Aug. 24, 1965 O. V. REYNOLDS 3,202,104

GRAVITY POWERED CASING PUMP WITH DOUBLE-VALVED PISTON

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Fig. 1

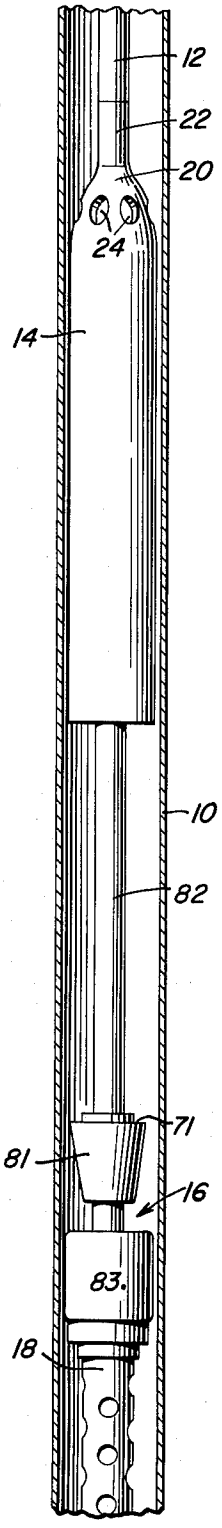


Fig. 2

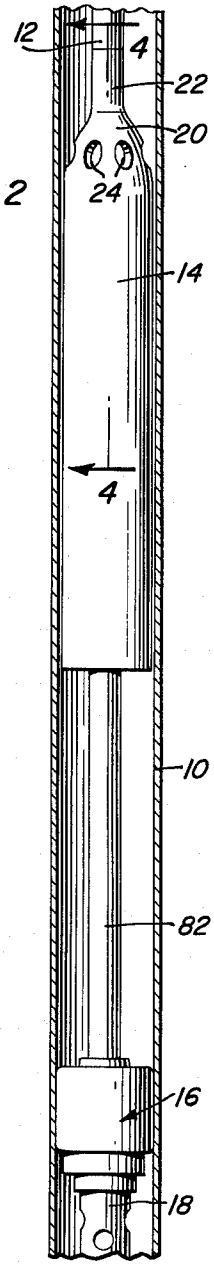
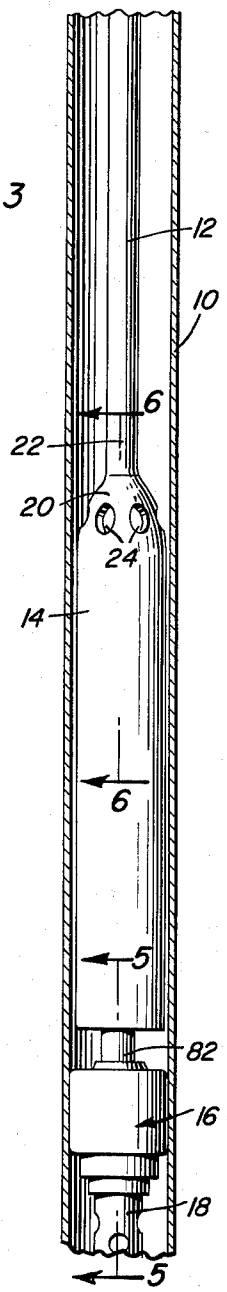


