

March 18, 1952

C. J. COBERLY
CLOSED FLUID-OPERATED FREE-PUMP SYSTEM
WITH THREE CONCENTRIC TUBINGS

2,589,669

Filed May 16, 1949

2 SHEETS—SHEET 1

Fig. 1.

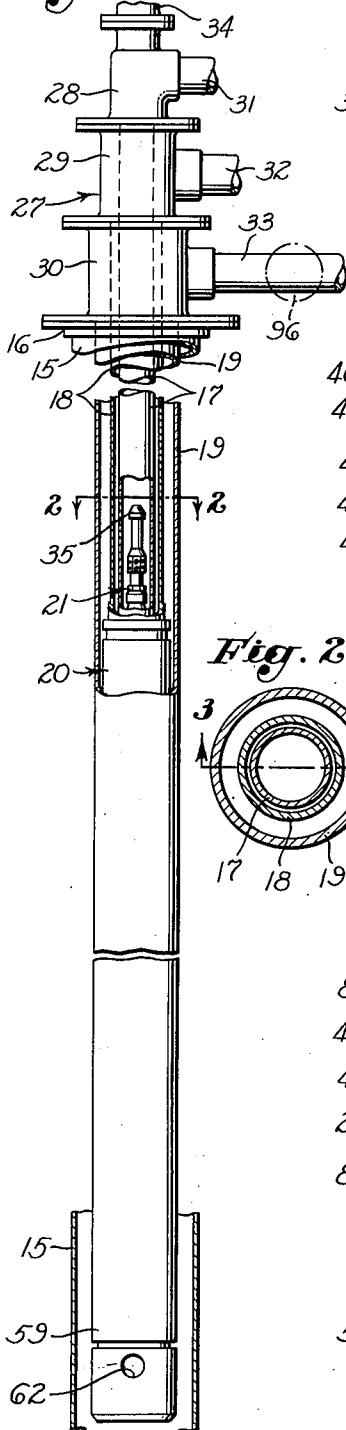


Fig. 3.

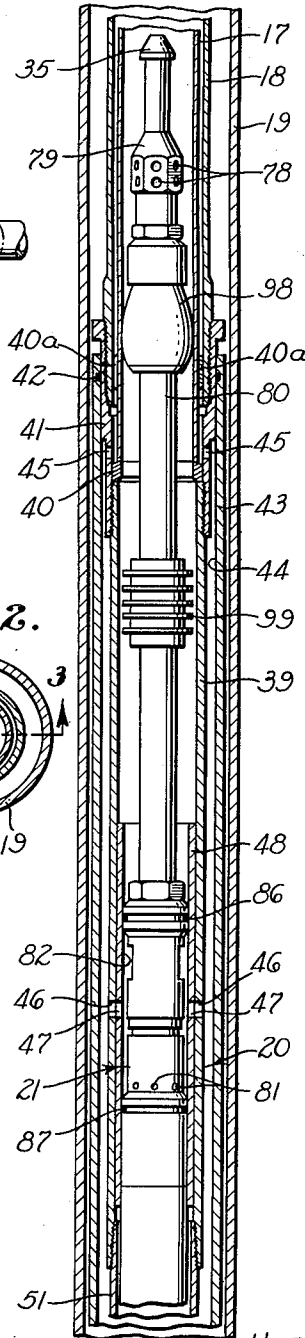


Fig. 2.

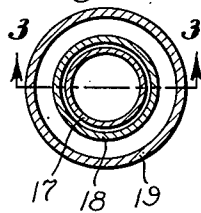
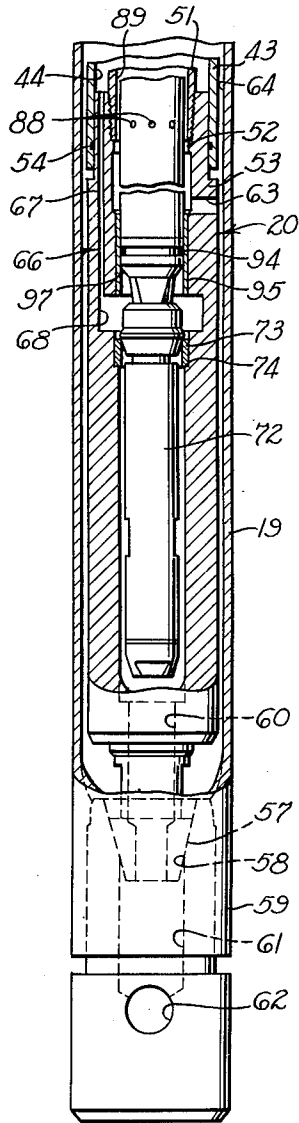
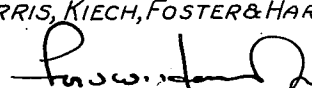


Fig. 4.



