2,404,524

PUMPING MECHANISM

Filed April 12, 1945

4 Sheets-Sheet 4



Joseph R. Norton *Inventor*

Jack Ashley
Joseph H. Ashley
Attorneys

UNITED STATES PATENT OFFICE

2,404,524

PUMPING MECHANISM

Joseph R. Norton, Tulsa, Okla., assignor to W. C. Norris, Manufacturer, Incorporated, Tulsa, Okla.

Application April 12, 1945, Serial No. 587,885

9 Claims. (Cl. 103-46)

1

This invention relates to new and useful improvements in pumping mechanisms.

As is well-known, certain strata of the earth's formation are pervious, while other overlying or underlying strata are impervious and these strata are not planular, but are frequently warped or folded. Since crude oil is lighter than natural ground water, it seeks an elevation above the water and, therefore, crude oil is usually found in the uppermost portions or domes of the folded strata or, geologically, the anticlines. An impervious strata, known as cap rock, generally overlies the anticlines so as to prevent upward migration of the oil which consequently accumulates in said anticlines. Due to the oil being supported in this position by the pressure of the ground water and the cap rock preventing migration of said oil, the latter is necessarily under considerable pressure. Therefore, upon a well bore being drilled through the cap rock, there is a sudden release of pressure which causes the oil to flow upwardly through the well bore to the surface, the first cycle of most wells. However, as the pressure declines, the natural flow ceases and the oil must be lifted artificially to the surface. Crude oil, under the above conditions, contains all phases from light, volatile gases to heavy hydrocarbons and it is necessary to control the pressure exerted against the exposed surface of the producing strata, because a pressure too low will accelerate the migration of the oil to a velocity sufficient to carry sand and silt from the pervious strata and thereby clog or sand up the well bore. Also, encroachment of the ground water into the well bore is permitted, since said water will flow from a high pressure region to a region of low or diminished pressure. In addition, as the pressure on the formation or strata drops, the gases and/or lighter hydrocarbons disassociate or escape from the heavier hydrocarbons of the crude oil and evolve in a gaseous condition. The evolution of these gaseous constituents not only reduces the quality of the remaining oil but also tends to gas lock the pumps employed to lift said oil.

With conventional rod pumps, the reciprocal motion of the rod is principally harmonic and transmits to the pump plunger or piston a reciprocal motion having a non-uniform velocity, the stretch of the rod further varying the velocity. During the downstroke, the plunger gathers an accumulation of crude oil thereabove and the upward motion of said plunger increases non-uniformly in velocity until it approaches the mid-

2

dle of its upstroke. However, due to the weight of the column of oil or hydrostatic load, imposed upon the plunger, the rod is stretched or elongated and the velocity is retarded until the inertia of said column is overcome. The velocity then exceeds that of the harmonic motion for a portion of the upstroke and is finally retarded non-uniformly by the rod reaching its upper limit of travel. The acceleration imparted to the plunger creates a low vacuum or suction within the working barrel therebelow, thereby permitting gas to evolve from the oil which decreases the quality of the latter. The down-stroke of the conventional plunger is substantially harmonic except for deviations caused by passing downwardly or falling through the accumulated oil and over-travel of said plunger, the latter being due to stretching or elongation of the rod by the downward acceleration of the mass thereof. Under any condition of conventional well pumping, wherein the plunger is reciprocated in a straight line motion translated from rotary or circular motion, the actual working time of the pump is substantially one-half the time of a complete cycle and the remaining time is consumed in dropping said plunger for a return stroke.

One object of the invention is to provide an improved pump mechanism for efficiently and economically elevating well fluids from a producing formation in accordance with the foregoing prerequisites so as to prevent the separation of the well fluids and the escape of the valuable lighter hydrocarbons.

An important object of the invention is to provide an improved pumping mechanism having expansible means adapted to be inflated and deflated to lift fluids within a well bore, the conducting means having a relatively small diameter and volume whereby the pressure fluid may be conducted to and exhausted from said member as rapidly as desirable within the limits of good practice, as controlled by the characteristics and condition of the producing formation.

Another object of the invention is to provide an improved pumping mechanism, of the character described, wherein the pressure fluid may be exhausted at a rate faster than the rate of supplying of said fluid, thereby minimizing the duration of the non-lifting intervals and materially increasing the duration of the lifting intervals so as to permit the use of a fluid of relatively low pressure or volume.