Fig. 3



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Fig.4

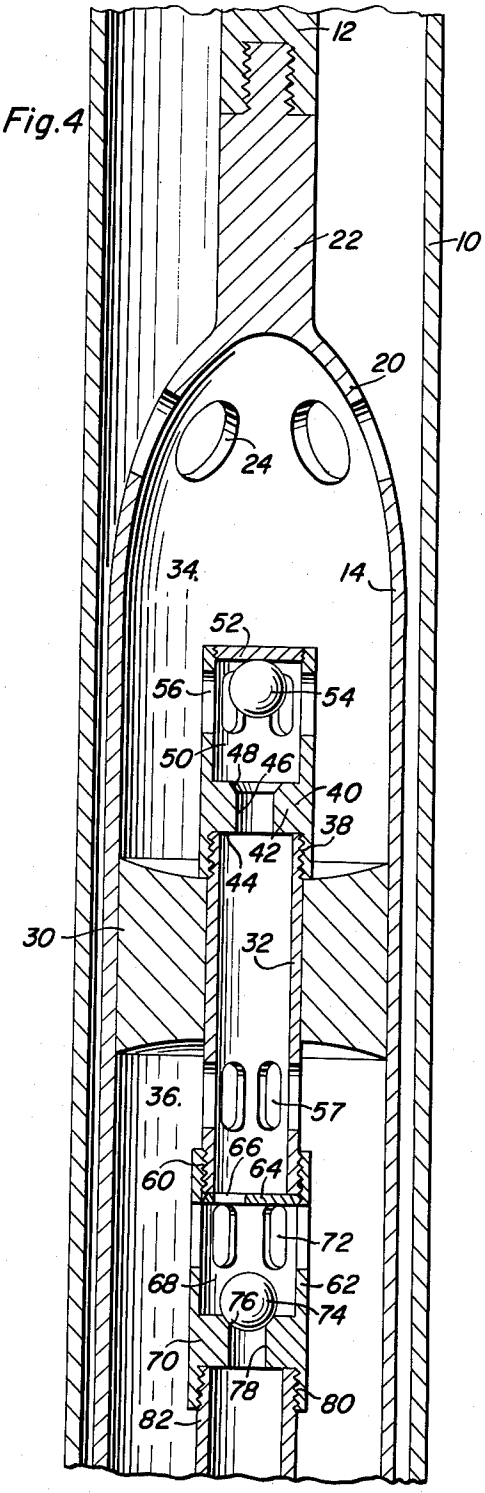
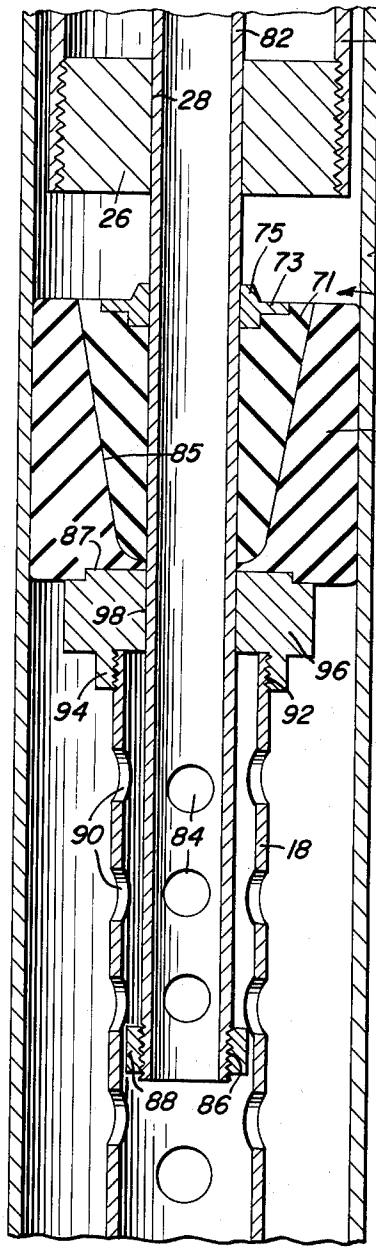