INVENTOR.
CLARENCE J. COBERLY
BY HIS ATTORNEYS.
HARRIS, KIECH, FOSTER & HARRIS
BY 

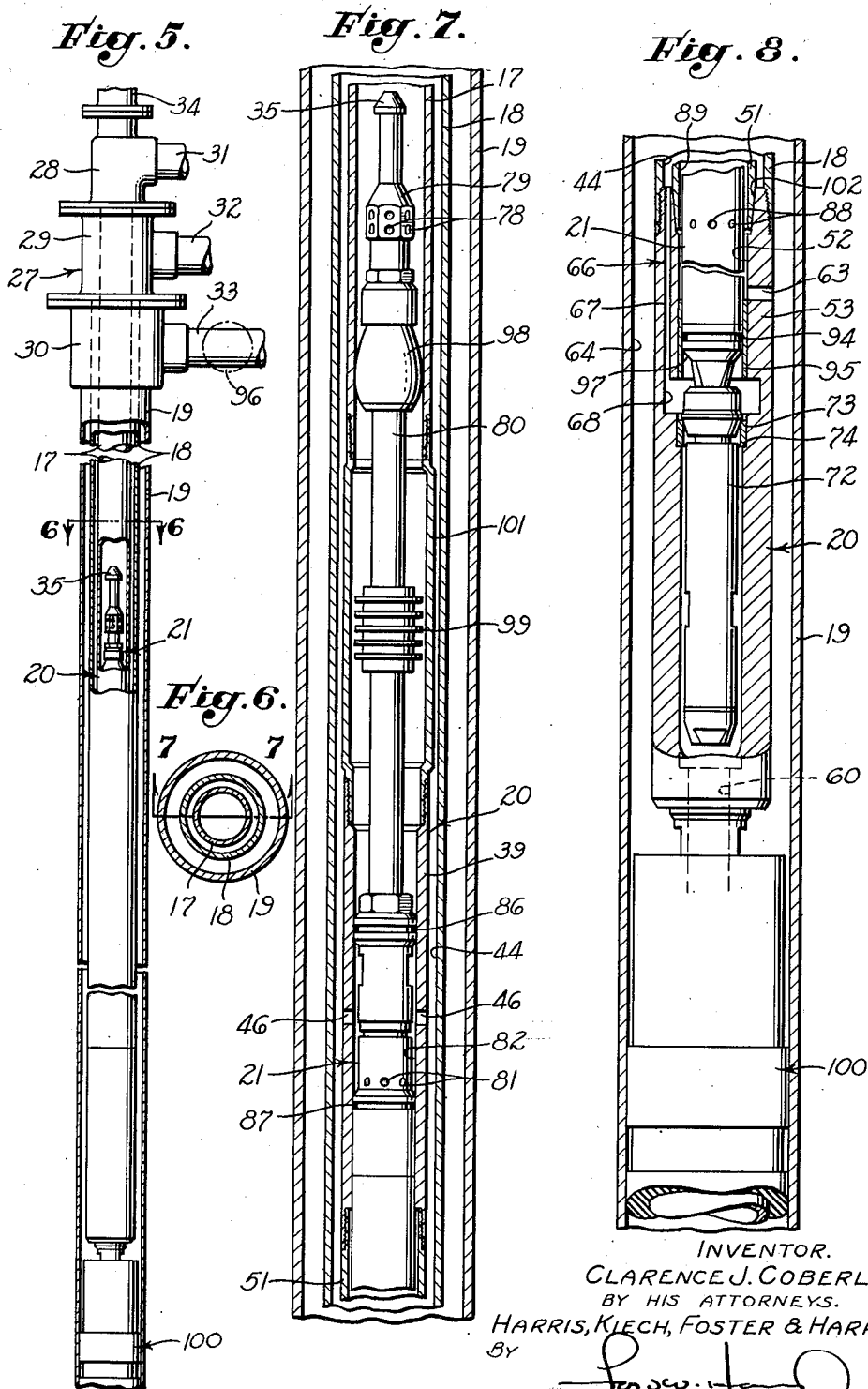
March 18, 1952

C. J. COBERLY
CLOSED FLUID-OPERATED FREE-PUMP SYSTEM
WITH THREE CONCENTRIC TUBINGS

2,589,669

Filed May 16, 1949

2 SHEETS—SHEET 2



UNITED STATES PATENT OFFICE

2,589,669

CLOSED FLUID-OPERATED FREE-PUMP SYSTEM WITH THREE CONCENTRIC TUBINGS

Clarence J. Coberly, Los Angeles, Calif., assignor, by mesne assignments, to Dresser Equipment Company, Cleveland, Ohio, a corporation of Ohio

Application May 16, 1949, Serial No. 93,481

21 Claims. (Cl. 103—46)

1

My invention relates in general to tubing systems for fluid-operated well pumps and, more particularly, to a closed tubing system for a fluid-operated well pump of the co-called "free" type.

Reference is hereby made to my copending applications Serial No. 93,483, filed May 16, 1949, Serial No. 93,482, filed May 16, 1949, and Serial No. 93,484, filed May 16, 1949.

It is conventional in the oil industry to employ a well pump apparatus which includes a free fluid-operated pump, such a pump being movable into and out of the well through a tubing set in the well and being adapted to assume an operating position at the lower end of such tubing. Examples of such fluid-operated, free-pump systems are disclosed in my Patents Nos. 2,230,830, granted February 4, 1941, and 2,338,903, granted January 11, 1944.

In conventional fluid-operated, free-pump systems, such as those disclosed in my aforementioned patents, two tubings are employed, one for conveying operating fluid downwardly in the well to the pump and the other for conveying fluid produced by the well upwardly therein from the pump to the surface, the two tubings being referred to hereinafter as the supply and production tubings, respectively. In such conventional systems, the pump is movable into its operating position through the supply tubing. The supply and production tubings are interconnected at their lower ends in fluid communication with each other and with the well so that the pump may receive operating fluid from the supply tubing and well fluid from the well and so that it may discharge well fluid into the production tubing as production fluid.