A further object of the invention is to provide an improved pumping mechanism, of the char-

3

acter described, wherein the expansible member is elastic and is disposed within a chamber for receiving and accumulating well fluids, said member and chamber having substantially equal dimensions so that the area of the chamber is completely filled or occupied by the inflated member, one end of said member being free so as to permit collapsing thereof upon deflation, whereby the deflated member occupies only a small area of said chamber and a maximum volume of well fluids may be displaced upon inflation of said member without undue distortion or stretching thereof.

Still another object of the invention is to provide an improved pumping mechanism, of the character described, which may include a single expansible member and receiving chamber or a plurality of the same, whereby in deep wells the fluids may be lifted in stages so as to eliminate the necessity of placing the lifting fluid under an excessive pressure.

A still further object of the invention is to provide an improved pumping mechanism, of the character described, having valve means for controlling the admission of the pressure fluid to the expansible member and exhaustion of said fluid therefrom, the valve means being so constructed as to open and remain open for supplying the fluid until inflation of said member is completed, the excess pressure acting upon and closing said valve means and opening an exhaust port to permit escape of said fluid and deflation of the member.

Another object of the invention is to provide an improved pumping mechanism, of the character described, having means for positively controlling the rate of exhaustion of the pressure fluid and thereby determine the rate of entry of the well fluids into the pumping mechanism from the producing formation and the vacuum or suction exerted upon said well fluids, due to the exhaustion rate of said pressure fluid, so as to prevent liberation of the lighter hydrocarbon constituents from the well fluids; the controlling means being adjustable in accordance with the characteristics and conditions of the formation to provide the most desirable operation.

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, wherein an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, of a pumping mechanism, constructed in accordance with the invention, mounted in a well bore.

Figures 2 and 3 are enlarged, longitudinal, sectional views, partly in elevation, of the lower portion of the pumping mechanism and showing the two lowermost stages.

Figure 4 is an enlarged, transverse, vertical, sectional view of the upper portion of the lowermost stage, showing the connection of the expansible member and the check valve construction.

Figure 5 is a view, similar to Figure 4, of the upper portion of one of the upper stages shown in Figure 3.

Figures 6 and 7 are views, similar to Figure 2, of the lowermost stage and showing the expan-

4

sible member deflated and partially inflated, respectively.

Figure 8 is an enlarged, transverse, vertical, sectional view of the surface control valve in its closed, exhausting position.

Figure 9 is a reduced, horizontal, cross-sectional view, taken on the line 9—9 of Figure 8.

Figure 10 is a view, similar to Figure 8, with the valve member in elevation and showing the same in its open, fluid admitting position, and

Figure 11 is an enlarged, transverse, vertical, sectional view of a moisture trap.

In the drawings, the numeral 10 designates a well bore which extends to the producing formation F and has the usual well casing 11 mounted therein. A well or casing head 12 is connected to the upper end of the casing 11 at the surface and includes the usual lateral outlets 13 and carries a flow cross 14. Depending from the head 12 and communicating with the cross 14 is a tubing or flow pipe, indicated generally at 15, which extends axially through the casing to a point below the level of the well fluids and includes several spaced sections. The annular space between the tubing and casing is preferably sealed off within the head 12 in a conventional manner by suitable means (not shown) so as to permit the holding of a desirable back-pressure upon the formation F. A pump chamber A is mounted on the lower end of the tubing and is preferably disposed within the well fluids and below the level thereof. As is clearly shown in Figure 4, the lower end of the chamber A is connected by suitable coupling collars 16 and 17 and a swaged nipple 18 to a perforated bull plug or other well screen 19 which has been shown for the purposes of illustration as being disposed within the open well bore. In deep wells, similar pump chambers B are connected in the tubing 15 at predetermined, spaced intervals and, as will hereinafter be more fully explained, the number of such chambers being subject to variation.