Fig.5



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Fig. 6

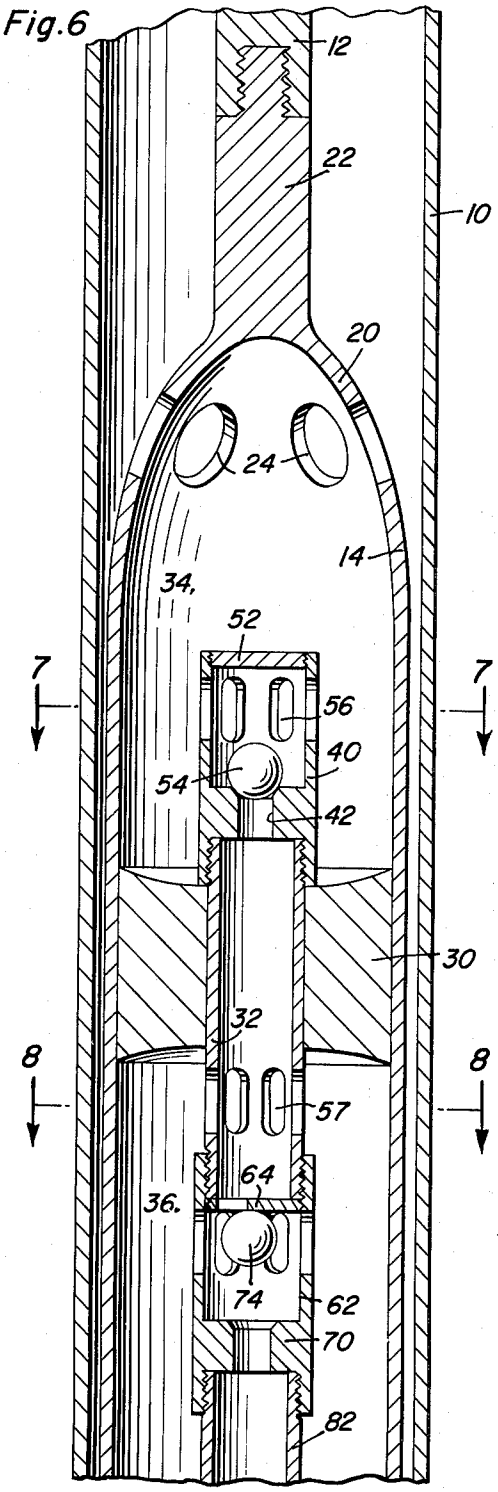


Fig. 7

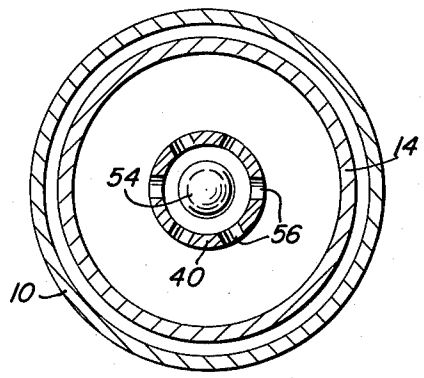
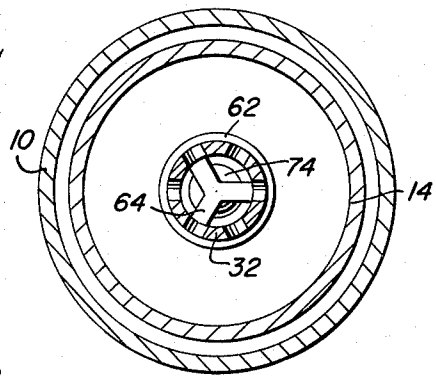


Fig. 8



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GRAVITY POWERED CASING PUMP WITH DOUBLE-VALVED PISTON

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11 Claims. (Cl. 103—158)

This invention comprises a novel and useful gravity powered casing pump with double valved piston and pertains more particularly to a reciprocating pump for producing liquids from deep wells and constitutes an improvement over the gravity-powered casing pump disclosed and claimed in my prior copending application, Serial No. 96,828 and filed March 20, 1961, now Patent No. 3,114, 327, issued December 17, 1963.

In the recovery of fluids such as petroleum or water from well bores, it sometimes occurs that owing to economical reasons a relatively small bore of five inches or less in diameter has been drilled into the productive formation and the fluid produced from pump tubing within the casing of this bore is frequently at a rate of flow which is less than the productive capacity of the formation penetrated by the well bore. When this condition occurs, the well operator fails to obtain the maximum potential output and therefore the maximum potential properties from the well owing to the lack of adequate flow capacity through the pump and tubing installation.

It is therefore the primary purpose of this invention to provide an apparatus to effectively overcome the foregoing difficulty and enable a maximum production from the well which is limited only by the volumetric capacity of the casing of the well.

More specifically, it is an object of the present invention to provide a bottom hole type of reciprocating pump in which the entire well casing is employed as the pump tubing string so as to obtain the utmost volume of delivery from the well.