In installing such a free pump in the well, it is moved downwardly through the supply tubing into its operating position at the lower end thereof either by the action of gravity or by the application of fluid pressure to the upper end of the pump. After the pump has been installed in its operating position, operating fluid, which is usually clean crude oil, is delivered to the motor section of the pump under relatively high pressure through the supply tubing. As is well known in the art, such operating fluid is alternately directed by a suitable valve mechanism in the motor section of the pump to opposite ends of a motor piston which is coupled to a pump piston in the pump section of the device, fluid from the well being admitted to the pump section by a suitable valve mechanism therein. Such alternating application of operating fluid pressure to the ends of the motor piston produces reciprocation of the motor and pump pistons with

2

the result that the pump piston pumps fluid produced by the well into the production tubing, the latter conveying the production fluid upwardly therein to the surface. When removal of the pump from the well is desired for any reason, as for service or repair, fluid pressure is applied to the lower end of the pump to move it upwardly out of its operating position and through the supply tubing to the surface. This is accomplished conventionally by reversing the flow through the system so that operating fluid flows downwardly in the production tubing to the lower end of the pump and acts on the pump to move it upwardly through the supply tubing to the surface.

In a conventional free-pump system of the foregoing character, the spent operating fluid discharged by the motor section of the pump is delivered to the production tubing so that the spent operating fluid and the production fluid are intermixed and conveyed upwardly together through the production tubing. Since the operating fluid delivered to the pump through the supply tubing must be clean, in order to prevent abrasion and corrosion of the moving parts of the pump, fresh operating fluid must be supplied to the system continuously. The continuous provision of such fresh operating fluid requires considerable surface equipment, normally in the form of settling tanks or filters, which is expensive to install and operate. Also, in the particular arrangement hereinbefore mentioned wherein the pump is disposed in the supply tubing, the flow reversal necessary to remove the pump from the well may carry any sand or other foreign matter present in the production fluid into the supply tubing with the result that such foreign matter may enter the motor section of the pump upon resumption of operation after reinstallation with the attendant possibility of damage to the pump.

In view of the foregoing, it is a primary object of this invention to provide a closed system for the fluid-operated free pump which includes a third tubing separate from the supply and production tubings for returning the spent operating fluid to the surface independently of the well fluid, the tubing for returning the spent operating fluid being referred to hereinafter as the return tubing. With such a closed system, the spent operating fluid is separately conveyed back to the surface for storage and re-use to actuate the fluid-operated pump so that there is very little loss of operating fluid from the system and, consequently, the surface equipment necessary to supply fresh operating fluid to the

3

system needs have only a relatively small capacity and can be relatively cheap and economical, both as regards initial cost and operating costs. Also, the reversed flow necessary to move the pump upwardly to the surface during removal of the pump may take place through the return tubing to avoid carrying sand and other foreign matter into that portion of the system reserved for the operating fluid, which is an important feature. As will be pointed out in more detail hereinafter, further objects of the invention reside in certain modifications of the pump and in the tubing arrangements employed to provide such a closed system.

Considering the invention more specifically, an object thereof is to provide a closed system for a fluid-operated, free pump comprising supply, return and production tubings which are set in the well and one of which is adapted to receive the pump and to provide an operating position for the pump at its lower end, the supply, return and production tubings respectively being adapted to convey operating fluid for actuating the pump downwardly into the well to the pump, spent operating fluid discharged by the pump upwardly in the well from the pump to the surface and production fluid discharged by the pump upwardly in the well from the pump to the surface.

An important object of the invention is to provide a closed system wherein the supply, return and production tubings are set in the well concentrically with the innermost tubing adapted to receive the pump.

Another object is to provide such a closed system wherein the three tubings are interconnected at their lower ends in fluid communication with each other and with the well so that the pump may, when in its operating position, receive operating fluid for its actuation from the supply tubing through an intake, discharge spent operating fluid into the return tubing through an exhaust, receive well fluid from the well through an inlet and discharge well fluid into the production tubing through an outlet.

Another object is to provide a closed system having means whereby a downward flow of fluid through one of the tubings, other than the tubing in which the pump is disposed, may be applied to the lower end of the pump to move it upwardly out of its operating position and through the tubing in which it is disposed to the surface whenever removal of the pump from the well is desired.

Another object is to provide a closed system which includes a tubular pump receiver disposed at the lower end of and in alignment with the tubing through which the pump is movable, the pump receiver being, in effect, an extension of such tubing and providing the aforementioned operating position for the pump. A related object is to provide a pump receiver having a seat at its lower end for the pump, the pump being seated on such seat when it is in its operating position.

Another object is to provide a pump receiver having passages which place the interior thereof in fluid communication with the supply, return and production tubings and with the well in such a manner as to provide fluid communication between the intake, the exhaust, the inlet and the outlet of the pump and the supply tubing, the return tubing, the well and the production tubing, respectively, when the pump is disposed in the pump receiver and seated on the pump seat.

Another object is to provide sealing means for

4

normally preventing direct flow between the tubings and the well by way of the pump receiver when the pump is in its operating position so that operating fluid may flow only from the supply tubing through the motor section of the pump to the return tubing and so that well fluid may flow only from the well through the pump section of the pump to the production tubing. More specifically, an object in this connection is to provide a sealing means which, when the pump is in its operating position, places the supply tubing in fluid communication with only the intake of the pump, the return tubing in fluid communication with only the exhaust of the pump, the well in fluid communication with only the inlet of the pump and the production tubing in fluid communication with only the outlet of the pump.

Another object is to provide a system wherein the aforementioned sealing means comprises annular sealing elements which are carried by the pump adjacent various of the ports, such as the intake, exhaust, etc., therein and which are engageable with the inner wall of the pump receiver to prevent direct flow between the tubings.

Another object is to provide passage means communicating at one end with one of the tubings, other than the tubing aligned with the pump receiver, and at its other end with a chamber in the pump receiver between the pump seat and the pump for applying a downward flow of fluid through such tubing to the lower end of the pump to move it upwardly out of the pump receiver and to the surface.