As is clearly shown in Figures 2 and 4, the chamber A includes an elongate, tubular body or sleeve 20 of greater diameter than the tubing and communicating therewith. The collar 16 connects the lower end of the sleeve to the nipple 18, while the upper end of the sleeve is connected by a similar collar 21 to a swaged nipple 22 which, in turn, is secured to a section of the tubing by a coupling collar 23. The external diameter of the latter collar is enlarged so as to provide a relatively thick wall. Thus, the well fluids may flow through the perforations of the bull plug 19 into the nipple 18 and then into the interior of the chamber A, the height or level attained by said fluids being determined by the depth or position of said chamber. For controlling the admission of the fluids to the chamber, the usual standing valve 24 is mounted in the lower end of the nipple 18 above the perforated plug 19. The valve 24 includes a conventional seat 25, ball 26, and combined clamping ring and ball cage 27, the clamping ring of the cage and the seat being confined between the upper end of the perforated plug and the lower end of the nipple by the collar 17.

An elongate, expansible member or tubular sack 28, of rubber or other suitable elastic material, is disposed in the chamber A and has a closed lower end. As shown in Figure 4, the upper open end of the sack 28 is reduced in diameter and the annular wall thereof preferably thickened and reinforced to provide a neck 29. A suitable clamping ring or split bank 30 fastens the reinforced

5

neck 29 in surrounding relation around a short sleeve or nipple 31 which is provided with a plurality of external, peripheral grooves or recesses 32 for coacting with and receiving the material of said neck to seal off therebetween upon tightening of the band; or if desired the neck of the sack could be vulcanized on the nipple. The nipple 31 is of less diameter than the bore of the swaged nipple 18 and is screw-threaded into a reduced, intermedial screwed counter bore 33, of the collar 23, so as to depend internally of said swaged nipple. A partition 34 extends transversely across the intermediate portion of the bore of the nipple 31 so as to separate the upper portion of the bore of said nipple from the lower portion thereof. The nipple has a plurality of ports 35 formed therein immediately above the partition for establishing communication between the interior of the chamber A and the tubing section 15, which is connected to the upper end of the collar 23. The lower end of the nipple projects downwardly from the neck 29 into the sack and is reduced at its lower end; being provided with a constricted opening 36, whereby collapsing of the sack upon deflation thereof is facilitated (Figure 6). For trapping well fluids within the tubing above the chamber A, a check valve 37, which is substantially identical to the valve 24, is disposed within the collar 23 upon an internal, annular shoulder 38 immediately above the counter bore 33.

The sack 28 is normally deflated or collapsed as shown in Figure 6 so as to occupy only a small portion of the area of the chamber A. However, upon inflation, the sack will substantially fill or occupy the entire area of its chamber (Figures 2 and 4) and, due to said sack normally having an external diameter substantially equal to the internal diameter of its chamber and a substantially equal length, there is little or no stretching or distortion of the sack upon inflation thereof. Since the purpose of the sack is to displace or force well fluids from the chamber A into the communicating tubing 15 thereabove, it is essential that said sack occupy as little space as possible, when collapsed, to permit the accumulation of a maximum volume of said fluids within said chamber and, when inflated, to substantially fill the chamber so as to elevate the fluids. In order to assure initial inflation of the lower portion of the sack, so as to prevent the trapping of fluid within the chamber therebelow, the annular wall of the lower portion of said sack may be reduced in thickness as shown at 39 in Figures 6 and 7. If desired, the same results could be obtained by inverting the sack.

For inflating the sack 28 and permitting the collapse or deflation thereof, a suitable pipe or macaroni string 40, extends through the wall of the nipple 22 and into the lower portion of the nipple 31 below the partition 34 so as to communicate with the bore of said nipple and the sack. As has been explained, the sack is normally collapsed or deflated so as to occupy only a small area of the chamber A (Figure 6) and such collapse or deflation will be assisted by the pressure of the well fluids, due to the fact that said chamber is immersed in said well fluids which are admitted by and through the valve 24. A suitable pressure or lifting fluid, such as air or gas, is conducted downwardly through the string 40, which extends up through the casing 11 to the casing head 12 and delivered to the sack for inflating the same. This inflation of the sack will close the valve 24 against downward escape of the well fluids from the chamber and will displace or force,