It is a further important object of the invention to provide an apparatus in accordance with the foregoing object which is capable of being operated by conventional wire line equipment and will eliminate the weight of the pumping string and the expense thereof which are incident to pumping by a rigid pumping string or sucker rod string.

Still another purpose of the invention is to provide a bottom hole reciprocating pump installation which shall reduce to a minimum the power requirements for operating the pump and in which gravity alone may be relied upon as the actuating means to effect the downward pumping stroke while the operation of a wire line may be utilized solely to lift the reciprocating mass of the pump assembly in preparation for the next gravity operated pumping stroke.

In carrying out the principles of this invention there is utilized a novel packer assembly which is appropriately secured in position in the lower end of the well casing to completely seal off the bottom of the bore from the casing thereabove so that the entire casing above the packing member may be utilized as the pump tubing of the apparatus.

A still further and very important object of the invention is to provide an apparatus in which the entire arrangement of a reciprocating pump barrel, stationary

piston, packer assembly and a supporting tailpipe therefor may be connected together into a unitary subassembly whereby they may be lowered into or removed from a well bore by a conventional wire line and when positioned in a well bore may be operated as a bottom hole pump by the wire line or any other desired operating means.

A further and more specific object of the invention is to provide in an assembly of the character above set forth a packer construction in which the packer may be expanded into its sealing engagement with the well casing through the weight of the pump as the assembly is lowered into the bottom hole of a well; and whereby the weight of the liquid column upon the packer to the surface may be utilized as a static load to retain the packer in a fluid-tight sealed engagement with the well bore; and whereby the packer and the entire assembly may be readily retrieved by a wire line.

An additional and still more specific object of the invention is to provide in an assembly of the character above set forth a reciprocating barrel pump having a stationary piston therein and which piston is provided upon opposite sides thereof with non-return upwardly opening valve assemblies to effect a bypass of the fluid from the lower side to the top side of the stationary piston in the reciprocating cylinder pump in a greatly improved manner.

A still further object of the invention is to provide in a pump mechanism of the character above set forth the stationary pump piston which carries upon its top and bottom sides thereof a pair of non-return check valves for effecting bypass of the fluid around the piston during the operation of the pump.

And a final and important object of the invention to be specifically enumerated herein resides in the provision of a pumping apparatus in accordance with the foregoing objects wherein an automatically operated venting or dumping valve is incorporated into the packer construction which will be closed when the pump is in normal pumping position and which will be opened during reset of the device in a well bore by the wire line and during withdrawal of the device from the well bore by the wire line to thereby permit the flow of fluid through the packer assembly and facilitate such lowering or lifting of the device.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a view in central section through a portion of a well casing and showing the unitary deep well reciprocating pump installation of this invention therein, parts being shown in the position assumed during the passage of the assembly into or out of a well bore;

FIGURE 2 is a view similar to FIGURE 1 but showing the position of the parts wherein the pump installation is properly seated in a well bore in condition for operation and with the reciprocating barrel of the pump unit being at the upper end of its stroke;

FIGURE 3 is a view similar to FIGURE 2 but showing the position of the pump barrel at the lower end of its pumping stroke;

FIGURE 4 is a detail view in vertical central section taken upon an enlarged scale substantially upon the plane indicated by the section line 4—4 of FIGURE 2 and showing the internal construction of the upper portion of the stationary piston and the reciprocating barrel of the pump;

FIGURE 5 is a detail view in vertical section taken upon an enlarged scale substantially upon the plane indicated by the section line 5—5 of FIGURE 3 and showing the lower portion of the reciprocating barrel of the pump and showing the packer assembly and its connection to the pump assembly of the invention;

FIGURE 6 is a further detail view in vertical section taken upon an enlarged scale substantially upon the plane indicated by the section line 6—6 of FIGURE 3 and is similar to FIGURE 4 but shows the position of the parts and of the double valves of the piston during the delivery stroke of the pump; and

FIGURES 7 and 8 are horizontal sectional views taken substantially upon the planes indicated by the section lines 7—7 and 8—8, respectively, of FIGURE 6.