Another object is to provide a sealing device for normally preventing fluid flow between two of the tubings by way of the aforementioned passage means and the pump receiver when the pump is in its operating position. Another object in this connection is to provide a system wherein the aforementioned sealing device is an annular sealing element adapted to be disposed between the pump and the pump receiver.

Another object is to provide a system wherein the tubing with which the aforementioned passage means communicates is the return tubing so that the pump may be moved upwardly to the surface by a downward flow of clean fluid through the return tubing to prevent introducing sand and other abrasive matter into the pump receiver.

Still another object is to provide a closed system wherein the pump is movable into its operating position in the pump receiver through the supply tubing and wherein the pump is movable upwardly to the surface by a downward flow of clean fluid through the return tubing so as to avoid carrying any of the sand or other abrasive material which may be in the fluid in the production tubing into the pump receiver during the pump-removal operation.

Another object is to minimize the power required to overcome friction between the production fluid moving upwardly through the production tubing and the wall of the production tubing by employing a production tubing having a large internal diameter. This feature is particularly important under well conditions such that a pump having a motor section of small capacity and a pump section of large capacity may be employed.

Another object of the invention is to provide a closed system wherein the outermost of the concentric supply, return and production tubings is the casing of the well.

The foregoing objects and advantages of the

5

present invention, together with other objects and advantages thereof which will become apparent, may be attained through the employment of the exemplary embodiments of the invention which are illustrated in the accompanying drawings and which are described in detail hereinafter. Referring to the drawings:

Fig. 1 is a utility view of a closed, fluid-operated, free-pump system which embodies the invention;

Fig. 2 is an enlarged, horizontal sectional view taken along the broken line 2—2 of Fig. 1;

Fig. 3 is an enlarged, vertical sectional view taken along the broken line 3—3 of Fig. 2;

Fig. 4 is a downward continuation of Fig. 3;

Fig. 5 is a utility view of another embodiment of the invention;

Fig. 6 is an enlarged, horizontal sectional view taken along the broken line 6—6 of Fig. 5;

Fig. 7 is an enlarged, vertical sectional view taken along the broken line 7—7 of Fig. 6; and,

Fig. 8 is a downward continuation of Fig. 7.

Considering first the embodiment illustrated in Figs. 1 to 4 of the drawings with particular reference to Fig. 1 thereof, I show a well casing 15 which is set in an oil well with its lower end open to an oil producing zone of the well as is well known in the art, the casing being provided with a casing head 16 at its upper end. Set in the well within the casing 15 is a closed tubing system which comprises concentric supply, return and production tubings respectively designated by the numerals 17, 18 and 19, the supply tubing being set within the return tubing and the return tubing being set within the production tubing. The tubings 17, 18 and 19 are interconnected at their lower ends in fluid communication with each other and with the well by a tubular pump receiver 20 which is aligned with and which, in effect, forms a downward extension of the innermost or supply tubing 17. The pump receiver 20 provides an operating position for a fluid-operated, free pump 21 which is movable downwardly through the supply tubing 17 into its operating position in the pump receiver, the internal diameter of the pump receiver being substantially equal to that of the supply tubing. As will be discussed in more detail hereinafter, the supply tubing 17 is adapted to convey operating fluid, such as clean crude oil, under pressure downwardly in the well from the surface to the pump 21 to actuate the pump, and the return tubing 18 is adapted to receive spent operating fluid discharged by the pump and to convey the spent operating fluid upwardly in the well to the surface. The pump 21 is adapted to receive well fluid from the well and to discharge it into the production tubing 19 as production fluid, the production tubing conveying the production fluid upwardly in the well to the surface.

The supply, return and production tubings 17, 18 and 19 are connected at their upper ends to a tubing head 27 which includes supply, return and production sections 28, 29 and 30 in fluid communication with the supply, return and production tubings, respectively. Connected to the tubing head sections 28, 29 and 30 in fluid communication therewith are supply, return and production lines 31, 32 and 33 which respectively communicate with the supply, return and production tubings 17, 18 and 19 through the corresponding tubing head sections. The supply line 31 leads to a suitable source (not shown) of operating fluid under pressure, which source may be a conventional triplex pump having its intake connected

6

to a suitable reservoir. The return line 32 leads to the reservoir and the production line 33 leads to a suitable point of disposal or storage for the production fluid. The tubing head 27 also includes a tube 34 which is aligned with the supply tubing 17 and through which the pump 21 may be inserted into or removed from the supply tubing. The tube 34 may have associated therewith a pump catcher (not shown) for the pump 21, the latter having at its upper end a tapered head 35 which is receivable by the pump catcher during removal of the pump from the well. The pump catcher may be of any suitable type, such as that disclosed in my aforementioned Patent No. 2,338,903.

Referring now to Figs. 3 and 4 of the drawings and considering the structure of the pump receiver 20, it includes an inner sleeve 39 which is aligned with and which, in effect, forms an extension of the supply tubing 17, an annular element 40 being clamped between the supply tubing and the sleeve 39 by a coupling 41 threaded onto the lower end of the return tubing 18 and onto the upper end of the sleeve 39. It will be noted that the upper surface of the annular element 40 and the lower end of the supply tubing 17 are complementary tapered so that the annular element 40 serves to center the lower end of the supply tubing in the return tubing. A spacer 40a having passages therethrough is disposed between the tubings 17 and 18 above the element 40.