6

fluids accumulated in said chamber, upwardly therein and out through the ports 35 into the upper portion of the nipple 31 above the partition 34 and then through the valve 37 into the tubing 15. As indicated in Figure 7, the inflation of the sack will be gradual and the lower portion thereof will be initially inflated so as to prevent the trapping of well fluids below said sack. Manifestly, the elevated well fluids will be trapped and accumulated within the tubing due to the provision of the valve 37. Upon the complete expansion of the sack as shown in Figures 2 and 4, said sack will fill or occupy substantially the entire area of the chamber A, whereby little or no well fluids remain within said chamber and also whereby a maximum volume of said fluids is displaced upwardly. The pressure fluid is then permitted to escape from the sack, as will be hereinafter described, so as to permit collapse or deflation thereof and the admittance of additional well fluids into the chamber A due to opening of the valve 24. It is pointed out that the small diameter of the string 40 makes it possible to quickly inflate and deflate the sack, because only the pressure fluid within said sack need be replaced or exhausted; however, the sack may be more quickly deflated than inflated, as will hereinafter be more fully explained.

As shown in Figure 1, the macaroni string 40 is connected through one of the lateral outlets 13 of the head 12 to a line 42 which has connection with the outlet side of a surface control valve 43. A suitable conductor or line 44, having a conventional needle valve 45 mounted therein, connects the inlet side of the valve 43 to a storage tank 46, to which a fluid, such as air or gas, is supplied under pressure by a suitable compressor 47 and pipe 48. A motor or engine 49 is provided for driving the compressor.

As shown in Figures 8 to 10, the control valve 43 includes a cylindrical block 51 and a cylindrical head 50 which are secured together by suitable bolts.

An axial, cylindrical bore 52 is formed in the upper portion of the block 51 which is provided with radial outlet and inlet ports 53 and 54 which extend from the bore and have their outer portions screw-threaded for receiving the outlet and inlet lines 42 and 44, respectively, whereby the bore establishes communication between said lines. An axially-alined, reduced counterbore 55 communicates with the lower end of the bore 52 and extends entirely through the lower portion of the block 51 so as to be open to atmosphere. In the lower portion of the head 50, a counterbore 56, of slightly greater diameter than the counterbore 55, is formed and terminates short of the upper end of said head so as to be closed against the atmosphere. A cylindrical valve piston 57 is slidably mounted within the cylinder 52 and includes an intermediate annular piston head 58 having axial, reduced shanks or plungers 59 and 60, preferably made integral with its top and bottom and complementary to and slidably engageable within the counterbores 56 and 55, respectively. The piston 58 is of less height or length than its cylinder and the plungers 59 and 60 are slightly less in length, than their respective counterbores, whereby said piston is freely reciprocal within the valve block. Since the upper plunger 59 is of greater diameter than the lower plunger 60, the top of the piston 58 has a greater effective cross-sectional area than the bottom thereof.

For sealing off the cylinder 52 and between the plungers and their counterbores, the inner ends

of the latter, adjacent said cylinder, are counter-bored or recessed as shown at 61 and 62, respectively, to receive annular packing members or rings 63 and 64, of rubber or other suitable elastic material. The upper recess 61 and packing ring 63, which are disposed in the head 50 above the cylinder, are of a diameter slightly greater than the diameter of said cylinder so as to project peripherally therebeyond for engaging the upper end of the block 51 and sealing off the upper end of the cylinder when said head is secured to said block. The upper portion of the valve block, which is engaged by the ring 63, serves as a shoulder or seat for supporting and retaining said ring in place. The external diameter of the lower recess 62 and packing ring 64 is slightly less than the diameter of the cylinder, whereby said ring seals off around the lower plunger 60, as well as between said cylinder and the lower counter-bore 55.

In order to prevent the piston 58 from engaging the bottom of the cylinder and closing the inlet port 54, an annular shoulder 65, which is of less diameter than the upper plunger 59, is formed at the upper end of the plunger 60 and engages the packing ring 64 when the valve piston is in its lower position (Figure 8). Thus, even when the shoulder 65 is seated against the ring 64, the effective area of the bottom of the piston head is greater than that of its top and the admission of pressure fluid through the inlet port 54 will result in the fluid acting upon the bottom of the piston head and lifting the piston 57 to the position shown in Figure 10. Since the outlet port 53 is disposed in a horizontal plane a slight distance above the inlet port, communication between said ports is established upon this upward movement of the piston. Due to this communication, the pressure fluid from the storage tank 46 is permitted to flow through the line 42 and pipes 41 and 40 to the interior of the sack 28 for inflating the same as has been explained hereinbefore. The piston 57 will remain in its upper position (Figure 10) until the sack is fully expanded or inflated as shown in Figures 2 and 4. Due to the opening of the outlet port 53, the pressure beneath the piston head 58 will be materially reduced and said piston head will cease to move upwardly when its bottom is above said port. Therefore, the top of the piston head will be spaced below the upper end of the cylinder when the piston 57 is in its upper position.