In the accompanying drawings, the numeral 10 designates a portion of a well casing for a well bore extending from the surface to any suitable subterraneous formation for producing liquids therefrom such as oil or water. The pump installation of this invention comprises a unitary assembly which is adapted for use in a well casing of this character and is particularly advantageous in its effects when the well casing is one of a relatively small or narrow diameter. The basic concept of this invention resides in the use of the well casing itself as the pump tubing through which the liquid from the formation is produced, thus dispensing with the usual pump tubing which is ordinarily disposed in such a well casing and which pump tubing therefore restricts the maximum flow of liquid from the formation to a rate of flow which is considerably less than that which can be accommodated by the well casing itself. In some instances, it will be preferred to initially install the casing pump of this invention in the well casing 10 when the well is initially produced, while in some other instances it will be advantageous to convert a well of this character from the employment of relatively small diameter pump tubing to the use of the well casing itself as the pump tubing. In this latter event the conventional pump tubing and bottom hole pump assembly are pulled from the well and are then replaced by the pump installation of this invention which is carried by and is manipulated by a conventional wire line rather than by a rigid sucker rod or pumping string, and is both inserted into the well bore, withdrawn from the well bore and is also operated by the use of the wire line.

FIGURES 1 and 4 illustrate the construction and arrangement of the components of the bottom hole pump installation in accordance with this invention and with the components illustrated in the position in which they are located as the device is being lowered into or withdrawn from a well casing.

FIGURES 2, 3 5 and 6 illustrate the position which the components assume after they are installed in the well bore in operation for pumping, FIGURES 2 and 4 showing the positions of the parts during the uppermost and intermediate positions of the reciprocating pump barrel at the beginning of the pumping stroke while FIGURES 3, 5 and 6 show the position of the parts at the lowest position of the reciprocating pump barrel upon the completion of the delivery stroke of the pump.

Shown at 12 is the lower end of a wire line or sucker or pump rod string by which the unitary assembly is to be lifted, lowered and operated, it being understood that any suitable source of power at the surface is employed for imparting reciprocatory movement to the line 12 and thus to the reciprocating barrel 14 of the pump assembly connected thereto.

The pump assembly of the installation includes as its main components the reciprocating pump barrel 14 which

may be of any size desired and which can be loosely received in the well casing 10 for reciprocation therein as well as for trips into and out of the well casing. Supportingly carried by the pump barrel 14 in a manner to be subsequently set forth is a packer assembly indicated generally by the numeral 16 while a tailpipe 18 comprises a support means or anchor for the packer assembly and performs certain other functions set forth hereinafter. As set forth in my above-identified patent, a centralizer indicated by the numeral 20 therein may be disposed between the pump barrel 14 and the wire line or pump rod string 12 for the usual purpose.

Referring now to FIGURES 4 and 6 in particular it will be observed that the pump barrel 14 is a generally cylindrical body having an ovate or conoidal upper nose portion 20 with an upstanding stem 22 which is releasably secured to the wire line or pump or sucker rod string 12 whereby the barrel of the pump is supported. The upper end of the pump barrel is closed except for the provision of discharge ports 24 therein which open from the interior of the pump barrel into the well casing 10.

At its lower end, as shown in FIGURE 5, the pump barrel 14 is closed by an end wall or plug 26 which is threadedly engaged therewith and which has an axial bore 28 therethrough.

Slidably received within the reciprocating barrel 14 of the pump assembly, see FIGURES 4 and 6, is a stationary pump piston 30 of any suitable and conventional construction which has a fluid-tight sliding fit with the walls of the cylindrical chamber within the pump barrel 14. The pump piston is fixedly secured to a central arbor or tube 32 having its upper and lower open ends projecting respectively above and below the pump piston. The piston thus divides the interior of the reciprocating barrel 14 into an upper pumping chamber 34 and a lower pump intake chamber 36.

From FIGURES 4 and 6 it will be observed that the open upper end of the arbor 32 is externally threaded at 38 and receives thereon the internally threaded lower extremity of the valve cage 40. The latter includes an intermediately disposed partition 42 whose lower surface 44 is adapted to seat upon the upper end of the hollow arbor 32 and which partition has a port or passage 46 therethrough whose upper end provides a valve seat 48. Above the partition the valve cage is provided with a diametrically enlarged chamber 50 whose upper end is provided with an externally threaded plug 52 comprising a closure cap therefor and by means of which a ball check valve 54 is retained for movement within the chamber. The ball cooperates with the valve seat 48 but is free to move therefrom upon pressure differences existing on opposite sides of the partition 42. A series of openings 56 in the side of the valve cage provides communication from the valve chamber 50 to the chamber 34 within the reciprocating barrel 14.