Telescoped over the coupling 41 and sealed with respect thereto by an annular sealing element 42 is an outer sleeve 43 which is spaced radially from the lower end of the coupling 41 and from the inner sleeve 39 to provide an annular space 44 for spent operating fluid, the lower end of the coupling 41 being provided with ports 45 therethrough so that spent operating fluid from the annular space 44 may flow through such ports into the return tubing 18, i. e., into the annular space between the supply tubing 17 and the return tubing. The spent operating fluid may enter the annular space 44 through radial ports 46 in the inner sleeve 39 and through registering ports 47 in a liner 48 pressed into the inner sleeve 39.

Threaded into the lower end of the inner sleeve 39 is another inner sleeve 51 which is threaded at its lower end into a bore 52 in a fitting 53 at the lower end of the pump receiver 20, the outer sleeve 43 being telescoped over the upper end of this fitting and being sealed with respect thereto by an annular sealing element 54. With this construction, assembly of the inner sleeves 39 and 51 and the outer sleeve 43 with the coupling 41 and the fitting 53 is facilitated since the outer sleeve may slide relative to the coupling and the fitting as the inner sleeves are threadedly connected thereto.

The fitting 53 is provided at its lower end with a tapered foot 57 which is adapted to seat on a complementary seat 58 in a fitting 59 at the lower end of the production tubing 19. With this construction, the supply and return tubings 17 and 18 and the pump receiver 20 may be removed from the well without removing the production tubing 19, which is a feature of the invention.

The bore 52 in the fitting 53 communicates with the well through a passage 60 in this fitting and through longitudinal and lateral passages 61 and 62 in the fitting 59 at the lower end of the production tubing. The bore 52 in the fitting 53 also communicates with the production tubing 19 by way of one or more ports 63 in the fitting 53,

i. e., communicates with an annular space 64 between the outer sleeve 43 and the production tubing 19, which annular space in turn communicates at its upper end with the annular space between the return tubing 18 and the production tubing. Thus, with this construction, the pump receiver 20 interconnects the lower ends of the supply, return and production tubings 17, 18 and 19 in fluid communication with each other and with the well.

The fitting 53 of the pump receiver 20 is provided with a passage means 66 for applying a downward flow of fluid through the return tubing 18 to the lower end of the pump 21 to move the pump upwardly out of the pump receiver 20 and through the supply tubing 17 to the surface when removal of the pump is desired for any reason, this passage means comprising one or more longitudinal passages 67 which communicate at their upper ends with the annular space 44 between the inner sleeves 39 and 51 and the outer sleeve 43 and which communicate at their lower ends with an annular chamber 68 at the lower end of the pump 21.

Disposed in the lower end of the bore 52 in the fitting 53 is an inlet fitting 72 for the pump 21, the latter having an inlet which is adapted to receive well fluid from the well through the inlet fitting by way of the passages 60, 61 and 62 when the pump is in its operating position, as will be discussed in more detail hereinafter. As is well known in the art, the inlet fitting 72 is preferably provided with a check valve (not shown) which permits upward flow of well fluid into the interior of the pump receiver 20, but which prevents downward flow of fluid out of the pump receiver into the well. The inlet fitting 72 also serves as a seat for the pump 21, the latter being in its operating position when it is disposed in the pump receiver 20 and seated on the inlet fitting. The pump 21 is adapted to seat on the inlet fitting 72 automatically when it is moved downwardly through the supply tubing 17 into the pump receiver 20 so that it automatically assumes its operating position. The inlet fitting 72 is seated on an annular insert 73 which is disposed in the bore 52 in the fitting 53 and which is seated on a shoulder 74 therein.

Except for certain modifications required to adapt it to the closed tubing system of the invention, the free fluid-operated pump 21 may be of conventional design and will not be described in detail. In general, the pump 21 includes a motor section and a pump section below the motor section, the motor and pump sections respectively including coupled motor and pump pistons (not shown). The motor section of the pump 21 is actuable by operating fluid under pressure delivered thereto by the supply tubing 17, the operating fluid under pressure being adapted to enter the motor section of the pump through ports which serve as an intake 78 for the pump and which are in fluid communication with the supply tubing when the pump is in its operating position. The ports of the intake 78 are formed in an intake fitting 79 which carries the aforementioned tapered head 35 and which is connected to the upper end of a tubular rod 80 extending upwardly from the motor section of the pump 21, the rod being adapted to convey the operating fluid under pressure from the intake to the motor section of the pump.

After the operating fluid admitted to the motor section of the pump 21 through the intake 78 has actuated the pump, it is discharged from the

motor section through ports forming an exhaust 81 for the pump. When the pump 21 is in its operating position, the exhaust 81 communicates with an annular space 82 between the pump and the liner 48 in the inner sleeve 39, this annular space communicating with the return tubing 18 through the ports 47 in the liner, the ports 46 in the inner sleeve 39, the annular space 44 between the inner sleeve and the outer sleeve 43, and the ports 45 in the coupling 41. Thus, the operating fluid under pressure in the supply tubing 17 flows through the motor section of the pump 21 to actuate it and is discharged into the return tubing 18 as spent operating fluid.

In order to prevent direct flow of operating fluid between the supply and return tubings 17 and 18 by way of the pump receiver 20, I provide sealing means comprising annular sealing elements 86 and 87 which are carried by the pump 21 respectively above and below the exhaust 81 and which are adapted to engage the liner 48 respectively above and below the ports 47 in the liner when the pump 21 is in its operating position. It will be noted that this arrangement places the annular sealing element 86 intermediate the intake 78 and the exhaust 81 of the pump. Thus, the annular sealing elements 86 and 87 isolate the intake 78 and the exhaust 81 when the pump 21 is in its operating position so that the intake may communicate only with the supply tubing 17 and so that the exhaust may communicate only with the return tubing 18.