For by-passing pressure fluid to the upper end of the cylinder above the piston head and for constantly equalizing the pressure above and below said piston head 58, a small duct 65 extends vertically through the piston head adjacent the periphery thereof. This by-passing of pressure fluid to the upper end of the cylinder above the piston does not alter the operation of the valve, as heretofore explained, due to the greater cross-sectional area of the bottom of said piston. In order to lower the piston 57 and shut off the supply of pressure fluid upon complete inflation of the sack 28, it is necessary to conduct said fluid to the upper counterbore 56, whereby the pressure of the fluid will act upon the upper end of the plunger 59. For accomplishing this purpose, an inclined port 67 extends from the upper portion of the bore 52 to the upper end of the block 51 and communicates with a vertical duct 68 formed in the head 50. An enlarged valve chamber 69 is formed above the duct 68 and houses a spring-pressed ball 70 which is seated

in and closes the upper end of said duct. The ball 70 is held in engagement with its seat by means of a coiled spring 71 and an adjusting screw 72 which is screw-threaded through a suitable packing nut or collar 73, the latter being screw-threaded into the upper end of the valve chamber 69 for closing the same. A transverse or duct 74 establishes communication between the valve chamber and the upper end of the counterbore 56.

It is pointed out that the ball 70 is normally seated and the compression of the spring 71 is adjusted by means of the screw 72 to hold the valve in its seated position until the pressure within the cylinder 52 exceeds the pressure necessary to completely inflate the expansible sack 28. Manifestly, since the pressure of the fluid within the tank 46 is in excess of the pressure required to completely inflate the sack, said pressure will build up within the cylinder and will unseat the ball 70 and flow through the chamber 69 and duct 74 into the upper counterbore 56. The combined area of the plunger 59 and the top of the piston head 58 being greater area than the bottom of said head, due to the provision of the plunger 60 and shoulder 65, the admission of the pressure fluid to the upper counterbore will result in downward movement of the piston 57 from its upper, open position to its lower closed position (Figure 8). As has been explained, the piston head 58 overlies or covers the outlet port 53 so as to shut off the flow of the pressure fluid to the line 42 when the piston is in its lower position. It is pointed out that the ball valve 70 will seat and close the duct 68 upon movement of the valve element to its lower position, since the pressure exerted against said ball valve is no longer sufficient to withstand the compression or force of the spring 71 and due to the equalization of the pressure within the chamber 69 with the pressure within said duct. Manifestly, the seating of the ball valve will shut off the flow of pressure fluid to the upper counterbore 56 and said fluid will be trapped within said counterbore as well as in the duct 74 and chamber 69. In order to relieve this pressure, and permit subsequent upward movement of the piston, an axial duct 75, of relatively small diameter extends entirely through the piston 57, establishes communication between the upper counterbore and the atmosphere and thereby permits the trapped pressure to bleed or dissipate itself from said counterbore, radial duct 74 and chamber 69. As soon as this trapped pressure fluid approaches atmospheric pressure, a predetermined pressure drop occurs and the pressure exerted against the greater area of the bottom of the piston head will again raise the piston so as to open the outlet port 53 and thereby supply pressure fluid to the expansible sack 28.

For controlling the escape of the pressure fluid from the expansible sack, an angular by-pass duct or port 75 is formed in the valve block 51 and extends downwardly from the outlet port 53, then diametrically of said body immediately below the cylinder 52 and the lower packing ring 64 and its recess 62. A manually-adjustable, needle valve 77, similar to the needle valve 45 is connected to the by-pass duct 76 by means of a short pipe 78 which is screw-threaded into the outer end of said duct. The lower counterbore 55 intersects the by-pass duct 76 and said duct is closed by the plunger 60 when the piston is in its upper or raised position as shown in Figure

10. For establishing communication between the two portions of the by-pass duct, an annular groove or recess 79 is formed in the external periphery of the plunger 60 and this groove registers with said duct when the piston is in its lowered position (Figure 8). Thus, when the fluid pressure is cut off from the expansible sack by the piston being in its lower position, the fluid within said sack may exhaust by flowing upwardly through the pipe 40 into the line 42, port 53, duct 76, groove 79 and pipe 78, and then out through the valve 77. Since the upward movement of the piston to its open position moves the groove 79 out of registration with the by-pass duct, flow through said duct is prevented and there will be no escape of the fluid flowing through the valve 43 to the expansible sack.