The open lower end of the arbor 32 is likewise externally threaded as at 60 and receives thereon the upper internally threaded end of a valve cage 62 carrying a plate 64 which abuts against and is held against the open lower end of the arbor 32. This plate is apertured as at 66 for the passage of fluid from an enlarged valve chamber 68 within the valve cage above an intermediate partition 70. Apertures 72 establish communication between the chamber 68 of the valve cage and the pump intake or lower chamber 36.

The ball check valve 74 is received within the chamber 68 and cooperates with the valve seat 76 at the upper end of the port or passage 78 extending through the partition 70.

It will thus be apparent that the arbor carries at its opposite ends a pair of non-return check valve assemblies for a purpose to be subsequently set forth.

It may be here noted that the upper valve cage 40 constitutes a traveling or delivery valve controlling flow into the upper or pumping chamber 34 while the lower valve

cage 62 constitutes a standing valve or intake valve for the lower or intake chamber 36 of the reciprocating deep well pump.

The valve cage 62 has its lower end internally threaded as at 80 for engagement by the upper end of a piston rod 82. This rod 82, as will be apparent from FIGURE 5, is slidably received through the axial bore 28 in the bottom closure wall 26 of the reciprocating pump valve 14, and likewise extends through the packer assembly 16 and has its lower end open into the well casing below the packer assembly. This lower open end is provided with a series of apertures 84 therein and is externally threaded as at 86 to receive thereon a threaded nut or collar 88. It will be noted that the tailpipe 18 consists of a tube or sleeve which is apertured as at 90 along its length to establish communication with the interior of the casing below the packer 16 and at its upper end is externally threaded as at 92 for engagement in the depending internally threaded flange 94 of a plate 96 which is apertured as at 98 to slidably receive therethrough the piston rod 82.

It will now be observed that the packer assembly 16 has a conical upper section 71 which is of a resiliently deformable material such as rubber or the like and is bonded to or fixedly secured to and surrounds the hollow piston rod 82, being retained between upper and lower retaining members such as the upper plate 73 which may be embedded in the material of the upper packer section 71 and has a hub 75 in the form of a collar which is fixedly engaged upon the piston rod 82 for movement therewith. It is to be particularly noted that the upper packer member 71 has a downwardly convergent tapering conical exterior surface 81 thereon and constitutes a packer valve.

The lower packer section consists of a main body portion 83 likewise of a resiliently deformed material such as rubber and its external diameter is such as to be slidable in the well casing 10 in close proximity to the latter during travel of the device into and out of the well casing. The lower section is provided with a conical recess or cavity 85, see FIGURE 5, which is upwardly divergent and is sufficiently complementary to the conical exterior surface 81 of the upper section or packer valve to wedgingly receive the latter therein and constitutes a packer valve seat. The bottom surface of the lower section is recessed or counterbored as at 87 to receive therein and to bondingly engage upon the metallic plate or body 96 as shown in FIGURE 5. Thus, the lower packer section 83 is slidable upon the piston rod 82 and is fixedly joined by the member 96 with the tailpipe 18 for movement with the latter.

As so far described it will now be understood that the piston 30, piston rod 82 and the upper packer section 71 operate as one unit which has relative movement with respect to the reciprocating pump barrel 14 on one hand and the unitary assembly of the lower packer section 83, the tailpipe 18 and the connecting body 96. Relative reciprocation between the upper and lower packer sections is limited by the engagement of the upper section in the lower section in the position shown in FIGURE 5 and by engagement of the collar 88 constituting a stop means as the latter abuts the underside of the member 96 when the parts are in the position shown in FIGURE 1 with the device being lifted from or lowered into a well casing.