As previously mentioned, the pump section of the pump 21 is provided with an inlet at its lower end through which well fluid is adapted to enter the pump section by way of the inlet fitting 72, the inlet of the pump section not being shown specifically. The pump section of the pump is also provided with ports forming an outlet 88 for production fluid discharged by the pump section, the outlet communicating with an annular space 89 which is disposed between the pump and the inner sleeve 51 and which communicates at its lower end with the ports 63 leading to the production tubing 19. Thus, production fluid discharged by the pump 21 through the outlet 88 flows through the annular space 89, the ports 63 and the annular space 64 into the annular space between the return and production tubings 18 and 19.

It will be noted that the annular sealing element 87 is disposed between the exhaust 81 and the outlet 88 so that it prevents flow between the return and production tubings 18 and 19 when the pump is in its operating position. Also, since the pump 21 is seated on the inlet fitting 72 when in its operating position, the pump seat provided by the inlet fitting serves to prevent direct flow between the well and the tubings 17, 18 and 19. In order to prevent flow between the return and production tubings 18 and 19 by way of the passage means 66 when the pump 21 is in its operating position, the pump carries an annular sealing element 94 which is adapted to engage a liner 95 pressed into the bore 52 in the fitting 53 of the pump receiver 20.

Considering the operation of the embodiment of the invention hereinbefore described, it will be assumed that the pump 21 is in operation to pump fluid from the well upwardly through the production tubing 19 to the surface. Under such conditions, the pump 21 is in its operating position in the pump receiver 20 so that it is seated on the inlet fitting 72, and operating fluid under

pressure is being conveyed downwardly to the pump 21 through the supply tubing 17 and enters the motor section of the pump through the intake 78 to actuate the pump, spent operating fluid being discharged into the return tubing 18 through the exhaust 81 and being conveyed upwardly in the well to the surface by the return tubing. The well fluid entering the pump section of the pump 21 through its inlet is discharged into the production tubing 19 through the outlet 83 and is conveyed upwardly in the well to the surface as production fluid. It will be apparent that, with this construction, the spent operating fluid is returned to the surface separately from the production fluid so that it may be re-used to actuate the pump 21, which is a primary feature of the invention.

In the event that removal of the pump from the well is necessary in order to service or repair the pump, or for any other reason, it is merely necessary to direct a flow of operating fluid under pressure downwardly through the return tubing 18, instead of through the supply tubing 17. This may be accomplished by connecting the return line 32 to the source of operating fluid under pressure, the supply line 31 preferably being connected to the reservoir associated with the source under such conditions. As will be apparent, this may be accomplished by a suitable arrangement of valves (not shown). Also, fluid flow through the production tubing 19 and the production line 33 under such conditions is preferably prevented, as by closing a valve 96 in the production line.

Under the conditions outlined in the preceding paragraph, operating fluid under pressure flows downwardly through the return tubing 18 and into the annular chamber 68 at the lower end of the pump 21 by way of the ports 45 in the coupling 21, the annular space 44 between the inner sleeves 39 and 51 and the outer sleeve 43, and the passage means 66. The pressure of the operating fluid entering the annular chamber 68 in the foregoing manner is applied to an annular area 97 at the lower end of the pump 21 so as to unseat the pump from the inlet fitting 72 and is then applied to the entire area of the pump so as to move it upwardly in the pump receiver 20, upward flow of the operating fluid applied to the lower end of the pump in this manner past the pump being prevented by the annular sealing elements 86, 87 and 94 which engage the liners 48 and 95. After the pump 21 is moved upwardly in the pump receiver 20 a distance such that the annular sealing elements 86, 87 and 94 disengage the liners 48 and 95, upward flow of operating fluid past the pump is prevented by packing devices 98 and 99 which are carried by the rod 80 and which are adapted to engage the inner wall of the supply tubing 17 in a substantially fluid-tight manner, the portions of the pump 21 which carry the annular sealing elements 86, 87 and 94 preferably being of smaller diameter than the internal diameter of the supply tubing so as to prevent damage to the sealing elements during movement of the pump through the supply tubing. After the pump has cleared the ports 47 in the liner 48, the downward flow of operating fluid through the return tubing 18 is applied to the lower end of the pump directly through the registering ports 46 and 47. Continued downward flow of operating fluid under pressure through the return tubing 18 results in upward movement of the pump 21 through the supply tubing 17 to the surface so that it may

be removed from the supply tubing through the tube 34 at the upper end of the tubing head 27.

During the foregoing pump-removal operation, flow of operating fluid employed to remove the pump out of the pump receiver into the well is prevented by the check valve in the inlet fitting 72 and flow thereof into the production tubing 19 is prevented because of the closed valve 96 in the production line 33. It will be noted that, since the valve 96 is closed during the pump-removal operation, substantially none of the production fluid can enter the pump receiver 20 during the pump-removal operation, which is an important feature since it prevents sand and other foreign matter which may be in the production fluid from entering the pump receiver. Thus, subsequent damage to the motor section of the pump from this source upon re-installation of the pump is prevented. It will also be noted that, under the conditions hereinbefore outlined, the operating fluid in the supply tubing 17 above the pump 21 may be returned to the reservoir associated with the source of operating fluid during the pump-removal operation so that substantially none of the operating fluid is lost from the system.