The needle valve 77 is conventional and merely meters or regulates the rate of flow of the pressure fluid exhausted from the expansible sack and, therefore, the rate of deflation or collapse of said member as well as the rate of entry of the well fluids into the chamber A. It is pointed out that the valve 77 may have its outlet or discharge opening connected to the intake of the compressor 47 or may, as shown be open to the atmosphere. The valve 45 is substantially identical to the valve 77 and is provided for the purpose of controlling the rate of flow of the pressure fluid supplied through the valve 43 to the sack 28. The adjustment of these needle valves is subject to variation and said adjustments may be dissimilar, whereby the pressure fluid may be exhausted from the sack at a different or faster rate than the admittance of said fluid thereto. It is desirable to exhaust the pressure fluid at a rate much more rapid than the admittance rate of said fluid, whereby the actual working or lifting time may be of prolonged duration.

Due to the relatively large volume of the chamber A, a sizable quantity of well fluids may be lifted upon each inflation of the expansible sack and such inflations may be infrequent so as to permit the use of a lifting fluid of relatively small volume or low pressure. Since the exhaustion rate of the pressure fluid controls the rate of entry of the well fluids into the chamber A as well as the vacuum or suction exerted upon said well fluids and the velocity of the same in flowing from the formation F, separation and escape of the lighter hydrocarbon constituents from the well fluids may be prevented by properly adjusting the exhaust needle valve 77 in accordance with the characteristics and condition of the producing formation. Of course, this valve is adjusted to provide a maximum rate of exhaustion without creating an undesirable or excessive vacuum or velocity of flow. Also, a desirable back-pressure is held upon the formation by the means (not shown) within the casing head 12 which seals off the space between the casing 11 and tubing 15. In order to provide a relatively slow admission of the pressure fluid, the needle valve 45 may be suitably adjusted so as to admit said fluid at the desired rate.

A pump of the construction described hereinbefore is limited as to the depth of its installation below the surface, due to the fact that it would be uneconomical to employ an operating fluid having an excessively high pressure. Therefore, in wells relatively deep, it is desirable to employ a plurality of lifting stages and each stage includes one of the chambers B as shown in Figures 1, 3 and 5.

Each chamber B is very similar to the cham-

ber A, but is of greater length, and includes a similar sleeve 80 having its upper end connected to the tubing 15 by a collar 81, a swaged nipple 82 and a coupling collar 83. As shown in Figures 3 and 5, a similar collar 84, swaged nipple 85 and coupling collar 86 connect the lower end of the sleeve to the tubing therebelow. The upper coupling collar 83 has an enlarged external diameter to provide a relatively-thick wall and the bore of said collar has its lower portion enlarged to form a recess or socket 87 for receiving the upper end of the swaged nipple 82. As shown by the numeral 88, the bore of the upper end or neck of the nipple is substantially equal to the external diameter of the tubing 15, whereby a short pipe sleeve 89, of substantially the same diameter as said tubing, may extend through said nipple neck and be screw-threaded within the internal lower portion of the collar 83. The short sleeve 89 depends a short distance into the chamber B and has its lower end connected to a swaged nipple 90 by a special coupling collar 91 which is substantially identical to the collar 23 and which includes an internal, annular shoulder 92 and a reduced, screw-threaded counter-bore or socket 93 therebelow. A check valve 94, substantially identical to the valves 24 and 37, is mounted within the collar 91 and is held in position by being clamped between the shoulder 92 and the lower end of the short sleeve 89 for trapping well fluids thereabove, as will be hereinafter more fully explained. The counterbore 93 receives the upper end of a tapered nipple 95 which extends through the upper end or neck of the swaged nipple 90 to a point slightly below said neck. The nipple 95 is substantially identical to the nipple 31 and has a similar transverse partition 96 with radial ports 97 thereabove for establishing communication between the upper portion of said nipple 95 and the exterior thereof.