The operation of this bottom hole installation is as follows:

When the components of the device are assembled together in the position shown in FIGURE 1 and in readiness for lowering into a well bore upon the lower end of a wire line or sucker rod string 12, it will be understood that the pump barrel 14 is suspended by the member 12. The piston 30 is at the lower end of its travel in the pump barrel 14, being at the bottom of the chamber 36 and resting upon the end closure plug 26. The pump rod 18 in turn, by means of the stop member 88, supports the bottom surface of the member 96 and the lower packer section 83 which latter is thus spaced from the upper packer section 71 as shown in FIGURE 1. In this position, the two packer sections spaced from each other thus permit an unobstructed passage of well fluid therethrough which well fluid may readily pass the packer by entering through the ports 90 of the tailpipe 18, and upwardly through the lower open end 86 of the piston rod and then pass through the apertures 84 of the piston rod which lie above the lower packer section and thus into the pump chambers 36, through the valve cage ports 57 at the lower end of the arbor 32 and the ports 56 at the upper end thereof and into the chamber 34 and then from the ports 24 into the well casing above the packer. Thus no obstruction is encountered as the assembly is lowered into or removed from the well bore.

However, with the tailpipe being of a requisite length, the device is lowered in the well bore in the position above described until the tailpipe strikes the bottom of the well or some other anchoring and supporting member provided for that purpose within the casing. This stops further downward movement of the tailpipe and thus holds the piston stationary on the bottom of the well bore or the supporting member. Consequently, further downward travel of the barrel 14 with the wire line 12 will now allow the upper valve section 71 to slide down to the lower section 83 and under the weight of the pump assembly thereabove will expand the packer 83 into a sealing engagement with the wall of the casing 10. Further, downward travel of the pump barrel will now cause relative movement of the stationary piston upwardly into the upper end of the pump barrel.

With the two packer sections in engagement as shown in FIGURE 5, the unloading portions of the packer 84 are disposed below the plate 96 so that the packer thus seals off the lower portion of the well bore from which the liquid is to be pumped from the upper portion thereof. It should be noted that the entire weight of the column of liquid above the packer at this point serves to retain the two packer sections in engagement with each other.

Now by manipulating the wire line or the sucker rod string 12 through an appropriate range of movement, the pump barrel is caused to reciprocate with respect to the stationary piston so as to alternately enlarge and expand the chambers 34 and 36 inversely.

Then the downward stroke of the pump barrel under the weight of the pump barrel itself and without requiring the addition of any supplemental downward force thereon other than the weight of a sucker rod or pump rod string if the element 12 is of such a character, causes a compression in the chamber 34 which is a pumping chamber of the device and an expansion in the chamber 36 which is the intake chamber thereof. The compression of the chamber 34 closes the check valve 54 against the seat 48 thus preventing return flow of fluid from the chamber and forces the fluid in this chamber through the port 24 into the well casing above the packer and thus to the surface of the ground using the well casing as a flow tubing.

At the same time, the expanding of the intake chamber 36 produces a sufficient suction therein communicated through the ports 57 and 72 to lift the valve 74 from its seat 76 and draw in a charge of fluid through the open lower end of the piston rod 82.

Upon the following upstroke of the barrel, the chamber 36 is compressed thereby forcing the fluid in the chamber 36 to be compressed and then discharged upwardly through the passages 37 and the hollow arbor 32 and on the return check valve 54 into the pumping chamber 34 to recharge the latter.

It will be noted that the double valve arrangement of the standing and foot valves and the non-return valve 74 will effectively assist and effect this operation.

The withdrawal of the device from the well bore is the reverse of that described in connection with the trip downwardly and need not be further described.

The present invention provides a greatly simplified pump barrel construction, a greatly improved standing and traveling valve assembly therefor and cooperates with the self-unloading packer assembly.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. A gravity operated bottom hole casing pump installation comprising the unitary assembly of a pump unit and a packer unit movably connected thereto, said pump unit including a reciprocating pump barrel having a relatively slidable stationary piston therein dividing the barrel interior into an upper pump delivery chamber and a lower pump intake chamber, said piston being fixedly secured to and disposed upon the mid-portion of a hollow arbor and a hollow piston rod secured to and communicating with the lower end of said arbor and extending through and beneath and being movably secured to said packer unit, a delivery valve assembly and a standing valve assembly on the upper and lower ends respectively of said arbor upon the opposite sides of said piston and controlling fluid flow therethrough, each valve assembly comprising a valve seat and an upwardly opening non-return check valve controlling the associated seat.