When re-installation of the pump 21, or installation of a replacement pump 21, is desired, it is inserted into the upper end of the supply tubing 17 through the tube 34 at the upper end of the tubing head 29 and operating fluid under pressure is introduced into the supply tubing above the pump through the supply line 31, the return line 32 preferably being connected to the reservoir associated with the source of operating fluid. Thus, the operating fluid under pressure entering the system through the supply line 31 acts on the upper end of the pump 21 to move it downwardly through the supply tubing 17 and into its operating position in the pump receiver 20 wherein it is seated on the inlet fitting 72, the operating fluid previously introduced below the pump during the pump-removal operation being displaced upwardly through the return tubing 18 and into the return line 32 leading to the reservoir. During the operation of installing the pump, the valve 96 in the production line 33 preferably prevents flow through the production tubing 19 so that all of the fluid employed during the pump-removal operation is returned to the reservoir during re-installation of the pump. It will be understood, however, that if the operating fluid in the supply tubing becomes contaminated prior to re-installation of the pump 21 for any reason, returning such contaminated operating fluid to the reservoir may be avoided by preventing fluid flow through the return tubing 18 and by permitting fluid flow through the production tubing 19.

As will be apparent, one advantage of the embodiment hereinbefore discussed is that it is possible to remove and re-install the pump 21 with substantially no loss of operating fluid from the system, the production tubing 19 being isolated from that portion of the system reserved for the operating fluid by the closed valve 96 during the operations of removing and re-installing the pump.

Another advantage of the embodiment hereinbefore disclosed is that it provides a production tubing 19 of large diameter so as to minimize friction losses between the production fluid stream and the production tubing, which is an important feature, particularly in wells permitting the use of a pump having a pump section

of large capacity and a motor section of small capacity, since it provides a high ratio of production to power input.

Referring now to Figs. 5 to 8 of the drawings, the embodiment of the invention illustrated therein is similar to that illustrated in Figs. 1 to 4 and the same reference numerals are employed to designate corresponding components insofar as applicable. The principal difference between the two embodiments is that, in the one illustrated in Figs. 5 to 8, the well casing 15 and casing head 16 are eliminated, the production tubing 19 being the well casing. In order to isolate the column of production fluid from the well, I employ a packer 100 connected to the fitting 53 at the lower end of the pump receiver 20. The passage 60 in the fitting 53 communicates with the well below the packer 100 so that well fluid may enter the inlet of the pump 21 through the inlet fitting 72 as in the preceding embodiment.

The pump receiver 20 of the embodiment presently under consideration is of somewhat different construction than the pump receiver of the previously considered embodiment, one of the differences being that the return tubing 18 is connected directly to the fitting 53, as by being threaded thereon. The pump receiver 20 includes the previously described inner sleeves 39 and 51, a third inner sleeve 101 being threaded into the upper end of the inner sleeve 39 and being threaded onto the lower end of the supply tubing 17. Instead of being threaded into the fitting 53, the lowermost inner sleeve 51 is tapered at its lower end and is seated on a complementary seat 102 in this fitting.

Except for the foregoing differences, the embodiment of Figs. 5 to 8 is identical to that of Figs. 1 to 4, and its operation is identical to the operation of the embodiment of Figs. 1 to 4. Consequently, a detailed explanation of the operation of the embodiment presently under consideration is unnecessary.

Although I have disclosed exemplary embodiments of the invention herein for purposes of illustration, it will be understood that I do not intend to be limited specifically thereto since various changes, modifications and substitutions may be incorporated in the illustrative embodiments disclosed without departing from the spirit of the invention.

I claim as my invention:

1. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; means for interconnecting the lower ends of said tubings in fluid communication with each other and with the well; and a fluid-operated, free pump movable in the innermost of said tubings into an operating position at the lower end thereof, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position.

2. In a closed, fluid-operated, free-pump system for a well, the combination of: three concentric tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid

produced by the well upwardly therein to the surface; means for interconnecting the lower ends of said tubings in fluid communication with each other and with the well; a pump seat at the lower end of and aligned with the innermost of said tubings; and a fluid-operated, free pump movable in said innermost tubing into an operating position at the lower end thereof wherein it is seated on said pump seat, said pump having an intake, an exhaust and an outlet which communicate with said tubings, respectively, when said pump is in said operating position, and having an inlet which communicates with the well when said pump is in said operating position.

3. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; a tubular pump receiver at the lower end of and aligned with the innermost of said tubings, said pump receiver being connected to the lower ends of said tubings in fluid communication therewith and being in fluid communication with the well; and a fluid-operated, free pump movable in said innermost tubing and movable into an operating position in said pump receiver, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position.

4. A closed system as set forth in claim 3 including sealing devices for normally preventing direct flow of fluid between said tubings and the well when said pump is in said operating position.

5. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; a tubular pump receiver connected to the lower ends of said tubings in alignment with the innermost of said tubings, said pump receiver communicating at its upper end with said innermost tubing and having substantially the same internal diameter as said innermost tubing, and said pump receiver having passages which provide fluid communication between the others of said tubings and said pump receiver and between the well and said pump receiver; a pump seat carried by said pump receiver at the lower end thereof and in alignment therewith; a fluid-operated, free pump movable in said innermost tubing and movable into an operating position in said pump receiver wherein it is seated on said pump seat, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position; and sealing devices for normally preventing direct flow of fluid between said tubings and the well by way of said pump receiver when said pump is in said operating position.

6. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface,

13

14

spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; a tubular pump receiver connected to the lower ends of said tubings in alignment with the innermost of said tubings, said pump receiver communicating at its upper end with said innermost tubing and having substantially the same internal diameter as said innermost tubing, and said pump receiver having passages which provide fluid communication between the others of said tubings and said pump receiver and between the well and said pump receiver; a pump seat carried by said pump receiver at the lower end thereof and in alignment therewith; a fluid-operated, free pump movable in said innermost tubing and movable into an operating position in said pump receiver wherein it is seated on said pump seat, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position; sealing devices for normally preventing direct flow of fluid between said tubings and the well by way of said pump receiver when said pump is in said operating position; a chamber in said pump receiver between said pump seat and said pump; and passage means providing fluid communication between said chamber and one of said tubings other than said innermost tubing.

7. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; a tubular pump receiver connected to the lower ends of said tubings, said pump receiver communicating at its upper end with said innermost tubing and having substantially the same internal diameter as said innermost tubing, and said pump receiver having passages which provide fluid communication between the others of said tubings and said pump receiver and between the well and said pump receiver; a pump seat carried by said pump receiver at the lower end thereof and in alignment therewith; a fluid-operated, free pump movable in said innermost tubing and movable into an operating position in said pump receiver wherein it is seated on said pump seat, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position; sealing devices for normally preventing direct flow of fluid between said tubings and the well by way of said pump receiver when said pump is in said operating position; a chamber in said receiver between said pump seat and said pump; passage means providing fluid communication between said chamber and one of said tubings other than said innermost tubing; and another sealing device for normally preventing flow of fluid between said passage means and said production tubing.

8. A closed system as set forth in claim 7 wherein said other sealing device comprises an annular sealing element positionable between said pump and said pump receiver.

9. A closed system as set forth in claim 1 wherein said innermost tubing is said supply tubing.

10. A closed system as set forth in claim 1 wherein said innermost tubing is said supply tubing and wherein the intermediate and outermost tubings are said return and production tubings, respectively.

11. A closed system as set forth in claim 1 wherein the outermost of said tubings is the casing of the well.

12. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface; means for interconnecting the lower ends of said tubings in fluid communication with each other and with the well; a fluid-operated, free pump movable in the innermost of said tubings into an operating position at the lower end thereof, said pump having an intake, an exhaust, an inlet and an outlet which communicate with said supply tubing, said return tubing, the well and said production tubing, respectively, when said pump is in said operating position; means for preventing direct flow of fluid between said tubings and the well by way of said interconnecting means when said pump is in said operating position; and passage means communicating with said innermost tubing and with one of the others of said tubings for applying a downward flow of fluid through said one other tubing to the lower end of said pump to move said pump upwardly from its operating position through said innermost tubing to the surface.

13. A closed system as set forth in claim 12 wherein said innermost tubing is said supply tubing.

14. A closed system as set forth in claim 12 wherein said innermost tubing is said supply tubing, and wherein the intermediate and outermost tubings are said return and production tubings, respectively.

15. A closed system as set forth in claim 12 wherein said one other tubing with which said passage means communicates is said return tubing.

16. A closed system according to claim 12 wherein said production tubing is of larger diameter than at least one of the other two tubings.

17. A closed system as defined in claim 12 wherein said production tubing is of larger diameter than either of the other two tubings.

18. In a closed, fluid-operated, free-pump system for a well, the combination of: concentric supply, return and production tubings set in the well and respectively adapted to convey operating fluid downwardly into the well from the surface, spent operating fluid upwardly in the well to the surface and fluid produced by the well upwardly therein to the surface, said supply tubing being the innermost of said tubings; a tubular pump receiver at the lower end of and aligned with said innermost tubing, said pump receiver being connected to the lower ends of said tubings in fluid communication therewith and being in fluid communication with the well; a fluid-operated, free pump movable in said innermost tubing into an operating position in said pump receiver, said pump having an intake, an exhaust below said intake, an outlet below said exhaust, and an inlet below said outlet, said intake, said exhaust, said inlet and said outlet respectively communicating with said supply tubing,

15

said return tubing, the well and said production tubing when said pump is in said operating position; an annular sealing element carried by said pump intermediate said intake and said exhaust and engageable with said pump receiver when said pump is in said operating position; another annular sealing element carried by said pump intermediate said exhaust and said outlet and engageable with said pump receiver when said pump is in said operating position; and sealing means providing a fluid-tight seal between said inlet and said outlet when said pump is in said operating position.

19. A closed system according to claim 18 including a passage communicating at one end with said return tubing and at its other end with said pump receiver at a point which is intermediate said other annular sealing element and said sealing means when said pump is in its operating position, said system including a sealing device for normally preventing flow from said return to said production tubing by way of said passage when said pump is in said operating position.

20. A closed system as set forth in claim 19 wherein said sealing device comprises an annular sealing element carried by said pump below said outlet and engageable with said pump receiver when said pump is in said operating position.

21. In a closed, fluid-operated, free-pump system, the combination of: a primary tubing and a pair of secondary tubings set in the well concentrically with said primary tubing innermost, said primary tubing being of a size to receive a fluid-operated, free pump and providing for

16

movement of the pump between an operating position at the lower end of said primary tubing and the surface; means interconnecting the lower ends of said tubings, said interconnecting means having passage means providing fluid communication between one of said secondary tubings and said primary tubing and having passage means providing fluid communication between the other of said secondary tubings and said primary tubing; inlet means connected to said primary tubing and having a passage providing fluid communication between the well and said primary tubing, said inlet means having means for preventing flow of fluid from said primary tubing into the well through said passage; and sealing means providing a fluid-tight seal between said secondary tubings.

CLARENCE J. COBERLY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,599,601	Watts	Sept. 14, 1926
1,765,457	Shutt	June 24, 1930
1,765,921	Joy	June 24, 1930
2,230,787	Swain	Feb. 4, 1941
2,230,830	Coberly	Feb. 4, 1941
2,277,181	Zuck	Mar. 24, 1942
2,327,503	Coberly	Aug. 24, 1943
2,338,903	Coberly	Jan. 11, 1944