As is clearly shown in Figure 5, an expansible member or sack 98, substantially identical to but of a less diameter and greater length than the sack 28, has its reduced, reinforced upper end or neck 99 engaging around and fastened to the lower portion of the inner nipple 95 above its tapered or constricted throat 102 by a suitable clamping band or ring 100. External, peripheral grooves 101 are formed in the inner nipple for receiving the material of the tube neck 99 upon tightening of the band 100. The pressure fluid is conducted to the sack 98 from the pipe 40 by a branch pipe 103, which extends from said pipe, through the swaged nipple 82, then through the swaged nipple 90 into the lower portion of the nipple 95 below its partition 96 so as to communicate with the interior of said sack. An elongate, cylindrical sleeve 104, of less diameter than the sleeve 80, surrounds the sack 98 and depends from the nipple 90 to which it is connected by means of a suitable collar 105. The sleeve 104 is of greater length than the sleeve 20 of the chamber A, but of less length than the sleeve 80, so as to terminate above the lower end thereof and is connected by means of a collar 106, a swaged nipple 107 and a special coupling collar 108 to a perforated bull plug 109, which is preferably disposed within the reduced or neck portion of the lower swaged nipple 85. A check valve 110 is mounted in the coupling collar 108 by being clamped between the nipple 107 and plug 109 and this valve as well as the other parts are substantially identical to the valve 24, plug 25, swaged nipple 18 and collars 16 and 17 of the chamber A. The sleeve 104 and the elements

connected thereto provide an accumulating chamber C of substantially the same capacity as the chamber A for receiving the well fluids lifted from said chamber A by the sack 28.

Upon inflation of the sack 28 as shown in Figure 2, the well fluids lifted from the chamber A through the valve 37 will build up or accumulate within the tubing 15 thereabove and within the chamber B. Although the chamber B and its sleeve 80 have substantially the same diameter as the chamber A and its sleeve 20, the former are of greater length so as to have substantially the same capacity or volume for accumulating the lifted well fluids. The sack 98 is actuated in exactly the same manner as the sack 28 and is preferably inflated and deflated simultaneously therewith. As soon as the well fluids commence to accumulate within the chamber C, said fluids will flow through the perforations of the plug 109 past the valve 110 into the chamber C upon exhaustion of the pressure fluid and deflation of the sack 98. Initially no well fluids are present within the chamber C to resist inflation of its sack 98 and, therefore, said sack will be inflated prior to the inflation of the sack 28 so as to prevent said fluids when subsequently elevated into the chamber B by said sack 98 from entering said chamber C. Thus, the lifted well fluids will substantially fill the chamber C upon first entering said chamber and will continue to fill the same upon each subsequent actuation of the sack 28. Upon inflation of the sack 98, the valve 110 will be closed and the well fluids within the chamber C will be forced or lifted upwardly through the space between the nipples 90 and 95, then through the ports 97, the upper portion of said nipple 95 and valve 94 into the short sleeve 89 and tubing 15 thereabove (Figure 5). As has been explained, the valve 94 functions in the same manner as the valve 37 of the chamber A for trapping and preventing the escape of well fluids lifted therethrough. With the surface control valve 43 in the position shown in Figure 8, the pressure fluid within the sack 98 will exhaust through the pipe 103 into the pipe 40 and will be conducted together with the pressure fluid from the sack 28 to the surface so as to escape by means of the line 42, angular duct 76, groove 79, pipe 78 and needle valve 77. The well fluids within the chamber B will then again flow into the chamber C so as to assist in collapsing or deflating the sack 98 and to substantially fill said chamber, whereby said well fluids will be lifted or forced upwardly upon subsequent inflation of said sack.

In order to prevent the creation of an undesirable pressure within the chamber B and to permit the escape of any excess well fluids which might accumulate therein, a plurality of vent openings 111 are formed in the swaged nipple 82 which is disposed at the top of the chamber above its sleeve 80. A moisture trap 112 (Figure 11) may be connected in the macaroni string 40 adjacent the point at which said string 40 extends through the swaged nipple 22 of the chamber A.

The pipe is divided in the trap and the ends thereof offset in the usual manner. A spring-pressed downwardly opening dumping valve 115 engages a seat 114 in the bottom of the trap. Periodically increasing the pressure of the fluid flowing through the string 40 will exert sufficient pressure upon the liquid accumulated in the trap to open the valve and discharge such liquid.