2. The combination of claim 1 including a tailpipe secured to, depending from and stationarily supporting said packer unit in a well bore, said piston rod having its open lower end received within said tailpipe.

3. The combination of claim 2 wherein said piston rod has stop means on its lower end engageable with said packer unit for limiting upward travel of said piston rod relative to said packer unit.

4. The combination of claim 1 wherein each valve assembly comprises a sleeve threadedly engaged upon the associated end of said arbor, each sleeve comprising a valve cage having a valve chamber therein with a valve seat and a check valve controlling said seat.

5. The combination of claim 4 wherein each cage has an apertured partition therein abuttingly engaging the adjacent end of said arbor.

6. The combination of claim 5 wherein said piston rod is secured to the cage of said standing valve assembly.

7. A gravity operated bottom hole casing pump installation comprising the unitary assembly of a pump unit and a packer unit connected for limited relative movement, said pump unit including a substantially vertical reciprocating pump barrel and a relatively stationary slidable piston therein dividing said barrel into upper and lower pump delivery and intake chambers respectively, fluid intake means and fluid delivery means respectively supplying fluid to and discharging fluid from said intake and delivery chambers, a hollow arbor upon which said piston is secured with the ends of said arbor respectively communicating with said intake and delivery chambers, a hollow piston rod secured to and communicating with the interior of said arbor at the lower end thereof and being movably connected to and extending through said packer unit and opening below the lower end thereof, upper and lower non-return valve assemblies secured respectively to the upper and lower ends of said arbor, each valve assembly allowing upward but preventing downward flow of fluid therethrough, said lower valve assembly being interposed between said piston rod and said arbor and controlling fluid flow therefrom and having outlet ports communicating with said intake chamber, said upper valve assembly controlling fluid flow through said arbor and having outlet ports opening into said delivery chamber, said arbor having an inlet port communicating with said intake chamber, said arbor, arbor inlet port and upper valve assembly comprising a by-pass means conveying fluid through said piston and charging said delivery chamber from said intake chamber.

8. The combination of claim 7 wherein said upper and lower valve assemblies are secured to the opposite ends of said arbor and are disposed in said delivery and intake chambers respectively.

9. A gravity operated bottom hole casing pump installation comprising a pump unit and a packer unit, said pump unit including a stationary section and a movable section, said movable section comprising a vertically reciprocatable pump barrel connected to and dependingly supported by a pump actuator, said stationary section comprising a pump piston and a hollow piston rod connecting said piston to said packer unit, said piston being relatively slidable in said barrel and dividing the interior thereof into an upper pump delivery chamber and a lower pump intake chamber, ports in said barrel communicating said delivery chamber with the exterior of said barrel, said piston having a passage therethrough opening into each of said chambers, said piston rod having its lower portion slidably received in said packer unit and communicating at its upper end with said intake chamber and communicating below said packer unit with a source of fluid to be pumped, a non-return upper check valve assembly mounted upon the upper portion of said piston and controlling communication between said passage and said delivery chamber for by-passing fluid from said intake chamber into said delivery chamber, a non-return lower check valve assembly mounted on the lower portion of said piston and controlling flow of fluid from said source through said piston rod into said intake chamber.

10. The combination of claim 9 wherein said packer unit comprises relatively movable body and valve with an opening through said body having a valve seat with which said valve cooperates, said valve of said packer being fixedly secured to said piston rod, said body being slidably mounted upon said piston rod, a stop means on said piston rod engageable with said body and limiting relative movement of said pump and packer units and supporting the former when said valve of said packer is displaced from said packer body valve seat thereby establishing free flow of fluid through said pump installation when the latter is being moved in a well bore.

11. The combination of claim 10 wherein said packer body has a member fixedly secured to its bottom surface, said member having an aperture slidably embracing said piston rod, said stop means comprising an annular laterally projecting member on the lower end of said piston rod abuttingly engageable with said packer body member bottom surface whereby to support said packer unit from said piston rod and pump unit.

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