The foregoing description of the invention is

explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

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

1. In a well pumping apparatus, the combination of, an accumulating chamber adapted to be immersed in the liquid in a well, an elongate expansible sack mounted in said chamber and free to collapse, a conductor for supplying pressure fluid to the upper end of the sack and for exhausting such pressure fluid therefrom connected to said sack and adapted to extend to the top of a well, the lower end of the sack being free and unsupported, an automatic valve for alternating supplying pressure fluid to the conductor and exhausting such fluid therefrom, means for supplying fluid under pressure to said valve, a well tubing extending from the upper end of said chamber, means for discharging well liquid from the chamber to the tubing, means for controlling the supply of pressure fluid to the valve, and means for controlling the exhausting of pressure fluid from the valve, whereby the pressure fluid may be exhausted from the sack at a higher rate than that at which it is supplied thereto.

2. In a well pumping apparatus, the combination of, an accumulating chamber adapted to be immersed in the liquid in a well, an elongate expansible sack mounted in said chamber and free to collapse, a conductor for supplying pressure fluid to the upper end of the sack and for exhausting such pressure fluid therefrom connected to said sack and adapted to extend to the top of a well, the lower end of the sack being free and unsupported, an automatic valve for alternating supplying pressure fluid to the conductor and exhausting such fluid therefrom, means for supplying fluid under pressure to said valve, a well tubing extending from the upper end of said chamber, means for discharging well liquid from the chamber to the tubing, a control valve connected in the fluid pressure supply, and a control valve connected with the pressure fluid exhaust of the valve.

3. A well pump including a cylinder adapted to be immersed in a well, a well fluid inlet valve at the bottom of the cylinder, a well fluid outlet valve at the top of the cylinder, a well tubing connected with the top of the cylinder, an expansible sack in the cylinder disposed to expand to the full internal cross-sectional area of said cylinder, the upright wall of the cylinder being imperforate, means for suspending the sack in the cylinder, and means for supplying a pressure fluid to the sack through its support.

4. A well pump as set forth in claim 1, and a moisture trap connected in the pressure supply means adjacent the chamber.

5. A well pump including, a cylindrical chamber adapted to be immersed in the liquid in a well and having a well fluid inlet valve at its bottom, a nipple mounted at the top of the chamber and extending only into the upper end of said chamber, an inflatable elastic sack suspended from said nipple and depending into said chamber, said sack being free to collapse, means for supplying a pressure fluid to and exhausting such fluid from the nipple for said sack to inflate the latter to the inner annular wall of the cylinder and to collapse said sack, means for conducting well fluid displaced by the sack from the cylinder, and

13

a well tubing connected to said conducting means.

6. A well pump as set forth in claim 5, and a back flow valve connected with the tubing above said nipple.

7. A well pump including, a cylindrical chamber having an inlet valve at its bottom, an elastic sack suspended in the chamber, and means for supplying a pressure fluid to the sack, the lower wall of the sack being reduced in thickness to cause initial expansion thereof, whereby the trapping of well fluid in the chamber is prevented.

8. A well pump including a cylindrical chamber adapted to be immersed in the liquid in a well and having a well fluid inlet valve at its bottom, a nipple mounted at the top of the chamber and extending only into the upper end of said chamber, an inflatable elastic sack suspended from said nipple and depending into said chamber, said nipple having a pressure fluid passage and a well fluid discharge passage separate from

14

the pressure fluid passage connected with the chamber, a single conductor connected with the pressure fluid passage of the nipple for supplying and exhausting pressure fluid, and a well tubing connected with the fluid discharge passage in said nipple.

9. A well pump including, a cylinder adapted to be installed in a well, a well fluid inlet valve at the bottom of the cylinder, a well fluid outlet valve at the top of the cylinder, a well tubing connected with the top of the cylinder, an expandible sack in the cylinder disposed to expand to the full internal cross-section area of said cylinder, the upright wall of the cylinder being imperforate, means for suspending the sack in the cylinder, means for supplying a pressure fluid to the sack through its support, and a larger cylinder surrounding and spaced from the first named cylinder and communicating therewith through the well-fluid inlet valve thereof.

JOSEPH R. NORTON.